

Review of egusphere-2024-2844

Title: *Impact Webs: A novel conceptual modelling approach for characterising and assessing complex risks*

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General comments:

The article presents a novel conceptual complex risk assessment methodology named 'Impact Webs'. The authors describe the conceptualization of this new approach to complex risk modeling and how they developed it based on combining the advantages of several existing conceptual risk modelling approaches. The steps for constructing such a 'Impact Web' are also described, and at the end the authors show the results of a complex risk assessment using a case study in Guayaquil, Ecuador to provide proof of concept.

In general, the structure of the paper is rather unfortunate chosen or the headings are simply inappropriate. The authors describe in Section 2 "Methodological development" that they did a literature review and how this inspired the development and conception of their new 'Impact Webs'. Furthermore, they write that they carried out further theory and conceptual synthesis within the research team (but no further information is provided) to develop the concept for the impact webs. They also briefly mention that they tested the concept with stakeholders in five different case studies. And then in Section 2 "Results" the structure of these 'Impact Webs' and the method for constructing such 'Impact Webs' is described. I think that this Section 3 describes the actual method and not the results. And Section 2 is more of a chapter that describes the methodological pre-considerations. And in Section 3.3, an example is given of how such a development of an 'Impact Web' is carried out using a case study. For me, this is rather a "Results" Section, presenting the results of actually applying the new approach in a case study. Overall, I suggest reconstructing and renaming the sections 2 and 3 including the subsections.

While I find this new 'Impact Webs' approach very exciting and interesting and valuable, I think it has not been sufficiently presented by the authors. Some work needs to be done to make it possible to replicate the method in future studies. Please see my specific comments for more details.

There are also some typos in the manuscript. I would advise the author to go through everything carefully again.

Overall, I recommend major revisions.

Specific comments:

1. The authors mention the term 'response risks' in the abstract and later in several places in the manuscript. In lines 52 and 228, they mention this in connection with the literature. But this term is not used in this literature. What do the authors mean by this? Do they mean "human responses", "response options" or "response actions"? Or do they mean here "responses" as a driver of risk (risks due to human responses that not achieve the intended outcome etc.)? If they are introducing a new term, then it should be identified as such.

Otherwise, the use of direct quotation marks in line 228 is confusing, because, as stated, the term as used by the authors here is not mentioned in the cited literature.

2. In lines 32-33 the authors talk about “both positive and negative outcomes of disaster risk management practices”. What do you mean by that? I suggest rephrasing it to better clarify what you mean by positive and negative outcomes.
3. In lines 80–82, the authors cite literature on other system mapping approaches on which they base their newly developed Impact Webs: “... such as Causal Loop Diagrams (Coletta et al., 2024), Fuzzy Cognitive Maps (Gómez Martín et al., 2020) and Bayesian Belief Networks (Scrieciu et al., 2021).” It would be good to provide further references per approach and to put “e.g.” in front of them, since these are only mentioned as examples of many others.
4. When describing the methodological development of the Impact Webs, the authors mention on line 116 that they “show other conceptual risk modelling approaches” that they drew inspiration from, without mentioning, however, that this overview was based on a literature review. It would be helpful to make this clear at this point, since the authors also name the next subsection accordingly.
5. In lines 121 to 127, the authors explain their literature search conducted as part of the study. But the information given about the process is much too thin. The method is not sufficiently documented to allow a replication of the review. Which search string was used? In which database was the search conducted? Why was this database selected and not others? Was the search restricted to peer-reviewed literature? How many articles were screened in total? What are the exclusion and inclusion criteria? Why was no systematic literature search conducted?
6. In Table 1, the authors provide an overview of conceptual risk modelling approaches. I find this table very helpful. I am just wondering what the different approaches are categorized by? The authors start with “Climate Impact Chains” and end with “Participatory System Mapping”. It might make sense to categorize the approaches by the degree of integration of quantitative data or the approaches' ability to capture the complexity of the system (from linear to non-linear approaches). Furthermore, I wonder what the key references in the last column are sorted by? Relevance? Does it matter who is listed first? I would suggest sorting them by year of publication.
7. Furthermore, I doubt that the last category presented by the authors “Participatory System Mapping” is not really a stand-alone conceptual model-risk model development approach. Participatory systems modelling can be done using various systems mapping methods (e.g. FCM or causal loop diagrams) to formalize knowledge. The mapping of conceptual systems can be done both participatory or on the basis of literature research. “Participatory” merely describes the process and the way in which the knowledge is generated. All of the first five approaches could be carried out in a participatory way. See, for example, the studies:
 - Videira et al. 2009. Scoping river basin management issues with participatory modelling: The Baixo Guadiana experience.
<https://doi.org/10.1016/j.ecolecon.2008.11.008>
 - Sahin et al. 2020. Developing a Preliminary Causal Loop Diagram for Understanding the Wicked Complexity of the COVID-19 Pandemic.
<https://doi.org/10.3390/systems8020020>

