

Urban growth and spatial segregation increase disaster risk: Lessons learned from the 2023 disaster on the North Coast of São Paulo, Brazil

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Response letter to reviewer #2 (Anonymous)

Response 1: *We would like to thank the reviewer for the interesting comments about our paper. We carefully evaluated the proposed suggestions and prepared the following responses accordingly. Please find below our point-by-point responses (in italics).*

Here is a review of “Urban growth and spatial segregation increase disaster risk: Lessons learned from the 2023 disaster on the North Coast of São Paulo, Brazil”. The authors have presented some perspectives on how urban growth and inequalities influence disaster risk in terms of exposure and vulnerability. In this case, rain-triggered landslide.

Here are some suggestions:

The authors used a more generalized term, disaster. I suggest that the authors consider being more specific as to which disaster is being studied here. Readers can get easily confused from reading the abstract as to which rainfall-triggered event is being studied for the 2023 event. One disaster that could come to mind would be flooding which is also very common to Sao Paulo, Brazil. Although the 2023 events included both flooding and landslides, the authors only considered landslides in their analysis.

Response 2: *We agree that the term “disaster” and the related hazard processes should be better distinguished and described in the abstract and introduction sections. We will correct this in the revised version. However, as mentioned by the reviewer, the 2023 disaster was characterized by a multi-hazard event combining landslides, mudflows, and flash floods. Unfortunately, we could not delineate crisp boundaries between these processes as there were several areas of spatial intersection. For example, we observed locations with streets covered by mud in the post-disaster image. While this is evidence of the hazard process, it becomes difficult to differentiate between flash floods and mudflows based solely on the aerial image. The same happens when identifying landslides and mudflows. However, these limitations did not influence our analysis. We based our study on the identification of the physical damage to buildings without a distinction between hazard processes. Thus, the comparison of very high-resolution pre- and post-disaster images was adequate for this purpose. In the revised version, we will adjust the text to be more explicit about this condition.*

Line 25 - For example, the authors cited “Tellman et al. (2021) demonstrated that the proportion of the global population occupying areas exposed to large riverine floods has increased by 20% from 2000 to 2015”. Literature reviews on floods and landslides could be misleading to readers. I’ll suggest the authors consider stating which disaster their work focuses on in the context of disaster risk and the 2023 event.

Response 3: *While we focused on specific hazards, the major topic of our study remains the association between exposure to hazard processes and urban growth. For this reason, we believe that presenting previous research such as Tellman et al. (2021) is still important to contextualize our study. In any case, we will adjust the abstract and introduction sections, as previously stated.*

Line 470 - Could this be a typo? “450%” or 45%?

Response 4: *The numbers are correct. The total urban area grew by 4.5 times (450%) from 1985 to 2015, according to information from the World Settlement Footprint evolution layer (as illustrated in Figure 4).*

Question - Has there been a history of landslides in the study location? That could expressly indicate some level of exposure to landslides and could be accounted for in the analysis.

Response 5: *There is no evidence of a history of landslides in the study location. To our best knowledge, the 2023 event in São Sebastião was an unprecedented event, both regarding the extreme rainfall and the large number of landslides. The only case of a similar event in the region happened in 1967 in the neighboring city of Caraguatatuba (not the same location, but nearby). We will mention this in the introduction section of the revised manuscript.*

In section 3.3 Understanding the patterns and drivers of urban growth and spatial segregation, you identified the factors driving urban development processes and how they are associated with disaster exposure and vulnerability. By extension, some of these factors also influence landslide occurrence, so maybe relating drivers of urban growth and spatial segregation to landslide factors could provide more context to exposure in the study area.

Response 6: *We agree that urban development processes are not only associated with exposure and vulnerability but also with hazard processes and can cause feedbacks. We acknowledged this in the Introduction section, lines 48 to 52:*

“... urban growth, especially the construction of irregular housing and settlements, can increase the probability of hazard occurrence due to human modifications in the environment. These modifications impact slope stability through processes such as vegetation deforesting, slope cutting, and inadequate drainage systems.”

However, quantifying this influence would require the development of models to investigate temporal changes in hazard processes. Modeling such “what-if” scenarios to investigate where landslides would have occurred if areas were not urbanized is beyond the scope of our study. It also involves uncertainties that we would not be able to quantify without a proper multi-temporal hazard inventory. In this paper, we focused exclusively on the 2023 disaster, thus using this specific hazardous event as a reference for our analysis.

In the result section, I suggest authors focus on facts from their analysis and less citation of literature. A bulk of geospatial analysis and some statistical analyses have been done and efforts need to be placed on interpreting them for ease of readability.

Response 7: *Thank you for this comment. We included citations from the literature because we combined the results and discussions in the same section. Thus, we believe it is also of great importance to relate our findings to previous research. From our perspective, the paragraphs and discussions presented in this section describe our main findings, figures, and tables in detail. However, we would be glad to accept suggestions if you believe that any specific part of the section is not clear or well-described. When revising the paper, we will also carefully look at this section and aim to better separate the description of the results and the discussion. We would like to keep a merged section, though.*

Generally, the authors have done very fine-scale work on improving our understanding of the risk increased urbanization and inequality pose to exacerbate exposure and vulnerability to disaster.

Response 8: *Thank you very much again for your time to review the paper.*