

Review article: current approaches and critical issues in multi-risk recovery planning of urban areas exposed to natural hazards - Soheil Mohammadi et al., 2023

Reply to reviewers' comments

Reviewer #2 (Robert Sakic Trogrlic)

Overall comment

My overall comment is that I would like to see the framing of the paper stronger at the very beginning: primarily, why urban areas? In my view, there is a need for a stronger case and I believe this could be easily added. And secondly, the multi-hazard framing needs to be stronger and come much earlier, already in the introduction. Also, how are the findings of your work unique for urban areas? Do they also reflect recovery and reconstruction beyond urban areas?

[Authors reply]

Regarding the focus on urban areas, we agree that this aspect was not sufficiently investigated in the introduction. For this reason, we have expanded the problem setting introduction to provide a more comprehensive understanding of the specific features and complexities associated with urban areas in risk management and disaster recovery. Please see the text reported in the answer to **comment C.4**.

Regarding the missing multi-risk framing, we provided more context about the multi-risk challenges in disaster recovery and the importance of adopting a multi-risk perspective in this realm, by adding some additional paragraphs in the introduction: *"When urban systems are affected by complex disaster scenarios, involving potential impact interactions, addressing the recovery process can become more complicated. In that circumstance, the system must be resilient to many types of risks, embracing a multi-risk perspective, which will introduce additional challenges in the decision-making process regarding the recovery (Curt, 2021). Multi-(hazard)-risk, as collectively named by Ward et al. (2022), encompasses all disaster risk assessment and management approaches that consider interactions or interdependencies among different hazards, vulnerabilities, or risks. These approaches are able to better capture complex risk dynamics which are increasingly impacting urban areas worldwide. The interrelationship of multiple hazards and their impacts, as well as the implications of DRM decisions on different economic sectors and regions, and the diverse impact of disaster risk reduction measures on*

different risks, make recovery in multi-hazard environments challenging (Ward et al., 2022; Hochrainer-Stigler et al., 2023). Among the different types of multi-hazard interaction mechanisms that can lead to a disaster such as compound, triggering, or cascading, (Gill and Malamud, 2014; Marzocchi et al., 2009; Tilloy et al., 2019), the occurrence of consecutive disasters is specifically challenging for the recovery process. Consecutive disasters are two or more disasters that occur in succession and whose direct impacts overlap spatially before the recovery from the prior event is considered complete (de Ruiter et al., 2020). The results of the interaction between the impacts generated by two consecutive hazards depend on the time interval between them, the rate of recovery of the system or the asset, or a combination of them (De Angeli et al., 2022; Marzocchi et al., 2012)."

Moreover, we supported these concepts by providing a real-world example that highlighted the complex challenges posed by consecutive disasters in recovery:

"As a real example in the western part of Iran, a devastating earthquake occurred on November 12, 2017, at the Iran-Iraq border, causing the death of at least 630 people (Naserieh et al., 2022). The recovery efforts began by providing temporary shelters to the more than ten thousand affected population (Omarzadeh et al., 2021). Prior to the earthquake, the country was facing a prolonged period of drought, and no one anticipated the possibility of a flood occurring within some months (Yadollahie, 2019). However, from mid-March to April 2019, widespread flash flooding occurred, affecting large areas of Iran, including the regions that were undergoing recovery from the earthquake (Miri et al., 2023). The potential occurrence of a flood was not taken into account, leading to the establishment of temporary shelters alongside canals, which resulted in the flooding of the people residing in those shelters and imposed significant economic impacts on them."

Regarding the issue of the uniqueness of our findings in relation to urban areas or their broader implications for recovery and reconstruction in general, please refer also to the detailed response provided to **comment C.19**.

In response to comment C.19, we emphasized that while our study primarily focuses on urban areas, the findings and insights that we have obtained can also contribute to a broader understanding of recovery and reconstruction processes in general. The complexities and challenges faced in urban areas, such as diverse stakeholder involvement, interdependencies, and governance issues, are often applicable to recovery and reconstruction efforts in other contexts as well.

More specific comments

(C.1) Abstract: In the problem setting, I miss a sentence referring to multi-hazards, before the introduction of the "two-aim"

[Authors reply] We agree with this suggestion, and we have included a reference to the "multi-hazard" concept in the introduction in the position you suggested:

*“Post- disasters recovery has been addressed in the literature by different sectoral perspectives and scientific communities. Nevertheless, studies providing holistic approaches to recovery, integrating reconstruction procedures and socio-economic impacts, **as well as including the additional challenges posed by the effect of complex multiple interacting risks on highly interconnected urban areas**, are still lacking. Furthermore, recovery has been only marginally explored from a pre-disaster perspective, in terms of planning and actions to increase urban resilience and improve urban systems recoverability”*

(C.2) P1 L22 more updated information available?

[Authors reply] Thank you for your valuable suggestion. We have replaced the reference with **Ritchie and Roser (2018)** to ensure a more updated and accurate citation and provided the appropriate credit.

Additionally, we have modified the term *“more than”* in the sentence to *“almost”* to provide a more accurate representation of the data and analysis presented in the study.

