

Interactive comment on “Assessing population exposure for landslide risk analysis using dasymetric cartography” by R. A. C. Garcia et al.

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Author Reply to RC2 – Alexandre Tavares Interactive comment on: “Assessing population exposure for landslide risk analysis using dasymetric cartography” by Garcia R.A.C. et al.

It is considered that the article is potentially relevant to NHESS journal readers and can constitute a methodological standpoint article. But the way it is presented and discussed makes it a technical note, which reduces the potential relevance can achieve in studies about hazardous processes.

A.Reply: The authors would like to acknowledge the referee for the deep review of the manuscript and by the constructive comments that will contribute to improve the new version of our manuscript. All the comments and suggestions will be considered in the

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new version of the manuscript and will be discussed individually in our reply to referee.

a) The manuscript presents a good introduction, enumerating the importance of analyzing the impacts, with a good state of the art, in which however lacks recent publications made in the Lisbon metropolitan area where the methodology of territorial vulnerability and the risks, have been discussed.

A.Reply: The authors completely agree with the referee comment. New references considering vulnerability studies at different scales and different risks will be added in the state of the art section, namely:

Guillard-Gonçalves, C., Cutter, S. L., Emrich, C. T. and Zêzere, J. L.: Application of Social Vulnerability Index (SoVI) and delineation of natural risk zones in Greater Lisbon, Portugal, *J. Risk Res.*, 18(5), 651–674, doi:10.1080/13669877.2014.910689, 2015.

Mendes, J. M., Tavares, A. O., Freiria, S. and Cunha, L.: Social vulnerability to natural and technological hazards: The relevance of scale, in *Reliability, Risk and Safety: Theory and Applications*, vol. 1, edited by R. Briš, C. Guedes Soares, and S. Martorell, pp. 445–451, Taylor & Francis Group, London. [online] Available from: [https://estudogeral.sib.uc.pt/jspui/bitstream/10316/25442/1/JMM Esrel 2010.pdf](https://estudogeral.sib.uc.pt/jspui/bitstream/10316/25442/1/JMM%20Esrel%202010.pdf), 2010.

Tavares, A. O. and Santos, P. P. dos: Re-scaling risk governance using local appraisal and community involvement, *J. Risk Res.*, 17(7), 923–949, doi:10.1080/13669877.2013.822915, 2014.

Tavares, A. O., dos Santos, P. P., Freire, P., Fortunato, A. B., Rilo, A. and Sá, L.: Flooding hazard in the Tagus estuarine area: The challenge of scale in vulnerability assessments, *Environ. Sci. Policy*, 51, 238–255, doi:10.1016/j.envsci.2015.04.010, 2015.

Tavares, A. O. and Santos, P. P. dos: Re-scaling risk governance using local appraisal and community involvement, *J. Risk Res.*, 17(7), 923–949, doi:10.1080/13669877.2013.822915, 2014.

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b) On the framework about the methodology for assessing the dasymetric exposure, and the related mapping, this is consistent, although limited in the discussion, which is reflected later in the discussion of the results, made on an incipient form, or based on the uncertainty related with people location inside buildings, which is a curiosity.

A.Reply: The authors thank the referee comment. The authors will clarify Data and methodology section. Changes will be made in figure 2 (general methodological approach), scale and source of building maps, criteria for classification of residential buildings, adopted methods to classifications/generalization of the susceptibility map, etc.. Additionally we will deeply emphasize on assumptions and uncertainties in the Discussion section.

c) It is considered that in relation to the structure the article it is unbalanced, with a long introduction. The presentation of results is scarce and the discussion is done in bullets through synthetic sentences, requiring a deeper discussion.

