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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Assessment of physical vulnerability of buildings and analysis of landslide risk at the municipal scale – application to the Loures municipality, Portugal" *by* C. Guillard-Gonçalves et al.

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Overall quality of the discussion paper ("general comments"):

This study intends to perform a semi-quantitative assessment of physical vulnerability to landslides of buildings at the municipality of Loures (in Portugal) and an analysis of landslide risk computed as the product of the vulnerability by the economic value of the buildings and by the landslide hazard. It is really appreciable the effort made by the Authors and the topic is of high value for the scientific community and within

the scope of the Journal. As a general comment, from the one side, the scientific approach is convincing and is appreciable the test of generalization process performed by the Authors but, from the other side, the main topic of the research is not totally original. Moreover, an important weak point may undermine the foundations of the research; from my understanding, vulnerability is a really site-specific parameter and, for this reason, the contribution of researchers from different European countries, by the proposed questionnaires, is questionable. In more detail, the conceptual scheme is clear but how much the questionnaires submitted to a pool of European experts may really limit the subjectivity of the vulnerability assessment remains an open question. Vulnerability depends on the architectural and structural characteristics of the buildings (potentially affected by a landslide) that change from site to site, from nation to nation, being strongly site-specific. Moreover, the Authors run up against the important problem of uncertainty given that many parameters taken into account in the risk analysis are source of uncertainty. How much this uncertainty really "controls" the final result (considering each factor composing risk) is not well documented. The English sounds good (but I'm not a native speaker) although some expressions give the impression to be ambiguous and confusing; they have to be rephrased. The paper can be considered for publication after major revisions.

We acknowledge the remarks of the reviewer. We agree that the main topic of the research is not totally original. Nevertheless, and thanks to the remarks of the reviewer, we will improve the originality of the study with two interpretations of the questionnaire instead of one. Indeed, in the new version of the manuscript, we will present the vulnerability assessed by the 14 landslide experts who know the study area, and we will compare the results with the ones we already have and which were calculated from the answers of the 52 landslide European experts. The risk will also be computed and mapped with the vulnerability assessed by the 14 landslide experts who know the study area. In the new version of the manuscript we will conclude that in some extension the vulnerability is a site specific parameter. Thanks to the remarks of the reviewer, we assessed the impact of the knowledge of the study area on the vulnerability assess-

ment. Excluding the European experts and keeping only the experts who know the study area, we observed a reduction of the variability in the answers. Nevertheless, there is still subjectivity in the answers, and it is true that it remains an open question. The study presented in this paper does not have the ambition to assess the uncertainty coming from all the parameters of risk; we only wanted to assess the uncertainty associated with vulnerability. Indeed, the impact on quantitative risk analysis resulting from the subjectivity on the vulnerability evaluation will be assessed in the new version of this work. We acknowledge the remark of the reviewer regarding the ambiguous expressions; we will send one more time the paper to a native English speaker to make these expressions clearer.

Individual scientific questions/issues ("specific comments"):

Paragraph 1. Page 5550: line 1-2. "Vulnerability is thus difficult to assess and the vulnerability models that have been proposed have a non-negligible uncertainty". I'm wondering if this paper provides some solutions and answers concerning uncertainty given that the Authors suffer the same problems that affected previous vulnerability and risk studies: lack or limited data, generalization and approximation processes, qualitative data, proxies, etc.

It is true that uncertainties are present in our study as well. Nevertheless, in the new version of the manuscript we address in deep the uncertainty associated to vulnerability assessment, resulting from the level of knowledge on the landslides and building environment of the study area.

Paragraph 3.1. Page 5553: line 10-11. "... the landslides in the study area were slow, very slow or extremely slow ". Probably, it would be better to add also the type of landslides.

We acknowledge the remark of the reviewer; we will add the type of landslides in the new version of the manuscript.

Subparagraph 3.1.1. Page 5554: line 4. "...and four scenarios in which the building location is on the foot of the slide". I would like to know if the buildings may be impacted laterally, by the displaced material, supporting dynamic pressures against the walls or, more simply, the buildings only support different vertical displacements affecting their structural components.

We acknowledge the remarks of the reviewer. We will add this small text in the manuscript to make it clearer: "A building situated on a landslide body may suffer vertical and lateral displacements, whereas a building situated on a landslide foot may support dynamic pressures against the walls, and may be buried (Glade et al., 2005; van Westen et al. 2005; Léone, 2007)". Glade, T., Anderson, M. and Crozier, M. J.: Landslide Hazard and Risk, edited by T. Glade, M. Anderson, and M. J. Crozier, John Wiley & Sons, Ltd, Chichester, West Sussex, England., 2005. Léone, F.: Caractérisation des vulnérabilités aux catastrophes ÂńnaturellesÂż: contribution à une évaluation géographique multirisque (mouvements de terrain, séismes, tsunamis, éruptions volcaniques, cyclones) – Mémoire d'Habilitation à Diriger des Recherches (HDR), Section 23 (géographie), Université Paul Valéry - Montpellier III, Laboratoire GESTER, Montpellier, 2007. Van Westen, C. J., van Asch, T. W. J. and Soeters, R.: Landslide hazard and risk zonationâĂŤwhy is it still so difficult?, Bull. Eng. Geol. Environ., 65(2), 167–184, doi:10.1007/s10064-005-0023-0, 2005.