(C.3) P1 L27-23 Incomplete sentence

[Authors reply] Thank you for your comment. We have modified the sentence as follows:

“The origin of the modern resilience theory and its application to natural ecosystems can be traced back to Holling’s seminal work in 1973 (Holling, 1973).”

(C.4) General: perhaps use more the term *“urban areas”* rather than *“cities”* throughout the paper. What is so specific about urban areas and their hazard and risk scapes that make it particularly important to study? Please elaborate on this in your problem setting.

[Authors reply] We have replaced the term *“cities”* with *“urban areas”* in the whole manuscript.

Moreover we elaborated more about the importance and complexity of urban areas for disaster risk management and recovery, including a couple of additional sentences in the introduction. The added paragraph is as follows:

“Historically, urban areas were often considered safe refuges, shielding inhabitants from the adverse effects of natural hazards. However, a paradigm shift has occurred, acknowledging that cities are now recognized as focal points where disasters and risks converge (Šakić Trogrlić et al., 2018). The rapid expansion of urban areas often necessitates construction in locations that are susceptible to multiple hazards. This is primarily due to

limited available land or insufficient time and resources to thoroughly evaluate these areas for their susceptibility to potential interactions between multiple hazards (Jenkins et al., 2023). Furthermore, Urban areas comprise diverse elements, including physical, social, and economic components (Jenkins et al., 2023). These elements collectively contribute to the overall makeup and functioning of urban environments. Moreover, urban areas have a dynamic and unpredictable nature that arises from the interplay between people, activities, institutions, resources, and processes. Enhancing resilience in urban areas can be a complex task, considering the multitude of components, processes, and interactions occurring within and beyond the physical, legal, and virtual boundaries of the urban area (Desouza and Flanery, 2013). An analysis of previous international disaster responses reveals a preference among international humanitarian agencies to provide assistance in rural areas when disasters impact both rural and urban regions (MacRae and Hodgkin, 2016) and when it comes to recovery, urban reconstruction efforts have primarily been undertaken within the scope of national reconstruction programs, receiving limited support from international humanitarian agencies because of the complexities of the recovery process in urban areas (Daly et al., 2017). One significant challenge faced in urban rebuilding endeavors is navigating the intricate web of stakeholders involved in urban environments (Daly et al., 2017). The complexity of urban settings often involves multiple layers of governance, diverse community interests, and various private and public entities, making coordination and decision-making more intricate compared to rural areas.”

(C.5) P3 L82-83 New research directions will not “enable” stakeholders to improve decision-making per se and by themselves. Therefore, this is an overstatement, please rephrase.

[Authors reply] We have modified the sentence as follows:

"The ultimate objective is to propose new research directions that can inform stakeholders' decision-making processes and optimize their investments in the pre-disaster phase. This contribution aims to enhance the recoverability of urban areas."

(C.6) P3 L86 Perhaps this should be a separate heading and section focusing on the details of the study approach. The Introduction is currently way too long and at times difficult to follow.

[Authors reply] Thank you for this valuable suggestion. We created a separate section (Sect. 2, Methodology) where we moved the text originally reported in L.86-131. This change has allowed us to provide more visibility to the methodology on one side, but also to lighten the introduction. This last aspect has allowed us to strengthen the multi-risk aspects of the introduction by adding some dedicated paragraphs (**see**

also reply to comment C.7). Moreover, as suggested in comment **C.10**, we also included in the new section 'Methodology' a figure (Fig.1), where we graphically depicted the relationship between the identified Issues and the guiding Research Questions. The figure is attached to this document as an annex.

(C.7) General: in the Introduction, I miss the definition of multi-hazards and multi-risks and why are these crucial to be studied in the context of urban recovery and urban resilience. Perhaps also include a real-world example of that shows the completely of MH recovery? This is currently way too late in the paper.

[Authors reply] We provided more context about the multi-risk challenges in disaster recovery and the importance of adopting a multi-risk perspective in this realm, by adding some additional paragraphs in the introduction:

"When urban systems are affected by complex disaster scenarios, involving potential impact interactions, addressing the recovery process can become more complicated. In that circumstance, the system must be resilient to many types of risks, embracing a multi-risk perspective, which will introduce additional challenges in the decision-making process regarding the recovery (Curt, 2021). Multi-(hazard)-risk, as collectively named by Ward et al. (2022), encompasses all disaster risk assessment and management approaches that consider interactions or interdependencies among different hazards, vulnerabilities, or risks. These approaches are able to better capture complex risk dynamics which are increasingly impacting urban areas worldwide. The interrelationship of multiple hazards and their impacts, as well as the implications of DRM decisions on different economic sectors and regions, and the diverse impact of disaster risk reduction measures on different risks, make recovery in multi-hazard environments challenging (Ward et al., 2022; Hochrainer-Stigler et al., 2023). Among the different types of multi-hazard interaction mechanisms that can lead to a disaster such as compound, triggering, or cascading, (Gill and Malamud, 2014; Marzocchi et al., 2009; Tilloy et al., 2019), the occurrence of consecutive disasters is specifically challenging for the recovery process. Consecutive disasters are two or more disasters that occur in succession and whose direct impacts overlap spatially before the recovery from the prior event is considered complete (de Ruiter et al., 2020). The results of the interaction between the impacts generated by two consecutive hazards depend on the time interval between them, the rate of recovery of the system or the asset, or a combination of them (De Angeli et al., 2022; Marzocchi et al., 2012)."

