Reviewer 2

In the manuscript "Impact Webs: A novel conceptual modelling approach for characterising and assessing complex risks", the authors make use of expert judgment and non-systematic literature review to build on lessons from different approaches to come up with a new conceptual modelling approach for systemic risk characterization. It is a relevant topic, however the contextualization and purpose of the paper are not clearly supported. I would thus recommend major revisions as outlined in the following.

Authors response: *Thank you for your useful comments on our draft publication. We are glad you think it is a relevant topic. We feel that, upon integrating reviewer feedbacks, it will add value to the peer reviewed literature on complex risk assessments.*

The structure of the manuscript is very unclear. It is unclear what is result, what is method, and most often, how certain conclusions were drawn. The authors should revisit their structure and narrative for this paper. It is not clear to me, what this paper offers to its readers. Is it the pure idea of impact webs (as an advancement of impact chains), is it the visualization, is it the guidance to build impact chains? In its current form, the authors seem to do everything a bit, but nothing sufficiently in depth. Re-structuring and clarifying the objective of this paper. Just outlining the process of developing the web (as mentioned in the introduction), seems to fail answering a specific research question.

Authors response: *Our aim with this publication is to offer a new methodology to improve understanding of complex risks. We agree that this could be made clearer in the introduction, and will do so in a second submission by setting out the aim clearly. To demonstrate how we achieved this aim, in submission 1 we offered the methodology of Impact Webs and guidance in how we made it as 'the result' – however based on you're and the other reviewers feedback we will significantly restructure sections 2 and 3 of the paper as follows: 1) Introduction (with more focus on the aim), 2) Methodology, 2.1) Methodological pre-development: Scoping review of conceptual risk models for inspiration, 2.2) Selection of elements, 2.3) Steps for constructing an Impact Web, 2.4) Trail in test cases (with more details of the cases), 3) Results: Proof of concept, 3.1) Complex risks linked to COVID-19, concurring hazards and responses in Guayaquil, Ecuador. We will then keep the discussion in the same structure, but reflect more on the aim and research gap that we closed with Impact Webs. Please see the restructured outline below:*

1. *Introduction*
2. *Methodological development*
   - ***2.1*** *Methodological pre-development: Scoping review of conceptual models of risk for inspiration*
   - ***2.2*** *Selection of constitutive elements in an Impact Web*
   - ***2.3*** *Steps for constructing an Impact Web*
   - ***2.4*** *Trail in test cases*
3. *Results: Proof of concept*
   - ***3.1*** *Complex risks linked to COVID-19, concurring hazards and responses in Guayaquil, Ecuador*
4. *Discussion*
   - ***4.1*** *Strengths*
   - ***4.2*** *Limitations*
   - ***4.3*** *Future research direction*
5. *Conclusions*

With this new structure, and additional details on the methodological development, the manuscript will be clearer offer to its readers insights on how we developed a new methodology in Impact Webs.

What is Impact Webs? It would be very valuable if authors could clarify what they mean when they refer to impact webs as a conceptual modelling approach. Part of what the authors present seems to be tools (how to visualize), some analysis guidance (see Figure 2). Overarchingly, it would be beneficial, if the authors could make it more explicit, what the purpose of impact webs is. They refer to Bayesian Belief Networks and other modelling methodlogies, include participatory elements which are then refined/complemented through desk studies. Are impact webs meant to be complete and/or correct? Used by who?

Authors response: *With Impact Webs we developed a conceptual model that aim to improve understanding of complex risks in the system or location being modelled. The methodology is flexible and can be applied in the chosen system the modeler wants to investigate. We drew on inspiration from Climate Impact Chains, Bayesian Belief Networks and other conceptual models which are used in risk assessments, which we highlight in table 2 through a non-systematic scoping review. We will significantly restructure the section 'lessons from the scoping review' to show more clearly what aspects of other models inspired us and how we selected different aspects from them for Impact Webs. In the paper we also show how we made impact webs, as its our intention for this to be a methodological paper where readers can replicate our method for their own setting. We can make more explicit in the introduction what we mean when we refer to impact webs, and will lay out more clearly the purpose of Impact Webs in the introduction.*

Method section: This paper seems to heavily rely on expert judgment - which makes it very difficult to reproduce and to offer evidence regarding the claims offered here. One key question I had when reading this section was why the authors limited their search for inspiration to the field of single-hazard risk assessment instead of learning from fields that address similar or different complex systems (e.g. integrated water management, agent based modelling, system dynamics research community). If I understand correctly, the authors propose this method based on iterations/refinements in 5 case studies. At least a short introduction of these cases would already offer insight regarding the complex risk context/dynamics Impact Webs has been developed upon I would recommend taking inspiration from studies that have developed methodological approaches or investigated how such approaches have been developed (e.g. McMeekin, 2020) to extend the method section and add an additional section covering the approach development process.