Subparagraph 3.1.1. Page 5554: line 10-13. The Authors state: "Physical vulnerability assessment is often based on historical records and on expert judgments and is largely subjective. To reduce this subjectivity, we decided to ask the opinion of a pool of experts". What's the difference between "expert judgments" and "the opinion of a pool of experts"? Are "opinions" so different from "Judgments" really to move from a qualitative to a semi-quantitative vulnerability and risk assessment? From my understanding, contributions from local experts may be even more valuable than European experts' given the skills, experience and expertise they gained in many years of research in the Loures study area: they may provide useful information concerning the damaging

events and the degree of loss experienced by the exposed elements in the past. The same is true for the European experts but in their study areas.

We acknowledge the remarks of the reviewer. It is true that even assessed by a pool of experts, the vulnerability is still subjective. That is why we will correct the sentence, replacing “To reduce the subjectivity” by “In this work”. Moreover, in the new version of the manuscript, the opinions of the local experts will be considered alone, as suggested by the reviewer.

Paragraph 3.2. Page 5557: line 5. Is EV a sort of market value of the buildings? If this is the case, isn’t available a national Portuguese database and/or (web)service able to provide it directly? For this reason, it could be useful to know if the Authors are referring to the market value or to the (re)construction value of buildings affected by landslides to perform vulnerability assessment. In the former case, each parameter of the formula is needed for calculation; in the latter case, only ACC is needed.

Yes, EV is a market economic value. We will specify it in the new version of the text, adding the word “market”, to make it clearer.

Subparagraph 3.3.1. Page5558: line 15. "Assuming that future landslides would have similar characteristics to the past ones. . .". It’s a matter of fact that this (old) sentence is becoming more and more questionable with each passing day.

We understand the remark of the reviewer, but in our opinion, this assumption is the only way to analyze the landslide risk. Nevertheless, we will add a small text in the “Discussion” paragraph about the limits of the method we used, which is based on this assumption.

Subparagraph 3.3.1. Page 5558: line 19-21. "In this study, the landslides were considered all together in order to know the probability associated to each Scenario". This sentence is questionable. The types of landslide considered in the study are too different from each other to be considered all together. Different models (and analysis) for

different landslide types.

We totally agree with the sentence of the reviewer “Different models (and analysis) for different landslide types”. However, in this study, all the considered landslides are slides in type. Flows are almost absent and we did not consider the rock falls, for which the physical mechanisms are different from the slides. We agree with the reviewer that it is necessary to separate the different types of slides for the susceptibility assessment, as we made in this paper. Nevertheless, regarding the magnitude, we had to join all the slides to calculate the frequency-magnitude, which is: considering a slide occurrence, the probability of this slide having an area larger than Xm2 (Malamud et al. 2004; Guillard and Zêzere 2012).

Subparagraph 3.3.1. Page 5559: line 3. ". . . We considered that the height-to-depth ratio is 0.5". Why do the Authors choose this value? Please, provide some more information to strengthen this choice. It is an important source of uncertainty.

As explained in the manuscript, this value was an average value of what was found during fieldwork.

Subparagraph 3.3.1. Page 5559: line 4-5. ". . .which is based on some landslides studied in the field whose depth is known". Please, provide references to strengthen the sentence.

We acknowledge the remark of the reviewer; we will add a reference in the new version of the manuscript (Zêzere et al. 1999). Zêzere, J. L., De Brum Ferreira, A. and Rodrigues, M.: The role of conditioning and triggering factors in the occurrence of landslides: a case study in the area north of Lisbon (Portugal), Geomorphology, 30(1-2), 133–146, doi:10.1016/S0169-555X(99)00050-1, 1999.

Subparagraph 3.3.2. Page 5559 line 10-11. "The susceptibility was mapped using a bi-variate statistical method called Information Value Method (Yin and Yan, 1988) ". Why did the Authors decide to apply this modeling technique? It’s a very (too) simple

direct method. Moreover, is there any evidence that this method is proper to model deep-seated landslides? Given the well-known skills and expertise of the Authors in landslide susceptibility/hazard assessment, the reader is expecting something more efficient than a simple Information Value Method.

