Correction of the paper for the first reviewer: RC C2086. Anonymous Referee #1 provided on 18 Dec 2013.

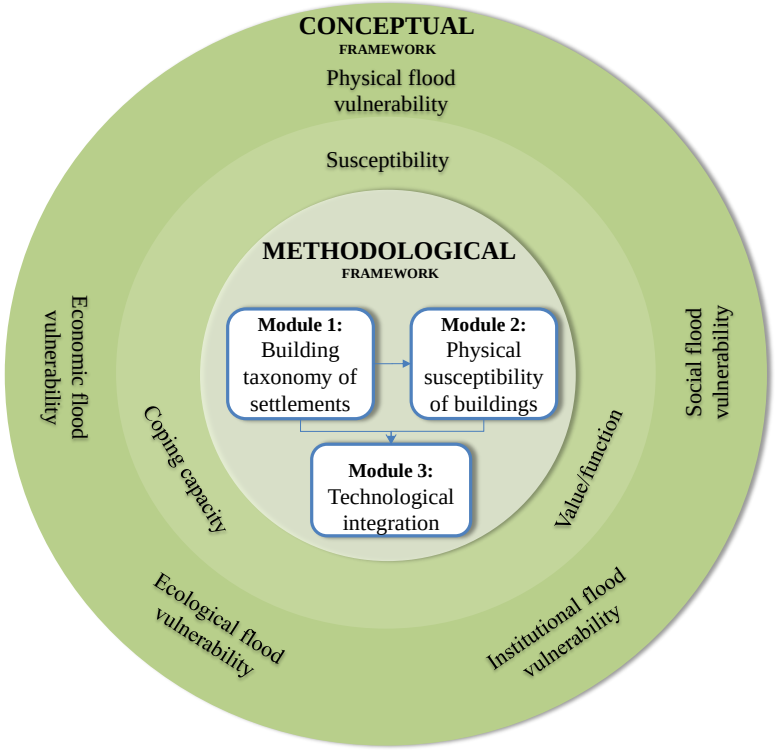
Conceptual and methodological frameworks for large scale and high resolution analysis of the physical flood susceptibility of buildings"

New proposed tittle: **"Assessment of the physical flood susceptibility of buildings on large scale – Conceptual and methodological frameworks"**

Version of the 13th February 2014

	Question of the reviewer	**Answer to the reviewer:**	**Page and line**
0	… to expand here to add additional comment about the different classifications of damage assessment (i.e. are they based on post-event analysis, pre-event physical basis) and how the approach presented here fits into these. In particular, it may be appropriate to draw on the paper by Jongman et al. (2012: NHESS)	We appreciate this comment of the reviewer to further reflect the different classifications of vulnerability and damage assessment. Since we already considered the different spatial scales in the manuscript, we particularly add a reflection of the pre- and post-event perspectives also referring to the proposed paper by Jongman et al. (2012). This led to the following revised wording: "There are various approaches available for assessing the flood vulnerability and damage to buildings and critical infrastructure. They cover pre- and post-event methods for different scales. However, there can hardly be found any method that allows for large scale pre-event assessment of the built structures with a high resolution. To make advancements in this respect, the paper presents, first, a conceptual framework for understanding physical flood susceptibility of buildings; and second, a methodological framework for its assessment. The latter ranges from semi-automatic extraction of buildings mainly from remote sensing with their subsequent classification and systematic characterisation to the assessment of the physical flood susceptibility on the basis of depth-impact functions." "There are various approaches available for assessing flood damage to buildings and critical infrastructure based on field data collected after an event such as FLEMO (Kreibich et al., 2010) as well as synthetic approaches for assessing the damage prior to a future event as e.g. HAZUS (Scawthorn et al., 2006) and HOWAD (Neubert et al., 2009). Differences between the assessment models for flood damage to and flood vulnerability of buildings in terms of scale, input data, damage calculation and outputs with their uncertainties are shown by Merz et al. (2004) and Jongman et al. (2012)."	Page 5696, line 1 to 11 Page 5696, line 16 to 22
1	There is little discussion about how the three elements of Susceptibility, function and coping capacity combine and contribute to physical	We agree with the reviewer that this should be further explained to facilitate uptake by the readers although these conceptual aspects are not the focus of this paper. Therefore, we have extended the reference	

