

Nhess-2020-12: Towards Resilient Vital Infrastructure Systems: Challenges, Opportunities, and Future Research Agenda

(Mehvar et al.)

Reply to the comments from Referee # 3

We appreciate the referee #3 for providing the fruitful and constructive feedback and comments. We have responded to the comments and we modified the manuscript in accordance to the received suggestions and comments. Our responses are given in blue. For all modifications affected the manuscript, line numbers are given in our responses, referring to the revised version of the manuscript which will be submitted in the next phase of the review procedure.

Comments:

This has scope to be an interesting paper and to make a useful contribution to the literature on this topic. However, in its current state I find it confusing and hard to follow. I would suggest that it is currently too long – and as such makes the points the authors wish to convey very difficult to follow. In addition to this – it is not clear [and thus non-reproducible] how the authors constructed the study and came to the points listed. Therefore, I have a number of points which the authors could consider before it is considered for publication.

Response: In response to your general comments, we would like to highlight that the paper has been undergone considerable textual and structural changes which are explained in details in our responses to your points below.

Main points:

1. While the authors introduce many competing definitions of resilience and systems [e.g. line 61-72], they do not define it within the context of this article. Given that this is for the most part a review I think it is critical that the authors define where their starting point is. It may be that this changes through the review [or the needs of future research must consider a different definition] but it is crucial that the paper starts from a solid/clear position.

Response: Thank you for highlighting this point. Addressing your comment, we added the missing definitions and elaborated the introduced concepts and definitions (briefly in the ‘Abstract’) and ‘Introduction’ sections to clarify this issue in the beginning of this paper. We also re-structured the paper and moved the definition of VIS to the beginning of the section 3. In this way we believe that the definitions of resilience concepts and systems are now clear to readers. Examples of corresponding changes are briefly as follows:

- Abstract: lines 32-34: Adding our definition of resilient VIS
- Introduction: lines 75 - 80: Including the definition of ‘systems resilience’
- Introduction: lines 84 - 97: Clarification on the definitions of the concepts: ‘Engineering resilience’ vs ‘Ecological resilience’, ‘Resilience engineering’ vs ‘Engineering resilience’

- Introduction: lines 99-102: Adding our definition of resilient VIS
- Section 3: line 179: Moving the definition of VIS to the beginning of the section
- Section 3.1: lines 215 - 219: Clarification on the terms: shocks, pressures, stresses, causes
- Section 3.3: line 310 - 326: Our descriptive definition of the ‘resilience engineering’ concept
- Section 4: Deleting Table 1 & moving the concepts/definitions (4.1) to the beginning of the section

2. Systematic review/expert opinion and examples? Methods section is inadequate in its current form.

It is commonplace within a systematic review to be clear on how many papers were included/excluded – how they were analysed [analysed for themes? themes identified etc?], and how the review leads to the structure of the results. This is not clear in this case.

Additionally, it is not clear how the expert opinion data is woven into the analysis at what stage. How were the experts targeted, what was the form of the interview; how was this undertaken, and how were the transcripts [were they recorded] analysed for themes? As it stands the methods section does not allow for method reproduction.

Finally, how were the examples chosen and analysed. By structuring this section – the result of the paper should be easier to follow.

a. How did the review go from 30000 documents to the selection of 160 literatures? How was this analysed? And synthesised?

b. Why was it not time bound? **c.** How were the 16 experts chosen – why only academic and how did they map onto the different disciplinary backgrounds?

Response: In response to this comment, we divided our responses to the two separate parts: (1) type of the paper and the interview part; and (2) literature review and selected documents.

1- With respect to the interviews, we clarify that most of the inputs that are derived from the interviews are the ones that have been collected from the interviews conducted with the co-authors of this paper who are specialized in a wide range of different fields related to the four selected infrastructure sectors. Therefore, most of the non-literature based materials included in this paper are the authors’ views who were mostly from academia (we also interviewed experts with non-academic positions). The reason for selection of mostly academic experts is because of the collaborative nature of the research project in which different faculties of the University of Twente were engaged in this project aiming to collaboratively explore the concept of resilience for designing VIS within different infrastructure sectors.

We did not cite the collected opinions in the paper, however, we included these views in agreement of (or in contradiction with) the literature-based inputs. For example, in sections 4.1-f where conceptual tensions are discussed, we analysed different opinions regarding the risk and resilience concepts (line 495), which come from the views of the interviewees. Other examples of such analysis/reflections included in this paper are as below:

- Line 423: Opinions of interviewees regarding resilience and justice issue
- Line 482: Opinions of the interviewees on “Unit of analysis”
- Line 562: Agreements between the literature inputs and opinions from the interviewees on cascading effects of failure
- Line 585: Agreements between the literature and views of the interviewees on over-confidence in the robustness of systems

- Line 592: Controversies within social and technical aspects which are derived from the interviews
- Line 619: Agreements between the opinions of the interviewees and literature on how multi-functionality of infrastructures may lead to an increase in the resilience of the system
- Line 632: Integration of the literature-based inputs with the opinions of the interviewees regarding the long time scale of action to build resilience
- Line 648: Agreements between the literature and authors' opinions on the role of trust between stakeholders for making resilience-oriented decision making
- Line 704: Agreements between opinions and literature on the importance of using system of system approach in designing resilient infrastructures
- Line 726: Opinions of the interviewees in agreement with the recent studies regarding the emerging techniques in pre/post disaster anticipation/identification
- Line 789 - 813: Presented examples of "Building with Nature" by the interviewees which are supported with the literature as referred
- Lines 907, 913, 939: Cognitive approach; team reflection, knowledge-sharing; and human-centred design, respectively, as presented approaches/measures by the interviewees supported by the literature