We do not agree with the comment of the reviewer because of several reasons: 1) The Informative Value Method, as any statistically based model, is not a direct method but an indirect method, which means it is objective and reproducible, thus contrasting with the expert based direct approach. 2) The evidence that this method is proper to model deep-seated landslides has been proved by the authors in previous peer reviewed literature. See for example Zêzere (2002), Zêzere et al (2008) and Guillard and Zêzere (2012). 3) The Information Value Method is a bivariate statistical method which was recently recommended by Corominas et al. (2014) for the landslide susceptibility assessment. 4) The objective of the study presented in this paper is not the assessment of the landslide susceptibility. This is why we used the one which was published in Guillard and Zêzere 2012, which has been made for the same study area. So the susceptibility assessment is not new, but it was not our goal to innovate in this field in this paper.

Corominas, J., van Westen, C., Frattini, P., Cascini, L., Malet, J.-P., Fotopoulou, S., Catani, F., Van Den Eeckhaut, M., Mavrouli, O., Agliardi, F., Pitilakis, K., Winter, M. G., Pastor, M., Ferlisi, S., Tofani, V., Hervás, J. and Smith, J. T.: Recommendations for the quantitative analysis of landslide risk, Bull. Eng. Geol. Environ., 73(2), 209–263, doi:10.1007/s10064-013-0538-8, 2014.

Guillard, C. and Zezere, J. Landslide susceptibility assessment and validation in the framework of municipal planning in Portugal: the case of Loures Municipality, Environ. Manage., 50, 721–735, 2012

Zêzere J. Landslide susceptibility assessment considering landslide typology. A case study in the area north of Lisbon (Portugal). Natural Hazards and Earth System Sci-

ences 2:73–82, 2002.

Zêzere J, Garcia R, Oliveira S, Reis E. Probabilistic landslide risk analysis considering direct costs in the area north of Lisbon (Portugal), Geomorphology 94:467–495, 2008.

Subparagraph 3.3.2. Page 5559: line 19. "Each map was classified as one of four susceptibility classes". Please, provide more information in the text concerning the classification technique applied given that it strictly controls the spatial variability of each susceptibility class.

We acknowledge the remark of the reviewer. We will complete the sentence, explaining that the susceptibility classes were defined taking into account the predictive capacity of the model.

Subparagraph 4.4.1. Page 5560: line 21. "Out of the 52 questionnaires completed by the experts,. . .". I strongly recommend to refine the analysis by excluding information coming from the European experts' questionnaires. In this way, it is possible to verify how much the results of the analysis change and, above all, how much the questionnaires submitted to a pool of European experts limit the subjectivity of the vulnerability assessment.

We acknowledge the remark of the reviewer. We made another study, excluding all the answerers who do not know the Loures municipality landslides and buildings. The result was interesting, and we will add the results found to the new version of the manuscript.

Subparagraph 4.4.1. Page 5561: line 4-6. "Most of the experts who had doubts expressed that it was difficult to assess the potential damage caused by a landslide to a building based only on the depth of the landslide slip surface or the height of accumulated material". It's a matter of fact.

We do not really understand the question of the reviewer. It is explained in the following text that "However, it was not useful to give them more detailed information about the

building position or about the characteristics of the landslides (e.g. the velocity of the landslide, the type of affected material, the height of the scarp) as they requested, because such information was not available for the complete landslide inventory and the aim of this study is to assess the vulnerability of the buildings of a whole municipality in a systematic fashion."

Subparagraph 4.3.1. Page 5564: line 21-24. "The landslides that have a maximum probability of occurrence are the 1m deep landslides and the ones with an accumulated material height of 0.5 m, which have a probability of 0.57. The landslides that have a lower probability of occurrence are the 20m deep landslides, with a probability of 0.02". As a general comment, this sentence provides decision makers with some useful and useless information at the same time. Stating that "20m deep landslides have a probability of 0.02" is useful because it provides decision makers with a low probability value (now, we are not considering the level of uncertainty related to this probability value); stating that "1m deep landslides and the ones with an accumulated material height of 0.5 m have a probability of 0.57" is not as useful as before because we are providing decision makers with a probability value that is not able to discriminate between two alternatives: as throwing a coin in the air. It's a value that cannot support a decision (50% of probability of occurrence).

We consider the original text in the manuscript was not clear enough. So, in the new version of the manuscript we will change the description to make it clearer. Indeed, it is not the probability of occurrence of a landslide that is referred here, but the magnitude probability, that is: occurring a landslide in the Loures municipality, the probability of its material having at least 0.5m high is 0.57.

Subparagraph 4.3.1. Page 5565: line 1-2. It sounds like a universal rule governing natural processes. We acknowledge the remark of the reviewer. We will add the idea to the text in the new version of the manuscript.