	vulnerability - are they all equally important to the susceptibility? I am also not convinced about using the term coping capacity as it implies a relation to the function and the ability of those using the buildings to switch activities elsewhere to minimise impact and disruption? Why have you selected to use this term rather than just building resilience?	to the mentioned publication as follows: "Schanze (2006) proposes to understand vulnerability as a "mathematical" function of susceptibility, value or function and coping capacity of a system considering the physical, ecological, economic, social and institutional dimensions. For buildings, the physical dimension of susceptibility, function and coping capacity can be conceived as follows:" The subsequent text explains the physical coping capacity as buildings resilience and hence is in line with the review comment.	Page 5698, line 1 to 5
2	Are you here linking the function of the building to wider social and economic vulnerability? You mention that physical vulnerability is linked to social and economic vulnerability – but not how and if you are looking at this in your approach. For instance, are you considering the level redundancy or dependency within the system within the susceptibility assessment and how the availability of alternative production locations or accessing services may impact any systemic impacts?	Yes, we relate the physical function to the wider social and economic vulnerability. Hereby, we avoid an in-depth explanation of the effects on these two vulnerabilities. The paper does not further consider aspects of social and economic vulnerability. Neither the level of redundancy or dependency within the system nor the availability of alternative production locations or accessing services are involved in the paper.	Page 5698, line 23 to page 5699 line 19
3	Is building collapse considered?	We thank the reviewer for this interesting question. The proposed method assesses the potential impacts to buildings caused by plain floods along large river. These floods are characterised by low flow velocity. Thus, we have supposed that they do not cause any collapse of buildings. However, we consider the collapse of the material of building's components which depends on their specific susceptibility. To clarify this aspect, we have included the following sentence: "Those properties should be documented, assessed and recorded photographically. The highest assessed value reflects that the material can generate the collapse of the component."	Page 5706, line 13
4	Is it possible to still argue that spatial data are an objective data source once you have attempted to fit them into a classification?	We also appreciate this question of the reviewer. The answer involves two aspects: first, GIS and remote sensing data may be seen as objective as far as data may be seen as objective at all. Second,	

		classification of course is not objective in this sense. This is why we see it as part of the assessment. Since, we do not insist on the term "objective", we just skipped it.	Page 5697, line 8
5	Figure 1 is very confusing and although presents many of the different elements of vulnerability. Please be much clearer about what your method is or is not considering? And what is wider context of vulnerability that is not being considered. Currently having many different types of vulnerability on the periphery of the diagram is not aiding understanding of how these are linked together with your approach nor how they link together. Perhaps this figure can be revised.	We agree with the reviewer that Figure 1 may be improved in terms of clarity. The revised version is shown below. 	Figure 1
6	With the building taxonomy it is not clear what different levels of information are used – maybe an example would assist the reader here. It is also difficult to understand how the building taxonomy is exactly constructed what the parameters are and how this leads to the different categories. You have mentioned the elements that you have selected by not really provided a scientific justification for doing so and suggested why other elements have not	We agree with the reviewer that a clearer introduction of the information basis of the building taxonomy should facilitate comprehension of the readership. Therefore, we have modified the respective sentence as follows: "The proposed building taxonomy approach bears on very high resolution spectral and elevation data for gathering building parameter that are key for the characterisation of the physical construction."	Page 5702, line 9

	been used.	In addition we have added a figure as visual example of the classification in order to illustrate how the buildings are clustered and what the meaning of the taxonomic code is. The figure is explained through the following sentences. "Two examples of the taxonomic code are displayed in Figure 3. The pictures show that the buildings with code '1221123' present similar roof eaves, whereof the buildings with the taxonomic building code '2121134' contain a balcony and similar roof construction."	Page 5703, line11.
7	From a methodological perspective – how have you used expert consensus to validate the classes – what was the process and how has this contributed to the validity of the method. E.g. how many experts were consulted and how important is the variation between regions in the type of properties and damages sustained? i.e. did the experts suggest that property damages were relatively homogenous based on the characteristics you are using or heterogenous?	The reviewer is right that the respective sentence could lead to misunderstandings in terms of the expert involvement. Four civil engineers have been consulted to comment on the relevance of the outcomes of the systematically derived building taxonomy for the subsequent impact assessment. Fortunately, consensus could be reached although this was not the basic goal. "The borders of the classes are adjusted through (i) statistical analyses: histogram diagram, scatter diagram and the correlation matrix in order to find trends and relations in the parameters and (ii) advice from experts (e.i. civil engineers, architects) who discussed the relevance of the classes for the subsequent susceptibility assessment." Variation between regions in the type of properties results from diversity of the built structures and is reflected by the taxonomic approach. In contrast, there is no damage considered in this step of the approach which requires more detailed investigations as presented under module 2.	Page 5702, line 29
8	Section 3.1.3 - What approach has been used to assess the potential flood impacts on buildings – how has this been assessed – is it based upon post-event damage information? Or the datasets you mentioned in the introduction or starting from another type of	At this stage of the methodology, no damage is considered. This is part of module 2. There, all impacts are calculated ex ante according to the concept of vulnerability. To avoid respective misunderstanding we have modified the sentence as follows: "Representative buildings have been selected from each building type as samples for the subsequent assessment of potential flood impacts (see sect. 3.2)." Datasets and approach are described under section 3.2.	Page 5703, line 16

