Revision

Title: A GIS based urban flood risk analysis model for vulnerability assessment of critical structures during flood emergencies

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General comment

The manuscript proposes a methodology for the evaluation of the flood risk in urban area considering the direct damages to buildings and infrastructures and providing also several indexes for the evaluation of the vulnerability of the urban system during floods. Referring to GIS application, the proposed methodology investigates the relationship between critical element at risk (e.g. schools, industries, etc.) and rescue centers (e.g. hospital, fire stations, etc.) providing the infrastructure vulnerability during the emergency of a flood. However, despite the interesting aims of the manuscript, the investigation performed and the results provided in the document are, in my opinion, not exhaustive. Before proceeding with the publication, the manuscript should include some additional information and a more comprehensive description of the performed analysis and results. Hereafter there are some remarks and specific comments that should be addressed in the revision process.

MAIN REMARKS:

- My main concern regards the lack of correspondences between what the Authors introduce in the methodological sections of the manuscript and what they really shown as results. Despite the definition of several vulnerability indexes in order to consider the complexity of the emergency system in an urban area, the description of numerical application is limited and focused only on the systemic vulnerability index, while other indexes (such as. eq. (1)-(3)) are not shown.

- 2412-L11-21 - Concerning the seven categories identified by Escuder Bueno (2012) it is not really clear in the manuscript how, and on the basis of which information, these classes have been associated to the study area in order to estimate the number of loss of life.

- Section 2.1.2 - In this part Authors describes the methodology adopted for the estimation of direct damages to buildings distinguishing different occupancy types. However, it is not clear to the readers on which type of data this analysis is performed. What are the data sources required for this accurate analysis? Authors refer only to maps of land use but their accuracy and resolution should be provided. How does the economic value of the different structures and activities was defined? Figure 3 provides several depth-damage curves but the difference between the two panels is not clear. What do the suffix _S and _C mean?
  Finally, in this study Authors refer to depth-damage curves provided by F-RAM 2008 which are evaluated for flood events occurred in the United States. This aspect implies that these curves may not be suitable for Italian case studies where economic and social characteristic are different. Some consideration on this point and on the limits of the application of the methodology should also be included to the discussion.

- 2417-L11 - The Authors introduce the index of weakness of each arc by referring to equations 1, 2 and 3. However, if I have well understood the meaning of different indexes, the eq. 2 and 3 clearly refer to a specific arc, while the eq (1) evaluates the degree of inaccessibility of an area, such as part of the city or buildings, etc., and should not be considered in the identification of the index of weakness of a specific arc.

In general, I think that a schematic representation of the city with the connection system and some buildings may enhance the clarify of the presentation.

- Section 2.2.3. The systemic vulnerability of each element (section 2.2.3) is defined as the max between the structural damage, S_i, and the influence of the road network, y_i. As I have understood S_i is the amount calculated following section 2.1.2, while y_i refers to eq. (4) and ranges between 3 and 6 (see 2418-L2). Is it true? These indicators should be previously introduced in their respective sections.
  Beyond this, I have some doubt on the choice of taking the maximum values. In fact, S_i and y_i represent two different type of damages that can coexist in case of a flood event and should be considered both, the first in order to consider the structural damages to the element and the latter the damages induced by its inoperability. Can the Authors further discuss this point?

- Section 4. The Authors reproduced the flood event by means of a 2D model but no information are reported in terms of model parameters (i.e. friction coefficients). Have the Authors performed a model calibration?

- In some parts the manuscript results not really easy to understand. I would recommend a general revision.

