

## ***Interactive comment on “Flood fatality hazard and flood damage hazard: combining multiple hazard characteristics into meaningful maps for spatial planning” by K. M. de Bruijn et al.***

**K. M. de Bruijn et al.**

karin.debruijn@deltares.nl

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We thank this referee for a very detailed and constructive review. We will summarize each remark and respond to it.

1. The reviewer's first concern is about our definitions of flood hazard, risk and vulnerability. Some clarification is asked for.

We define hazard as 'the potential to cause harm', that is as a combination of the probability of flooding and the flood's characteristics such as extent and depth (page 125, line 11). This is cf. FLOODsite's 'Language of Risk' (Samuels, 2009) and the

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EU Floods Directive. We could not find any location where we define hazard as the probability of a design flood, as the reviewer maintains. As for vulnerability, we indeed use a broader definition than by damage functions only. We use the broad definition because we focus on the vulnerability of areas, not of individual objects. Therefore, we include exposure in vulnerability, which is not uncommon (see the discussion on different vulnerability definitions by Merz and Thieken (2004; p. 27, 3rd column). Merz and Thieken also explain that two areas facing the same hazard will have a different flood risk, if one area is more vulnerable than the other. That corresponds with our use of vulnerability being related to the affected objects (number and susceptibility), whereas hazard refers to the flooding characteristics and frequency. We are thus fully in line with Merz and Thieken (2004).

2. The reviewer states that there are publications which show that vulnerability is not increasing and refers to Barredo (2009) and Fuchs et al. (2013). A more diversified referencing is asked for.

We checked and found that Barredo (2009) also states that flood losses mainly rise due to societal change, such as increased wealth, increasing populations and developments, instead of as a cause of climate change. That corresponds with our statement. We chose to refer to IPCC and EEA since they reviewed and summarized almost all relevant publications on this matter. Instead of trying to redo those very thorough literature reviews and to avoid being definitively selective in our referencing, we rather refer to these comprehensive assessments which to our opinion sufficiently underpin our introduction.

3. With respect to section 2 the reviewer suggests to look at the work of Volker Meyer et al (2012) and to avoid too many references to own and other Dutch work.

We first and foremost looked at the EXCIMAP project since this aimed to provide a review and overview of the practice of hazard mapping in the majority of the EU member states. We thus did not consider Dutch work only, which by the way never put

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much effort into hazard mapping so provides a poor source of practical experience. We referred to other literature on the subject as much as appropriate. As for the work of Volker Meyer et al. (2012): they give recommendations in particular on mapping for strategic planning and emergency planning, but much less so for spatial planning. They discuss the participation process of the end users of the maps and provide recommendations on content and on visualization techniques. However, they focus on identifying what the maps should represent, which is a very different focus for ours. They do not go into the question how different hazard parameters can be combined into one meaningful map, which is our focus.

4. The reviewer asks: "Why do the authors not use the classical risk approach?"

We do not use the 'classical risk approach', because we aim to assess hazard and not risk. It appears that despite our introductory section and the explicit aim of our paper the reviewer still assumes that we are seeking to map risk, which is not the case. As explained in the paper, for spatial planning it is more relevant to have information on hazard: the 'potential to cause harm' to whatever development a planner might be considering. By using damage functions (which some indeed call vulnerability functions) to unify all relevant information on hazard characteristics we do, however, indeed connect with the 'classical risk approach'. The main difference is that we do not use data on the current land use because we want a quantification of the hazard which is independent of the present land use.

5. The reviewer comments: "Further the authors state that they are not interested in the classical way of computing risk. ....I got the feeling that in principal the topic is about the production of flood risk maps, but not hazard maps. ...." The reaction of the reviewer shows that we may need to clarify and improve this section, although we feel we have been quite explicit about our aim to produce meaningful hazard maps and not risk maps. We nowhere state we are not interested in the classical risk approach, but we explicitly state that for this paper we are not interested in assessing the actual risks because our aim is to produce meaningful hazard maps for spatial planners. For other

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purposes maps of actual risk are of course very relevant. We could improve the text on page 130 lines 10-27 to clarify this, although we feel the paper is already quite clear on this matter.

6. The reviewer further remarks: "In sections 3.1 and 3.2 I am wondering whether or not it is acceptable to call a map combining factors of flood magnitude and exposure as a "hazard map" since by definition information on exposure is included." In contrast to what the reviewer assumes here, we do not include actual exposure in our hazard map as we are not seeking to map actual risk. Instead, in order to obtain a degree of hazard, we assume the hypothetical presence of buildings and calculate the annual expected percentage of maximum damage. We feel the present text in the paper is quite clear about this.

