

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

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General comments:

The objective of the paper is to present a method for vulnerability assessment of critical structures in case of flooding. The method is first presented and then applied to a case study. Results shown how the method allows to identify infrastructures and structures (hotspots) whose loss could cause important damages and problems to emergency services in case of flooding.

The paper addresses innovative aspects such as spatial accessibility and functional/operability failure in case of flood. The major findings are: (1) the definition of several indexes that allow to estimate accessibility and operability of the urban system to inform emergency management, and, (2) integration of direct and indirect flood damages using GIS.

However, the following general remarks are provided:

- a) The paper describes a method for vulnerability assessment but probability of flood events are not estimated thus the title should be modified (a flood risk analysis model must include probability and consequences).
- b) The abstract should be modified. “The proposed model is unique in that it provides a quantitative estimation of flood risk...”. Flood probability is not considered, I would recommend using “estimation of flood vulnerability”. “This information can be used...to prioritize...” No detailed description on how to prioritize risk reduction measures based on results from this method is provided in the paper.
- c) The *terminology* should be standardized. Check terminology on flood risk (see Floodsite project, Language of risk, 2005; or ISO 31000, 2009). The terms ‘analysis’, ‘evaluation’ and ‘assessment’ are frequently used in the paper but referring to ‘estimation’ (e.g. page 2411, l.12, “the assessment of loss of life”, while section 2.1.1. is entitled “Loss of life estimation”; page 2414, “Road closure evaluation” vs. page 2432, “Road closure estimation”). In addition, the terms ‘method’ and ‘model’ are used indistinctly (e.g. page 2413, l.17, “the adopted method models”; page 2411, l.1, “this phase of the model”). Please note that a ‘method’ is not a ‘model’ and vice versa. I would recommend to clarify this aspect.
- d) Overall description of the method in Section 2 is found along with information and hypotheses for the case study analysis (see page 2411). More distinction between overall methodology and case study description should be made. Information on the case study should be included only in Section 3.
- e) I would recommend reconsidering the structure of Section 2 based on the phases established in Figure 1 (phase III is described in section 2.1 and phases IV and V in section 2.2).
- f) I would recommend including a simple example (case study or theoretical example) to estimate impedance, reliability and influence indexes for a system with several “origin-destination” pairs and paths. The case study does not provide enough information/results about this phase.
- g) In general, several parts of the manuscript would benefit from re-drafting and editing (some paragraphs are difficult to understand; e.g. page 2412, l.15-18; page 2416).

Therefore, I suggest re-drafting the paper before publication. In addition, I recommend including some discussion on the applicability and limitations of this method.

Specific comments:

1. [Page 2405, Title]

The term “critical structure” has to be explained in the paper. How a structure is classified as “critical” or “non-critical”?

2. [Page 2406, Abstract]

“Within this context, a flood risk analysis model was developed in this study that is based on GIS, and integrated with a model that assesses the degree of accessibility and operability of strategic emergency response structures in an urban area...” Please clarify the outcomes of the study: method or model/method including the use of 2 models...

3. [Page 2406, l.25]

Check reference: Jonkman and Kelman, 2005.

4. [Page 2407, l.2-4]

Check references

5. [Page 2407, l.7]

The term ‘whole life’ has to be explained.

6. [Page 2407, l.20]

The term ‘residual damage’ has to be explained.

7. [Page 2409, l.8]

“in an efficient way”. How do you consider the degree of efficiency of the analysis?

8. [Page 2409, l.14]

“The proposed model for flood risk assessment in urban areas provides a comprehensive and quantitative evaluation of direct damage to inform decision-making in terms of loss of life and structural and economic damage”...

The model does not provide flood probability thus it cannot be defined as flood risk assessment. The term ‘comprehensive’ can be used in flood risk analysis when both risk components are estimated (probability and consequences).

9. [Page 2410, l.1]

“The proposed model can aid in prioritizing the decisions...” This aspect is not later described in the paper. How decisions can be prioritized?

10. [Page 2410, l.6]

Renumbering section 2 based on phases shown in Figure 1. (2.1. Phase I, 2.2. Phase II, 2.3. Phase III- GIS Direct impact assessment...)

11. [Page 2411, l.2]

The term ‘assessment’ includes analysis and evaluation.

12. [Page 2411, l.9]

The term ‘flood severity’ is not introduced in section 2.

13. [Page, l.16-18]

References to the case study should be included in Section 3. Description of the method in Section 2 should be more general.

14. [Page 2411, l.20-21]

Definition of Flood Wave Arrival Time not clear. The flood wave arrival time is independent of being during the day or at night. On the contrary, warning times in case of flooding may differ.

Please explain the two components of the vector unit flow rate and definition of the DV parameter.

15. [Page 2411, l.25]

The DV parameter was proposed by Graham in 1999 (USACE).

16. [Page 2412, l.7]

The use of the fatality rates proposed in the SUFRI project is suggested in this paper for the case study (since it has been previously applied in Italy). This should be included in Section 3. Is it possible to use other fatality rates for life-loss estimation? If so, then this section should give general guidelines on how to estimate loss of life, providing the example of the fatality rates from Escuder-Bueno et al. as an example in Section 3.