Notably, this paper is primarily based on the inputs from the literature, and review is the largest contribution in this paper, therefore we structured it as a 'review' paper. This implies that the reflected opinions of the co-authors have been used mainly as the inspiration for the paper and we did not aim to necessarily confront them with the literature. However, these interviews provided supplement source of inputs, which are in support or in contradiction with the literature-based materials. In addition, we would like to highlight that due to the large extent of the paper, which extensively included several concepts and approaches, more elaborations on the provided claims and opinions are excluded in this review. We believe that such an integration of the contradictory and compatible opinions/claims with the literature-based inputs would help readers to better understand the concepts, challenges, and measures in applying the resilience concept to VIS.

To clarify this issue in the paper, we revised the methodology section by excluding the terms 'interview' and 'state of the art', and thus, the 'literature review' is only presented as the main source of inputs and the methodology used in this paper. By excluding the term 'interview' and associated description, we did not make any change in the content of the paper, and we keep all the opinions and discussions as they have been already reflected, representing the paper as a 'review paper', which is enriched by relevant discussions and opinions of the authors on each concept/approach. This exclusion has led to removing all interview-related descriptions (e.g., number of interviewees, their interdisciplinary backgrounds, etc.).

2- With respect to the literature used in this paper, application of the searched keywords (mentioned in the line 156-157) resulted in selection of 160 documents in which resilience of infrastructure systems was explored by both empirical and theoretical overviews. Total number of 30,000 documents was the initial search result for the general terms, e.g., 'Resilience Engineering', and do not represent the result of searching the combined terms. To make this clear, we removed the initial search result (line 158), and only indicated the final number of documents (160) used in this paper.

Regarding your point: how the review leads to the structure of the results and (in general) to the structure of this paper, we would like to clarify that reviewing the selected literature unravel the current gaps, missing knowledge, and further development needed in the field. Therefore, having this literature review, the authors decided to ground this paper on three main cores as the title promises so: (i) conceptualisation of the resilience engineering for VIS; (ii) challenges to design resilient VIS; and (iii) potential solutions and

future research agenda. Therefore, the results are presented in current structure which are aligned with these three components of the study.

Regarding the selected examples, at the beginning of the section 5.2 (lines 976-980) it is indicated that (among the 160 literature) we included studies that have focused on initial phases of a design process (e.g., assessment or analysis of resilience) as well as studies that design, analyse or evaluate interventions to enhance resilience in the four selected sectors. Such a criteria resulted in choosing 50 studies which are sorted based on the: (i) sector; (ii) methods and approaches used; (iii) aim of the study; and (iv) type of shocks and/or pressures. The result of our paper pertaining to the selected examples are therefore derived from this basis. Given the current extent of our paper, we did not go through the details of these studies, analysis and elaboration of their results.

Inclusion of many concepts, definitions, and systems perspectives has led us to not bound this review on a certain time period. This is especially the case when introducing the concepts and presenting a short history of them. However, the paper is rather based on the inputs derived from recent literature and advancements in the field.

3. Paragraph 92-101 – this is difficult – it is very hard to follow the reasoning for the structure of this paper – I think this needs to go later [after the methods] if indeed the methods drive this as a reason for the structure?

Response: Referring to our previous response for designing the structure of this paper, we agree with the reviewer that the mentioned paragraph is not needed to be in the introduction. Since the methodology section itself presents the research questions and already gives an indication of the content and structure of the paper to address these questions, we prefer to not move the paragraph after the methodology. To avoid having such a redundancy, we removed the whole paragraph in the introduction section (line 125-134).

4. Figure three is poorly explained – why are the circles different sizes and what do them mean? Is the biggest circle supposed to be in the centre?

Response: The size of circles depends on the number of represented challenges, so the biggest one in the centre means that most of the referred challenges belong to the three systems components. Notably we did a minor modification to the figure (as shown in the revised version) in response to the other referee's comments. Regarding the provided explanation, we mainly aim to highlight the relation of each challenge to specific component(s), and given the extent of the paper, we think that the paragraph in its current form (line 675-687) clearly explains this relation.

5. Figure 4 – does this add anything to the description

Response: We believe that this schematic depiction of the engineering and non-engineering based measures to improve the five main system's capabilities provides a quick and better insight on the content of this section. In addition, with this figure we aim to shed a light on the main five VIS's characteristics (as our presented definition of a resilient VIS in this paper) and its relation to the potential measures. However, the specific relation of each measure to the system's abilities is described in the text, and is not illustrated in the figure, to not make it confusing visually.

6. Table 2 – how were these studies identified and why? I miss the logic of these specific studies being used over others.

Response: We addressed this comment at the end of our response to your point 2 (page 3).

7. By explaining the methods better, the results section could be streamlined, and the conclusions drawn more clearly.

Response: We believe that with the considerable changes we have made to the structure of the paper (e.g., added definitions for the systems and resilience concepts in the introduction section; clarification on the inputs derived from the interviews and associated changes throughout the paper; significant modifications in the section 3 and shuffling the sub-sections of this section; remove of the Table 1) now the revised version of the paper has been considerably improved in terms of the structure, and is more clear in presenting the main message to the readers. Some of the mentioned examples of changes are explained in our response to your point 2.