7. The reviewer ask to "add a comparison between the new and classical risk approach."

As explained under remarks 5 and 6, we repeat: we do not propose a new risk approach, but aim to derive hazard maps.

8. The reviewer questions whether a gridsize of 25m in the Netherlands is not too coarse?

The resolution of any grid-based analysis or mapping should always relate to the application it is intended for. Especially for a nationwide application it is impossible and also irrelevant to strive for more detail, whereas flood hazards in the Netherlands are moreover distributed quite homogeneously. Furthermore, this is about the size of a building plot. For spatial planning at national, regional and even local scales, this grid-size suffices.

9. The reviewer expresses the notion that hazard and risk maps are dynamic and must be updated, and that this is a general challenge to flood risk management.

We fully agree. It is also noted in our discussion to remind the readers and to make

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spatial planners aware. But we feel that going into this issue any further is beyond the scope of our present paper.

10. From section 5.2 the reviewer concludes that the only difference to existing risk maps is the use of multiple parameters to describe the flood hazard (FFH) whereas only classical parameters were used in FDH map compilation (water depth and probability).

Again, the reviewer does not appear to make the same distinction between hazard mapping and risk mapping as we consistently do. We repeat that hazard mapping serves another purpose. The approach we propose for this is very simple, but has not been applied before and may be very useful for spatial planners. We therefore consider it innovative. But we agree that our example mapping for the Netherlands is relatively simple because of a lack of accurate and reliable data (NB: in the country with perhaps the largest number of data!): if damage functions and data would have been available, it would have been possible to combine even more relevant parameters into the one indicator for flood hazard. However, with our paper we primarily wanted to propose the approach, whereas the case results merely illustrate this.

11. The reviewer questions whether or not information on one (dimensionless) parameter can be understood by multiple stakeholders, and asks for clarification.

This applies to the intended use of the maps. However, the proof of actual application has not been passed yet, as the Netherlands does not have a policy on hazard-based spatial planning yet. So we cannot answer this question. We do feel, however, that a map which combines many different parameters into one hazard indicator is much easier to understand and apply than a whole set of maps of various parameters as produced in the context of the EU Floods Directive or the majority of the overlay results as shown in EXCIMAP.

12. As to the conclusion section the reviewer feels that our statements are not supported by the material presented. The reviewer again stresses that we need to have information on exposure in order to compute risk (as this is given by the general risk

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equation).

We repeat that quantifying or mapping actual risk was not the aim of this paper. Consequently, all the suggestions from the reviewer for further reading and data on this issue are irrelevant to our paper; however relevant for flood risk mapping they are!

13. Also with respect to the conclusions the reviewer states that hazard-based spatial planning may be an emerging topic in the Netherlands, but that in France or the Alpine countries this is not new.

This is true, and that is why we looked at the EXCIMAP project as well as into experiences in the UK and France with well-established hazard-based spatial planning in place. However, we still feel that we made a step forward in dealing with a lot of relevant information and transferring that into understandable maps by seeking a unifying conceptualisation of hazard.

Overview of the reaction:

As final overall reaction we would like to make the following observation and statements. The 2nd reviewer is very consistent and pertinent in imputing us to propose an alternative to a classical risk approach, which we nowhere maintain to have done nor intend to do. Instead, we advocate an approach to hazard mapping aimed to support spatial planning which is as closely connected to available methods for flood risk analysis as possible and complementary to it. In doing so, we attempted to consistently comply with the terminology and definitions proposed and applied by the European projects FLOODsite ('Language of Risk'), EXCIMAP (on 'hazard mapping') and the EU Floods Directive. We may sharpen the introduction and conclusion a little to convey this message more clearly.

For spatial planning hazard maps are more relevant than maps of actual risk, because by sound spatial planning the steady increase of risk into the future can be prevented. This requires a more systematic and thorough consideration of flood hazards in spatial

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planning, as socio-economic developments are considered the most important driver of increasing flood risks worldwide. To support spatial planning we proposed an approach which allows including all relevant hazard parameters in one meaningful map instead of overwhelming the planners with many maps of individual flood parameters which they then need to combine and weigh themselves.

Although we have not found an earlier example of such a unifying approach to combine probabilities and flood characteristics into one hazard indicator, we may be wrong considering us to be the first, however. We would be very pleased to learn about other proposals on this matter, as we have not found any yet.

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