

## ***Interactive comment on “Participatory flood vulnerability assessment: a multi-criteria approach” by Mariana Madruga de Brito et al.***

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Dear Dr. A.B. Rimba,

Thanks for the helpful comments and feedback. The manuscript will be revised according to the provided suggestions, which will help to improve the paper before final submission. Please find our point-by-point response to each one of your comments below.

**1) “This research is very interesting for me, you used MCDM approach for flood vulnerability assessment.”**

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We are glad that you found the manuscript interesting. Your comments helped to clarify a number of issues

**2) “When I read this research from the beginning (page one) until part 3.8. validation (page 9), I could not imagine what the criteria or parameters for MCDM that used in this research. Difficult to understand the MCDM if we don’t know the criteria. In this research, we could find the criteria in the result. Hence, I thought, it will be better and easy to be understood if the authors show and explain the criteria in the method.”**

We thank the Referee for having raised this issue. We consider this a good suggestion and that the description of the criteria will improve the quality of the paper. Hence, we will add a table with the selected criteria, their measurement units, and data source in section 3.2 “Selection of vulnerability criteria using the Delphi technique”.

**3) “In some part of the research, the authors referred de Brito (2017). However, I could not find it in the references.”**

This paper is cited in the reference list (please see Page 22, lines 24-26):

“de Brito, M. M., Evers, M. and Höllermann, B.: Prioritization of flood vulnerability, coping capacity and exposure indicators through the Delphi technique: A case study in Taquari-Antas basin, Brazil, Int. J. Disaster Risk Reduct., 24, 119–128, doi:10.1016/j.ijdrr.2017.05.027, 2017.”

We used Mendeley<sup>®</sup> software using HESS citation style to create the reference list. Even though the name of the first author has a particle “de”, the reference was placed under the letter B and not D. We will check with the editorial support personnel of HESS to verify the correct citation format.

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**4) “Some determinations are confusing for example; Page 1 line 7; what do you mean vulnerability drivers, please give some explanation or example.”**

By vulnerability drivers, we meant the factors that induce and influence vulnerability. In this context, this word could be changed to variables or factors. Although, the term “vulnerability drivers” is commonly used in the scientific literature (e.g. Działek et al., 2016), we will change it to “vulnerability factors” in order to avoid any kind of ambiguity.

**5) “Page 4 figure 1 What do you mean with flood return period? According to Fig.1. dark blue color shows return period 100 years. Does it mean in 100 years, a flood occurs 1 time, and for the soft blue color means in 2 years, flood occur 1 time? If so, 2 years flood return means more vulnerable compared to 100 years. Hence, the color for 2 years should be darker comparing to 100-years flood return.”**

Return period is a statistical measure that indicates the average period of time that it takes for a flood to recur at a given location. For example, a flood with a return period of 100 years has a probability of occurrence of 1/100 or 1% in any one year. This does not mean that if a flood with such a return period occurs, then the next will occur in about one hundred years' time. Instead, it means that, in any given year, there is a 1% chance that it will happen, regardless of when the last similar event was (ASCE, 1996).

As the Referee mentioned, the places with a flood return period of 2 years are more susceptible to flooding as there is a higher probability of occurrence when compared with a flood with a return period of 100 years. Thus, we will change the colors of Figure 1 as suggested by the Referee (darker blue for 2-years flood and light blue for 100-years flood).

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We did not include a definition of return period in the original text because we consider that the HESS-readers are usually familiar with this concept, since it is common in the hydrology field. Nevertheless, we agree with the Referee that in order to reach a broader public the paper should be understandable by researchers from other fields. Thus, we will add a brief description of return period in the caption of Figure 1.

**6) “Page 5 Figure 2 Why is the number of experts different for each criterion?”**

Thanks for pointing out this issue. The number of experts is not different for each criterion, but for each stage of the index development process. For example, 101 experts participated in the online Delphi Survey. However, it is not possible or desirable to conduct focus groups with such a large group. Thus, as explained in Section 3.1 and fully detailed in a previous paper (de Brito et al., 2017), we conducted a social network analysis to identify key experts. The selected key experts were invited to take part in small workshops and focus groups. The participants of these meetings were different (see Table S1) as the exercises were performed at different localities. We will modify the introductory text of Section 3, as well as the caption of Figure 2 in order to clarify this issue.

**7) “Page 6 line 10 What are the 11 criteria? Please give the explanation”**

The 11 criteria that were selected using the Delphi survey are: (1) persons under 12 years; (2) persons over 60 years; (3) persons with disabilities; (4) monthly per capita income; (5) households with improper building material; (6) households with accumulated garbage; (7) households with open sewage; (8) disaster prevention institutions; (9) evacuation drills and training; (10) distance to shelters; (11) health care facilities. A detailed description of how the criteria were selected is provided by de Brito et al. (2017).