- Melles et al. (2021). COVID 19: Causal Loop Diagramming (CLD) of Social-Ecological Interactions for Teaching Sustainable Development. In: Leal Filho, W. (eds) COVID-19: Paving the Way for a More Sustainable World. World Sustainability Series. Springer, Cham. https://doi.org/10.1007/978-3-030-69284-1_16
 - Olazabal et al. 2018. Transparency and Reproducibility in Participatory Systems Modelling: the Case of Fuzzy Cognitive Mapping. <https://doi.org/10.1002/sres.2519>
8. The text in lines 131-173 in subsection 2.1 on the “Lessons from the review” does not really fit with the results presented in Table 1. The authors introduce three broad types of approaches following a study by Elsayah et al. (2017) in this section. However, the connection to the categories the authors have identified from their review (presented in Table1) is not entirely clear. I do not see the benefit of introducing this broad classification by Elsayah et al. (2017). The examples in the table are not organized according to this classification. It just seems so disconnected. It would be better if the authors simply focus on the lessons learned from their own review and discuss and compare the strengths and weaknesses of the identified methods, in order to derive what they used for their new approach. The authors do this from line 161 onwards, but it would be interesting if the authors elaborate on this further. I would advise the authors to shorten the section (L132-173) and focus more on the actual results of their review.
 9. In line 172 to 173, I do not understand what the authors mean with “of what stakeholder value and want to protect.” I am not sure what the word “protect” means in this context. Please consider revising the sentence.
 10. In section 2.3, the authors describe the next steps in how they made this methodology feasible for practical application. They briefly state that they tested the methodology with groups of stakeholders in various case studies. What I am missing here is a better overview of the five different case studies. Simply saying that you have five different case studies and giving their names is not enough. Why were five case studies selected? Why these in particular? What characterizes each case study? A table would be nice that provides an overview of the uniqueness and challenges (including the complex risks) of each case study in comparison to the others.
What did the authors learn from each case study?
The authors further describe that there were two workshop rounds with a number of different stakeholders. Were there two workshop rounds in total or two workshop rounds for each case study? This is not entirely clear.
 11. In line 179, the authors mention that the identified various theories and concepts were synthesized within a “research team”. However, the authors do not provide any further details about this research team. It would be useful to get a clearer sense of how this team and this synthesis process was organized. How big was the team? Did all belong to the same institution? What was the team composition? What disciplines were represented in the team? What about the disciplinary bias of the team? Were there members of this team who led this conceptual development? What was the expertise of these members? And how long did the process of this conceptual development take?
 12. As already described in my general comments, I suggest renaming Section 2 and restructuring and renaming Section 3. The current structure is misleading. The way I understand the text, Section 2 contains only preliminary methodical considerations (for

example, a preparatory literature search), while Section 3.1-3.2 describe the actual new method/approach of 'Impact Webs'. In fact, I see section 3.3 as a "Results" Section in which the application of the new approach is presented and tested in a case study.