	assessment? Also what happens to the unrepresentative buildings?	This is an interesting question. We have included an explication about the non-representative buildings: "Then, the non-representatives are grouped to the building type with the largest values of membership depending on the degree of similarity. A threshold of similarity was selected of 80% for grouping the non-representatives to the representatives. The buildings under this threshold are considered atypical and hence also selected for the assessment."	Page 5704, line 4
9	Section 4.1.1 – why are us using a segmentation process? And how important is it to overcome the inconsistencies in the process that you mention and that could be overcome with a higher spatial re solution? It is necessary to use this higher resolution?	We thank the reviewer for this question. As response, we have included a detailed explanation about the use of segmentation and the importance of the resolution of the data: "Segmentation was used for dividing the image into regions that are supposed to be the building roofs with similar spectral and topological characteristics. In this approach, the roof footprint is considered the building boundary which is the input for the calculation of size, elongatedness, roof form, adjacency and compactness. Building height and building roof slope depend on the ground samples from digital surface models." High resolution images (e.g. aerial photos) and surface models provide the level of detail for identifying the characteristic of the buildings such as e.g. the amount of vertices of the roof. Information which can allow differentiate a building to others. The proposed approach of the building taxonomy provide effective results if the sources have a resolution lower than 1 meter, of course, depending on the complexity of the area.	Page 5707, line 22
10	Is it possible to make greater comment about how the method might be used and under which circumstances it is a relevant approach and under which you might use a more precise approach?	We agree with the reviewer's comment which goes in line with the proposal of the second reviewer to include a discussion section in order to reflect on the limitation of the methodology. "Transferability of the approach to other study regions seems mainly to depend on the accessibility of very high resolution data. Although there are currently certain limitations in many regions of the world, improvements may be expected from new sensors. There is a rapidly increasing trend towards the availability and accessibility of spatial	Page 5710, line 25

	Also additional comment about how you might validate or ground test the approach is also appropriate	data and improvements of their properties in terms of resolution. For instance, unmanned aerial vehicles may be supposed to provide support for the collection of very high resolution images and the improved accuracy of the extracted features. Additionally, new free algorithms for features extraction play a role, such as SpaceEye (ICIS 2009) which allows processing of the global data of Google Earth with simple functions on the imagery such as segmentation and edge extraction. These technological advances will contribute in the near future to the collecting of a huge amount of data which require to be classified for the analysis of settlements." We thank the reviewer for this question. Since susceptibility assessment is based on field surveys considering some building representatives of the same building type, validation is mainly a task for the initial building classification and characterisation. To enhance the manuscript in this respect, we included two sentences in order to clarify the validation of the approach: "The validity of this building typology is borne out visually comparing pictures of the buildings with the obtained parameters in the taxonomic code."	Page 5711, line 31
11	I am not sure figures 2 and 3 add much to the paper perhaps these can be combined with figure 1 into an overall figure for the journal.	This suggestion of the reviewer is appreciated. We have considered skipping Figures 2 and 3. This would reduce the visibility of the internal structures of modules 1 and 2, on the one hand. Inclusion in Figure 1 would reduce clarity which has been requested from the reviewer earlier in the list of comments, on the other hand. Against this background we prefer to keep both figures.	
12	Tables 1, 2 and 3 are good and clear. Although the explanation of how these have been generated is not very clear – perhaps some explanation can be added around these tables.	We thank the reviewer for this comment. Based upon, we have checked referencing and explanation of these tables. As results, we may say that Table 1 is referred to on page 5703, line 7 as well as on page 5708, line 6. Table 2 is referenced to on page 5709 line 16 and Table 3 on page 5709 line 20. Maybe, this additional information is helpful for the reviewer's intention regarding referencing the three tables.	