SPECIFIC REMARKS:

- 2406-L24 - please remove one of the citation about Jonkman, 2005.
- 2407-L3 - the reference "Institute of Civil Engineers 2001" is not clear. What does it stand for? Also see some other important references on this point (i.e. Djordjević et al., 2011, and references therein).
- 407-L14 - please check Jongman et al., 2010; it is not in the reference list. For the Damage Scanner model please refer to Klijn et al., 2007.
- 2409-L9-13 - please reformulating this part, it is a little bit confused. USACE, 2008, is missing in the reference.
- 2409-L16 - in this case I think that it is more correct to refer to an "innovative methodology" than to an "innovative model". The new methodology can be implemented into an hydraulic or GIS model for the evaluation of a specific flood event.
- 2410-L3-5 - Please revised this paragraph. The structure is repetitive while the content does not exactly represent the structure of the manuscript. For example Section 3presents the case study only.
- 2410-L19 - "simulation" fits better to the context than "evaluation".
- 2411-L8 - please remove "as in phase III of Fig. 1".
- 2411-L19-20 - please check the sentence, a bracket is missing. Also, the concept of Peak Unit Flow Rate is not clear. Is it the same of the flow impulse (i.e. the product of water depth and flow velocity) ? Furthermore, it is not clear to me the definition of the Twv at night…are there specific demonstrations and references about the difference of 15 minutes?
- Fig 2. The Figure 2 can be reformatted as an additional table. The Figure label (i.e. "Table 8. Flood severity … ") should be removed and DV values converted following the International System of Units.
- 2412-L1-2 - This sentence is not clear. Please consider to reformulate it.
- 2412-L5 - What does "residual damage" mean for the Authors? I think in this case "additional" or "indirect" damage could be more appropriate.

- 2414-L16 - please remove the part in brackets.
- 2414 - L25 Can be the Authors more detailed? What is the water depth threshold adopted to close the road? I think that a road can become inaccessible for water depth lower than the vehicle height (e.g. 50-70 cm).
- Eq. (1) - Eq. 1 is not very clear. Why the index reports the symbol Δ?
  The equation (1) also refers to Pe_j. Is it an error or the index refer to a specific emergency path? In this case, the index should report the j. Also, the numerator should be simplified in the term of Ps_i. What does the first sum refer to? Finally, the range of variation of the index should be added to the text.
- 2416-L11 - Are there some references on this index?
- 2416-L17 - "The Reduncancy Index, RI_{od}, developed …"
- 2416-L18 - The explanation of "od" should be moved before equation (1).
- Eq. (2) - Since the RI index refers to a specific arc it should use the subscription j. At line 19 Authors refer to arc j, while then to $a_{j.}$ Please make the text consistent. N_{ps} is not defined. As before, Authors should describe the significance of the values assumed by RI.
- Eq. (3) - Is the element a_{ijs} necessary in this equation? What is the meaning of OI? Also in this case the index refer to a specific arc, so subscript j may be added.
- 2417-L12 - "represent the Index of Weakness, IW, of each arc"
- 2417-L17-18 - please better clarify this point.
- 2417-L19 - it is not clear to which elements the influence index refers.
- 2420-L19 - Which kind of discrepancy did you found? Please better explain this point, otherwise, if the discrepancies do not affect the analysis you should remove this sentence.
- 2420-L21 - Which data have you extrapolated from ortophoto?
- 2421-L11 - "using the Digital Elevation model"
- Figures 5 and 6 - please provide a complete legend for all the elements.
- Figure 7 - It is not clear if Fig. 7 refers to the results of this work or to previous investigation performed by IRPI (see the legend).
- Table 3- I suggest to convert this table into a Figure.
- Table 4 - Have the Authors performed a comparison with respect the real damages registered after the event.
- Figure 9 - please check the language.
- Figure 10 - please better describe its meaning. If I am not wrong the brown color means more isolated (and potentially damaged) areas. However, this depend on the position of the strategic structures such as hospitals or fire stations that are not shown in the map.

ADDITOINAL REFERENCES

Djordjević, S., Butler, D., Gourbesville, P., Mark, O. and Pasche, E.: New policies to deal with climate change and other drivers impacting on resilience to flooding in urban areas: the CORFU approach, Environmental Science & Policy, 14(7), 864–873, doi:10.1016/j.envsci.2011.05.008, 2011.

Klijn, F., Baan, P., De Bruijn, K. M., and Kwadijk, J.: Overstromingsrisico's in Nederland in eenveranderend klimaat: verwachtingen, schattingen en berekeningen voor het project Nederland Later, WL Delft Hydraulics report Q4290.00, 2007 (in Dutch).