17. [Page 2412, l.11]

The fatality rates proposed in Escuder Bueno et al. (2012) are classified in 10 categories (not 7). Check reference.

18. [Page 2413, l.1]

"The methods were based..." I would suggest avoiding the use of past tense.

19. [Page 2413, l.18]

Please clarify the term "content-structure value ratio".

20. [Page 2413, l.22-24]

Move content to Section 3.

21. [Page 2413, l.27]

Please describe the different phases of a flood event as it is assumed in the paper (the terms "emergency phases" and "pre-event phase" are used in page 2413 and 2414, respectively; also "emergency response phase" in page 2417).

22. [Page 2414, l.1]

I would suggest avoiding the use of first-person narrative.

23. [Page 2414, l.5]

Check the use of the term 'residual damage'. Residual damage (or residual risk) generally refers to existent damage or risk that cannot be reduced by structural and non-structural risk mitigation measures.

24. [Page 2415, l.11]

"Degree of inoperability of a path" and "reliability" are two related but opposite terms. Please clarify relationship between terms.

25. [Page 2415, l.13]

Equation 1 is presented before explaining "od" (origin-destination).

26. [Page 2416, 2417]

The term "index" is used in lines 1 (referring to impedance index), 5, 6, 9, 11, and 17. Please review the description of all indexes.

27. [Page 2418]

Please describe the role of the proposed Classification A, B and C in the method and its connection with the indexes described in section 2.2.2.

28. [Page 2419, l.1]

Systemic vulnerability is defined as the maximum value among the structural damage and the influence index. Why is life-loss not considered as direct loss? Traditional direct loss analysis includes life- and economic-loss. Please clarify index units.

"Since it highlights the maximum risk"...What does it mean? Please clarify whether it refers to maximum flood damage (risk would include flood probability).

29. [Page 2421, l.13]

Include Results in section 3 (3.1 Data; 3.2 Results).

30. [Page 2421, l.26-27]

I suggest using "flooded area" instead of "risk area"

31. [Page 2422, l.2]

"the highest probability of loss of life" Do you mean highest fatality rate?

32. [Page 2422, l.8]

"We made the assumption that the first notice peak corresponded to the first damage flow..." Then, is the warning time equal to zero?

33. [Page 2422, l.10]

"There is no public education... despite the low flood severity due to low values of the Peak Unit Flow Rate" This paragraph is difficult to understand. The existence of public education, risk communication, etc. is a characteristic of the urban area that may inform on the level of flood severity understanding of the population at risk and it is not related to flood severity values of the analyzed flood scenario.

34. [Page 2422, l.15]

"...1 fatality due to low population density". It would be interesting to analyze the scenario with seasonal variability (higher population at risk) with the aim of comparing results for both situations.

35. [Page 2423]

Quantitative results (or summary of results) regarding population at risk, fatality rates, impedance and influence index values for the case study are not included.

36. [Page 2424, l.10]

"the innovative aspect ...is to provide a quantitative estimation of flood risk" Combination of flood probability and consequences is not considered in the manuscript. The case study has been analyzed for a unique flood scenario.

37. [Page 2425, l.126]

Write all references in alphabetical order.

38. [Page 2428]

Categories C8, C9 and C10 are missing in Table 1.

39. [Page 2431]

Show results in MEuro.

40. [Page 2432]

How population at risk or life-loss is included in the definition of the influence index? Please clarify.

41. [Page 2433]

Include units (SI) of the DV parameter.

Check references (LSM shown in the title and DHS in figure caption). DV values were proposed by Graham (1999).

42. [Page 2434]

Divide Figure 3 into two figures (one for each graph).

43. [Page 2438]

Please define acronyms (IRPI, AVI...)

44. [Page 2438]

Loss of life is represented using three qualitative levels (low, medium and high) but the method describes quantitative life-loss estimation (by using fatality rates).

45. [Page 2439]

Systemic vulnerability estimation (figure 9) or systemic vulnerability evaluation (figure 1). Check the use of 'evaluation'/'estimation' in the paper.

Other comments:

<i>Page</i>	<i>Line</i>	<i>Comment</i>
2407	9	Delete "It can be seen that"
2407	12	with particular attention on emergency management
2407	20	in case of emergency
2410	1	Delete "In this manner"
2410	1	Delete "the decisions on the type and site of "
2410	1-5	In Sect. 2, the overall GIS framework is outlined. In Sect. 3, the validation and results on a real flood event are described. In Sect. 4, results are provided, and, overall discussion and conclusions are provided in Sect. 5.
2411	6	Replace incidents by events
2412	5	multiplied...times
2412	7	The fatality rates proposed in the SUFRI project (Escuder-Bueno et al., 2012) were adopted...
2412	13	C1 to C10
2413	13	Replace demonstrate by show
2413	22	Figure 3 shows the depth-damage curves used in this case study.
2414	20	considered
2414	25	Replace utilized by use
2414	26	Replace less by lower