Subparagraph 4.3.1. Page 5565: line 12-13. "The landslide susceptibility maps are

shown in Fig. 12, with the landslides used for computing and for validating the models." The question concerns the modelling technique applied: have the Authors used the entire landslide bodies or only the scarps to run the model? I suppose they have used only scarp areas, where the detachment occurs and where the "critical combination" of different geo-environmental parameters triggers the landslide (the main aim of each landslide susceptibility model is to define the "critical combinatiosn" and find where there occur in the study area).

We will explain, in the new version of the manuscript, that for each landslide type, we calculated and plotted the fraction of the landslide depletion areas and the total landslide areas in each class of each predisposing factor. We chose to model landslide susceptibility with the total areas of the landslides because the spatial signature of the depletion area and the total landslide area are very similar for every predisposing factor (Guillard and Zêzere, 2012).

Subparagraph 4.3.1. Page 5566: line 5-8. "That is why the "High" and "Very high" susceptibility classes, which have the highest probability of occurrence values during the next years are the ones that those involved in civil protection and municipal planning need to focus on." As a general comment, the long-term overview of the urban and spatial planners makes this information very crucial for them. From my understanding, the same could not be true for Civil Protection in its response and rescue activities (short-term overview).

The contribution of this study to the research field and possible practical applications for different end users will be removed from this part, but will be addressed in the Concluding Remarks section of the new version of the manuscript.

Paragraph 4.4. Page 5567: line 19. ". . .independently of other aggravating factors like climate change". As stated before, uniformitarianism is becoming more and more questionable and the influence of climate change has to be considered into the analysis given that changes in magnitude and frequency of many natural processes are visible

to all.

We understand the point of the reviewer. We will rephrase the sentence with the following formulation: “because even if the risk is quite low for the next few years, its probability increases when longer periods of time are considered, namely due to climate change and land use change”.

Paragraph 5. Page 5567. This paragraph is a mix of discussion and conclusions. We acknowledge the remark of the reviewer. We will reformulate the concluding paragraph, including some parts of it in a new “Discussion” paragraph, in the new version of the manuscript.

A compact listing of purely technical corrections at the very end ("technical corrections": typing errors, etc.).

Paragraph 3.1. Page 5553: line 10. Change "Cruden and Varnes's (1996) classification" in "Cruden and Varnes' (1996) classification".

We acknowledge the remarks of the reviewer, we will change "Cruden and Varnes's (1996) classification" in "Cruden and Varnes' (1996) classification" in the new version of the manuscript. Paragraph 3.1. Page 5553: line 14. Change "...some data is available" in "...some data are available".

We acknowledge the remarks of the reviewer, we will change "...some data is available" in "...some data are available" in the new version of the manuscript.

Subparagraph 3.1.2. Page 5555: line 2. Change "...only data provided and used by this geodatabase is the..." in "...only data provided and used by this geodatabase are the...".

We acknowledge the remarks of the reviewer, we will change "...only data provided and used by this geodatabase is the..." in "...only data provided and used by this geodatabase are the..." in the new version of the manuscript.

Subparagraph 3.1.2. Page 5555: line 7-8. Change "...each basic administrative unit - which is the “civil parish” into sections and subsections" in "...each basic administrative unit (which is the “civil parish”) into sections and subsections".

We acknowledge the remarks of the reviewer, we will change "...each basic administrative unit - which is the “civil parish” into sections and subsections" in "...each basic administrative unit (which is the “civil parish”) into sections and subsections" in the new version of the manuscript.

Subparagraph 3.1.2. Page 5555: line 15. Change "...the data which is available for...” in "...the data which are available for..."

We acknowledge the remarks of the reviewer, we will change "...the data which is available for...” in "...the data which are available for..." in the new version of the manuscript.

Subparagraph 3.1.3. Page 5556: line 24. Change "...to assess the cost/benefice ratio" in "...to assess the cost/benefit ratio".

We acknowledge the remarks of the reviewer, but this part will be deleted in the new version of the manuscript. Paragraph 3.2. Page 5557: line 13. Change "...(habitation, store or...)" in " (residential, store or...)".

We acknowledge the remarks of the reviewer, we will change "...(habitation, store or...)" in " (residential, store or...)" in the new version of the manuscript.

Subparagraph 4.3.1. Page 5563: line 25. Change "...the data obtained by fieldwork is much more..." in "...the data obtained by fieldwork are much more...".

We acknowledge the remarks of the reviewer, we will change "...the data obtained by fieldwork is much more..." in "...the data obtained by fieldwork are much more...".in the new version of the manuscript.

Subparagraph 4.1.2. Page 5563: line 1. Change "...different magnitude landslides" in

"...different landslides magnitude".

We acknowledge the remarks of the reviewer. Nevertheless, we will change "...different magnitude landslides" in "...different landslide magnitudes " in the new version of the manuscript.

Subparagraph 4.3.2. Page 5566: line 11. Change "...this data is not available" in "...this type of data is not available".

We decide to remove the sentence that includes this piece of text.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 3, 5547, 2015.