13. The authors present in Section 3.1 the constitutive elements of an 'Impact Web'. Unfortunately, this is not very illustrative. It would be much better if the authors present these eight model elements in a separate table directly next to Figure 1. It would also be important for the recognition of the individual elements that the elements are not grouped together or named differently. For example, the authors have combined "Interventions & response risks" and "Risks that did non manifest". I would strongly advise against this. It would also be good to use the same colors for the elements in such a table as in Figure 1.
14. For the model element "Connections between elements", please explain the syntax in more detail. It is not entirely clear from the text what the different line types (solid, dashed) mean.
15. For the model element "Multiple interacting hazards", please indicate that you use icons in the model.
16. For the model element "Direct & cascading impacts", please explain that you distinguish between positive and negative impacts, which are indicated by cross and hook signs. Why did the authors choose these symbols? Wouldn't plus and minus signs be more intuitive?
17. The authors mention in L292 that during the scoping step an important step for selecting the scale to model by looking at geographical or administrative boundaries. It would be interesting to learn more about when the authors would suggest considering geographic or administrative boundaries. Risks can cross administrative boundaries. What would be the argument for looking at administrative boundaries anyway?
18. L306-307: I don't get what you want to say with this sentence: "This perspective acknowledged that the systems relationships emerge more clearly when under stress, i.e. become more visible and therefore easier to observe." What do you mean with "under stress"? Please consider revising this sentence.
19. In lines 364 to 367, the authors mention that they only select one case study to demonstrate the use of the new 'Impact Webs' approach. I fully understand why only one case study was selected. But why did the authors choose the Guayaquil case study and not one of the others? It would be good to provide a justification. Now, reading on, I see that the authors state in Section 3.3. "Step 1: Scoping" why they chose this case study. But perhaps it would be good to make this point earlier.
20. In lines 386 to 394, the authors summarize the results from step 2,3 and 4 for the Guayaquil case study. But actually, they only mention which elements are included in the final model. That provides no added value. The reader learns nothing about the process, how the elements were selected, how the workshops with the stakeholders went, whether there was disagreement, or how many elements there were initially and how many the model was reduced to in the end? More details about the actual steps 2, 3 and 4 would be extremely helpful for further future applications of the 'Impact Webs'. And also, how long did each step take? Please provide further details in this regard.

21. In “Step 5: Narrative storyline for Guayaquil, Ecuador”, the authors provide the storyline they have developed for this case study. The story is very interesting and important for the later communication with stakeholders. But wouldn't it also be interesting for the reader to learn more about the process of writing this story? Who of the team wrote it? How was the story constructed? Was an overarching storyline followed? Were there difficulties? How often was the story reflected upon with the entire team? How long did the process take? It would also be good to highlight the “actual story” in the text, for example by using italicized font. If I understand it correctly, the actual story goes from line 402 to 438. Or am I wrong?
22. Figure 3: It would be important if the elements were listed in the same order in the legend as in Figure 1, which presented the basic structure of an ‘Impact Web’. It would also be important to use the same terminology. In Figure 3, for example, the authors only refer to “Root cause” instead of “Root cause of risk and vulnerability”.
23. In lines 439 to 451, the authors highlighted and described the advantages of the ‘Impact Web’ approach in the case study of Guayaquil. But that doesn't fit into “Step 5: Narrative storyline for Guayaquil, Ecuador” at all, does it? Wouldn't it be better in a separate paragraph? Somehow it is a bit misleadingly placed.
24. In Section “4.1 Strengths”, the authors say that the new approach “is useful to conceptualise, identify and visualise networks of interconnected elements across different systems and sectors.” To prove this, it would be good to get a brief overview of the challenges and successes and lessons learned from the other case studies. A short overview table would be good for this. It might also be helpful to show the other impact web models of the other 4 case studies in the supplementary material.
25. L472-473: “Given the models effectiveness for mapping the complexity of an event such as COVID-19 suggests that you could equally develop an Impact Web to understand the complexity of climate change risks.” I don't understand this sentence. Is it related to what was said in the previous sentence, that a simple cause-effect chain model was developed first?
26. In lines 482 to 484, the authors state that, apart from the outputs (the visual and the narrative storyline), it was rather the process of developing the model that stimulated critical reflection in the modeler and involved stakeholder. Unfortunately, however, we did not learn much about this process when the example of Ecuador was presented. Please elaborate on this in an appropriate place.

Technical corrections:

There are some grammatical errors and typos. I have highlighted the ones I noticed, but I suggest that the authors read the manuscript carefully again.

1. L29: “the methodologies usefulness” → “the methodologies’ usefulness”
2. L87: “compared with Climate Impact Chains” → “compared **to** Climate Impact Chains”
3. L116: “In section 2, we present our methodological development from Impact Webs.” → “In section 2, we present our methodological development **of** Impact Webs.”
4. L118: Is the word “trailed” really appropriate in this context?

5. L179: There is a typo: “until we synthesized an agreed” → “until we synthesized **and** agreed”
6. L217: “Following the inclusion multiple hazards” → “Following the inclusion **of** multiple hazards”
7. L267: There is a typo: “For exmaple” → “For **ex**ample”