A.Reply: The authors acknowledge the referee comment. A restructure of the manuscript will be done. Therefore, Introduction will be split in sub-chapters to make it clear. Disproportionality with other chapters will be taken into consideration but it will decrease with the increasing size of study area (with considerations about the adopted criteria to choose this study area), methodology (as referred in our previous reply), results and discussion sections, (e.g. with a test to evaluate changes in obtained results depending on the generalization from raster to statistical terrain units).

d) In terms of the graphical elements presented, they have quality and are illustrative, although a summary table that show the comparative results of the two approaches (1 and 2) it was important.

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A.Reply: The authors totally agree with the referee suggestion. Instead of figure 6 two new tables will be inserted in the new version of the manuscript with the results obtained in the comparison of the different approaches: 1) Landslide susceptibility classes weight (%); 2) Potential exposed population per susceptibility class.

e) About the quality of the edited English, this is limited, with poor formal expressions, so it is suggested a review by a native speaker.

A.Reply: The authors understand the reviewer comment and apologize for that. Indeed, we hired a specialized translation service to an English native speaker to review the complete final manuscript in order to avoid spelling and grammatical errors.

We now present some considerations that the authors should note in reviewing the manuscript:

1 - The introduction is written considering multi-hazards concerns, and then the authors have evolved to the landslides exposed population, based on the landslide susceptibility map characteristics. This concerns about a single hazard could be better explained and supported.

A.Reply: The authors acknowledge the referee comment. Despite the references made in introduction to several hazards in the present work only landslide hazard will be considered. In fact the presented methodology can be applied to other hazards but in this specific case the team worked exclusively in landslides, which is not the only hazard that affects the study area but it is one of the most important. The importance of landslides occurrence and consequences in the north of Lisbon region, where study area is located, will be clearer in the new version of the manuscript.

2 - It is not clear that the added value resulting from this methodological development using dasymetric cartography, will be applied to the mapping for the emergency management, as suggested in some paragraphs, or will be applied to the risk prevention or spatial planning, as suggested in other sentences.

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A.Reply: The authors thank the referee comment. We agree that the information as presented by authors is not useful to Civil Protection. A map where inhabitants are addressed to each specific building should be provided for Civil Protection end users. This will be discussed and a new figure will be inserted in the new version of the manuscript. Additionally, sentences that suggest that dasymetric cartography results are useful for spatial planning will be removed.

3 - There is a clear choice for the analysis of the Alenquer river basin. This choice is not discussed, nor its importance in relation to Lisbon. Urban sprawl appears to justify the choice of Alenquer municipality, and then devalued the functions and mobility regarding the centrality of Lisbon. The presentation of the data also highlights the high agricultural and forestry land use and occupation in certain areas, losing the relevance of the research.

A.Reply: The authors acknowledge the reviewer comment. The study area is part of the Alenquer municipality and is located in the area north of Lisbon, known as an important landslide prone area (Zêzere et al., 2008). Despite the importance of urban sprawl and the proximity to Lisbon, that certainly influences territorial land use, the option for this study area was supported by three reasons: 1) landslides incidence; 2) type of urban occupation; and 3) social vulnerability. 1) The study area is located in the north of Lisbon region that is a landslide prone area (Zêzere et al., 2008) and according to the DISASTER database (Zêzere et al., 2014), is one of the most important areas in Portugal, considering landslide damage; 2) Additionally, the study area, presents two types of “urban landuse”: small villages with a “dense” urban grid as well as disperse settlements. Once the Census units boundaries were quite influenced by settlements density the presence in the study area of two different kinds of territorial occupations allow the comparison of the proposed methodology in two different urban contexts; 3) Moreover, Mendes et al. (2010) in a social vulnerability study for Portugal at municipal scale evaluate the Alenquer municipality as medium criticality (“...defined as the ensemble of individuals’ characteristics and behaviours that may contribute to

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the system's rupture") and Low capability ("defined as the set of territorial infrastructure that enables the community to react in case of disaster"). With this combination the Alenquer municipally is, theoretically, in the region north of Lisbon affected by landslides, one of the least capable to manage hazard consequences; This information will be inserted in the new version of the manuscript and text will be rewritten to not overemphasize the importance of agricultural and forestry land use.