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We fully agree that in order to increase the understandability of the text it is better to provide this information in the methods section. Thus, as mentioned in the answer to the comment 2, we will include a Table with the selected criteria, measurement units, and data source in Section 3.2.

**8) “Page 6 line 18 and 20 How do you transform the data base into 20 m raster resolution? Why do you make it into 20 meters? why don’t you select 10 meters or 30 meter?”**

In order to conduct map algebra more efficiently, all data were transformed to raster files using “polygon to raster” tool in ArcGIS® using the cell center method (ESRI, 2017b). The cell center technique assigns each raster cell the value of the vector object that lies at the geographic centroid of the newly created raster cell. Figure 1 below illustrates how this procedure works in a GIS software.

The choice of 20 meters was not arbitrary. Indeed, it was based on the spatial resolution of the least detailed data used in the analysis, which is the location of health care facilities and location of persons with disabilities. The GPS used to map these locations had an accuracy of 15 – 20 meters. We could have used a larger cell size (e.g., 30 meters) but not smaller, as it is not possible to obtain any more detailed information by resampling the raster to a smaller resolution. We will modify the text to explain that the 20 meters cell size was chosen due to the spatial resolution of the input data.

**9) “What do you mean with “selected criteria” in this manuscript?”**

In this study, the selected criteria are the variables used to assess the vulnerability. The input criteria were selected by 101 experts using the Delphi technique, as explained in section 3.2. We consider that this issue will become clearer when we add

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a Table with the results of the Delphi survey (see reply to comment number 2 and 7).

**10) “Page 9 line 11 What is the opinion of the 22 experts?”**

It is the degree of satisfaction of the 22 experts that participated in the AHP and ANP workshops with several aspects of the methodology. In the feedback questionnaire we tried to capture their thoughts about the efficiency of different steps of the proposed methodology (e.g. the AHP weights, the ANP weights, the way the criteria were grouped, the transparency of the process, etc.). We will reformulate this sentence to make it clearer for the readers.

**11) “Page 9 line 19 Why do you select 4-point Likert scale?”**

A 4-point Likert scale was chosen to avoid neutral responses as this scale forces the users to form an opinion (Croasmun and Ostrom, 2011). We will modify the text to explain the choice for a 4-point Likert scale.

**12) “Page Figure 9 What do you mean with 22 vulnerability scenarios?”**

The 22 vulnerability scenarios are shown in Figure S1. They correspond to the individual vulnerability maps created by the 22 experts that participated in the AHP and ANP workshops. In the developed Web-GIS platform, the participants could access all final vulnerability maps created, including the intermediate maps (structural vulnerability, social vulnerability, and coping capacity maps). The caption of Figure 9 will be modified to clarify this issue.

**References**

ASCE: Hydrology handbook, New York., 1996.

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Croasmun, J. T. and Ostrom, L.: Using Likert-Type scales in the social sciences, *J. Adult Educ.*, 40(1), 19–22, doi:10.1007/s10640-011-9463-0, 2011.

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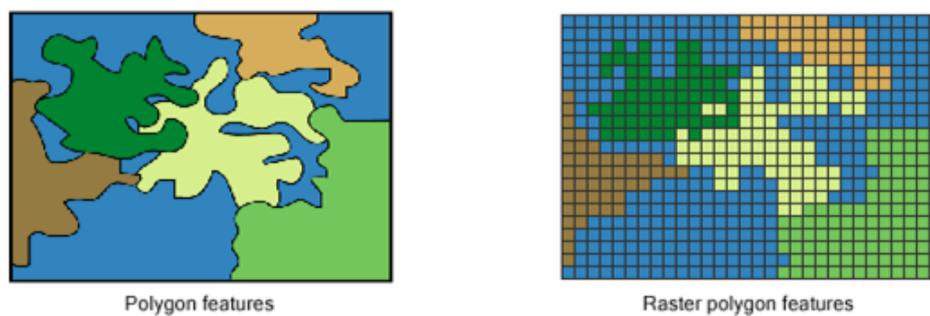
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ESRI: How polygon to raster works, [online] Available from: <http://pro.arcgis.com/en/pro-app/tool-reference/conversion/how-polygon-to-raster-works.htm> (Accessed 5 September 2017b), 2017.

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**Fig. 1.** Polygon to raster transformation (ESRI, 2017a)

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