Authors response: *Based on your and the other reviewers' feedback we will significantly restructure the methods section (see above response to the structure). In our scoping review, we did not limit our search to single-hazard approaches. We reviewed and drew inspiration from various other conceptual modelling approaches that are used in risk assessments. Some of these approaches are applied more for single-hazard risk assessments, and some more in multi-hazard or multi-risk assessments. Agent-based modelling was not one of the approaches that we included in the table as we aimed to develop a model that drew on graphical aspects and did not rely on heavy use of computational and quantitative data. Nearly all of the papers we include in table 1 integrate system dynamics and take a systems perspective, which is stated in chapter 2.1, and the reason we did not explicitly draw on integrated water management is because it is not a conceptual modelling approach. We will remove the participatory system mapping row from the table based on the other reviewers' feedback, are can replace this with agent-based modelling if you think this is an important category to include in such an overview of conceptual models of risk.*

We will also include more details on the 5 case studies in the new section 2.4, and we feel it is best to remove the current section 2.2. 'concept development' as it will make the methodology clearer based on the new structure. While developing Impact Webs, we held a number of internal conceptual development discussions within our team (the Vulnerability Assessment, Risk Management and Adaptive Planning section at UNU-EHS) where we brainstormed and critiqued ideas from one another. While this was done to inspire concept development, the team and synthesis process was not systematically organized. Under the new structure of the paper, where we intend to present the Selection of elements (2.2), Steps for construction (2.3) and Trail in test cases (2.4) in the methodology, we think the approach development process will be sufficiently covered.

Regarding the Impact web development process: Table 1 looks like something that would be worth for the Appendix or could be used in a shortened version to support a discussion of the different methods in the context of complex risk elements to be addressed with Impact Webs (section 3.1?). It would also be interesting to learn, why authors refer to storyline approaches as one of the steps in the impact web development process but did not consider them in Table 1 for inspiration. Section 3.1 seems a mix of presenting the complex risk elements of interest and mentioning what elements from which approach were used to visualize. I would suggest to separate these two purposes and rather provide more justification regarding the choices regarding the visual elements, e.g. by referring visualization research that justifies the choices. I also want to point out that terminology in Figure 1 is inconsistent (and not referred to in the paper). 'driver of risk', 'hazard', 'vulnerability' are all concepts that overlap (at least partially) and thus do not offer clear guidance what visualization element should be used.

Authors response: *We will significantly restructure section 2.1. based on your and other reviewers' feedback, and will highlight the different strengths in the approaches presented in table 1 and discuss why we drew on these for Impact Webs. This would then better support a discussion of the different aspects of approaches that are useful in a complex risk context that inspired us. We did not include storyline approaches in table 1 as they are not conceptual modelling approach. However, we did include storylines as we did not only limit our methodological development to the scoping review of conceptual models, although we understand this may be confusing in how the paper is currently structured in submission 1. In the restructured methods section we feel it will be clearer, and can in elaborate that the scoping review of conceptual models was not our only source of inspiration. We will provide more justification regarding the choices of elements and the visual elements, and will produce a new table next to Figure 1 which includes the elements, how we chose to visualize them, and a short description and key references so there is clarity in terminology. We additionally agree to not group the elements, and will separate them.*

The development steps (section 3.2) is unclear whether they are an outcome of the paper or the method to derive it. It is presented as a method (with limited justification why it is done that way), but lack insights/guidance into how the complexity of systemic risk (and the corresponding visualization) can be managed.

Authors response: *We will restructure the paper so this is now in the methodology – it was our original intention with the paper to present the method (i.e. how to make impact webs) as the result, but will change this based on both reviewers feedback. We reflect and give strengths and weaknesses into how the complexity of systemic risk can be understood and managed through the corresponding visualization and development of impact webs in the discussion section. We feel this is the best situated place for such a reflection in the paper.*

McMeekin, N., Wu, O., Germeni, E., and Briggs, A. (2020). How methodological frameworks are being developed: evidence from a scoping review. BMC Med. Res. Methodol. 20, 173. https://doi.org/10.1186/s12874-020-01061-4

Authors response: *Thank you for providing this reference. This will be useful inspiration for restructured manuscript.*