4 - Resulting from the application of the methodology it is not clear the relationship between the two approaches and the type of movement, superficial or deep mass movements. It seems that this discussion could increase notably the cartographic results. The severity of the movements and the speed thereof could be also discussed on the basis of the two approaches.

A.Reply: The authors thank the referee comment. The presented work only presents deep rotational slides susceptibility maps. In the study area they are generally slow but with displacements capable to significantly damage structures and consequently requiring people evacuation. To avoid misunderstandings all the references to landslides and susceptibility figure caption will indicate that the landslides are deep rotational slides. Additionally, a reference to the velocity and to the severity of damages caused by landslides will be added to the new version of the manuscript.

5 - An important aspect to be pointed is that the population assigned to a BCU is only the resident population according to the values of the Census in Portugal. The buildings that are represented seem to include both those who have residential functions as the buildings with services and commercial functions. This disagreement must be discussed and presented their performance for both approaches. We consider the option using a simplification between residential building/not residential building areas may have conditioned the results.

A.Reply: The authors acknowledge the referee comment and agree that it is no clear that the type of buildings used as ancillary information are only the ones that have

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residential purposes. Vector building maps have attribute fields that allows differentiating some type of buildings (e.g. police stations, fire stations, schools, court, medical facilities, among others). Additionally, during detailed field work other buildings were identified as storage buildings or factory buildings. However, some buildings could have more than one use. In the present work all the buildings exclusively residential (93%) or mainly residential (5%) were considered as ancillary information. For the remaining buildings there were not assigned population and they are not cartographically represented. This information will be included in the new version of the manuscript.

6 - It makes sense discuss the evaluation of the dasymetric exposure due to the uncertainty, and this in relation to the susceptibility mapping. Still seems relevant explaining the added value with this approach in relation with low and moderate probability process, a logic of large disasters, or with exposure to the high probability events associated with small disasters.

A.Reply: The authors thank the referee comment. The main aim of this work is to demonstrate that “dasymetric exposure” can be a good method to increase the reliability of the exposed inhabitants distribution when compared to the statistical units approach. We agree that assessing the number of inhabitants is just a single step in a complete risk analysis, which should contemplate cost-benefits analysis considering, for example, probability-intensity relations. We are confident that the proposed methodology can be useful in both situations: (i) low probability phenomena and high magnitude that can result in high level of damages, and (ii) high probability events and lower magnitude that is expected to result in low quantity of affected elements. In both cases, when the output is the number of inhabitants per building, once it can help to increase Civil Protection measures efficiency. In fact, the prioritisation of buildings considering the potential affected inhabitants can help the accuracy of rescue operations. In events that cause generalized damages over a high territorial extension the focus on a specific building could not be so important because a whole region is affected. The exception could be, in low density urbanization areas, the buildings where

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a high concentration of people is expected. In low magnitude/high frequency events, local damages gain importance and therefore this approach could be slightly more useful. However, this understanding is completely dependent of the type of process, elements at risk, Civil Protection procedures, among many other factors that can influence emergency management operations. A reference to the practical applicability of the proposed methodology in different probability-intensity scenarios will be done in the new version of the manuscript.

7 - It makes sense to discuss the types of damages associated with buildings. However the cartographic analysis could also considered, nor only the damage in the structure of buildings, but the access to buildings, the infrastructure damages, e.g. on sewerage, water or electricity supply, which requires complementary graphical representation.

A.Reply: Although the aim of the present work is only to assess the number of inhabitants potentially exposed to a specific hazard, the new version of the manuscript will include reference to other topics that significantly influence the real exposure of people to landslide hazard. Topics as degree of people vulnerability due to their characteristics (e.g. mobility, age, education, number of year living on that place, etc.), due to building resistance, access to buildings or access to infrastructures and facilities (e.g. sewerage, water or electricity supply, medical care, etc.) will be included in Discussion section

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