Moreover, we supported these concepts by providing a real-world example that highlighted the complex challenges posed by consecutive disasters in recovery:

"As a real example in the western part of Iran, a devastating earthquake occurred on November 12, 2017, at the Iran-Iraq border, causing the death of at least 630 people (Naserieh et al., 2022). The recovery efforts began by providing temporary shelters to the more than ten thousand affected population (Omarzadeh et al., 2021). Prior to the earthquake, the country was facing a prolonged period of drought, and no one anticipated

the possibility of a flood occurring within some months (Yadollahie, 2019). However, from mid-March to April 2019, widespread flash flooding occurred, affecting large areas of Iran, including the regions that were undergoing recovery from the earthquake (Miri et al., 2023). The potential occurrence of a flood was not taken into account, leading to the establishment of temporary shelters alongside canals, which resulted in the flooding of the people residing in those shelters and imposed significant economic impacts on them.”

The multi-risk concept has been also strengthened in other sessions on the manuscript, by adding some dedicated paragraphs inside the discussion of Issues 1, 2, and 3, discussing more in detail:

- the difficulty of keeping DRM phases separate when dealing with multi-risk and emerging DRM models alternative to the traditional cyclic approach (Sect. 2.2)
- the exploitation of the build-back-better concept from a multi-risk perspective (Sect. 2.3)
- how multi-hazard conditions can exacerbate the communities' dilemma in balancing the need to enhance resilience against future disasters and the desire to quickly rebuild their houses and livelihoods (Sect. 3.1)
- multi-risk multi-sectoral challenges related to interdependencies among urban system components (Sect. 4)

As a consequence of this spread of multi-risk related criticalities along the manuscript, we also reorganized more effectively the section originally devoted to multi-risk (Sect. 3.2). More specifically we focused it more on the recovery requirements seen from a multi-risk perspective and we consequently renamed it as “Multi-hazard risk recovery requirements”. Furthermore, we moved some of the paragraphs into the Introduction, and added some paragraphs covering the following aspects:

- multi-risk prioritization in recovery planning
- asynergies of DRR measures implemented during reconstruction and recovery
- impact of multi-risk scenarios on the allocation of resources for recovery activities

(C.8) General: The DRM cycle is highly criticised by some researchers as the phases are not easily distinguishable and they overlap in practice. Would be useful if you would make sure this literature is included and reflected on.

[Authors reply] Thank you for your comment. We have carefully reviewed the initial paragraph of section 2.2 and made the necessary modifications. The revised paragraph now includes sentences addressing the literature on DRM criticism.

The updated paragraph reads as follows:

“The DRM cycle is widely recognized in the global DRM community as a framework for managing various types of disasters, both natural and anthropogenic (Coetzee and Van, 2012). It is characterized by separate and sequential phases with varying durations and actions. While phases' number and their naming vary in the literature, the following main ones (before, during, and after the event) can be identified: preparedness and mitigation, response, and recovery. However, the current DRM cycle falls short in effectively addressing the complexities of multi-hazard risk scenarios. The DRM cycle, characterized by separate and sequential phases, fails to adequately capture the dynamics and interaction of these multiple hazards particularly those involving both sudden-onset (e.g., earthquakes, flash floods) and slow-onset hazards (e.g., pandemics, droughts, conflicts) (Terzi et al., 2022). Consequently, numerous authors have proposed alternative frameworks for DRM, challenging the current circular representation (Bosher et al., 2021; Staupe-Delgado, 2019; Terzi et al., 2022). Despite the aforementioned considerations, the conventional DRM cycle continues to prevail as the predominant discourse within the realms of decision makers, practitioners, and the academic community focused on disaster risk and it is used as a reference for the current research.”

(C.9) P4 L113 Was there a combination of keywords used and if yes, what combinations?

[Authors reply] We did not use keywords in a combined way since some of them were already composed of more than a single word.

(C.10) General: I strongly advise creating a figure that will represent your literature searcher and selections and a series of research issues mapped against your objectives. It will aid the clear overview of the paper and make it easier for your reader.

[Authors reply] We added a figure (Fig.1 in Sect.2, Methodology), where we graphically depicted the relationship between the identified Issues and the guiding Research Questions. The figure is attached to this document as an annex.

(C.11) P5 L151: Nice distinction, however, a dated reference. I am wondering if there is anything more up to date?

[Authors reply] We appreciate your suggestion to include an additional, up-to-date reference in the manuscript. We have now included the reference to **Ryan et al. (2016)** to provide a more comprehensive and current perspective on the topic.

(C.12) P7 L194: Perhaps add "recovery" before "socio-economic activities"

[Authors reply] We have added the term according to your suggestion.

(C.13) Figure 1: Great figure and very clear! Was this based on some inputs from a literature as there are not references in the figure? Fine if not, but wondering about the description of the figure in the text: I would expect some references as it is a review paper?

[Authors reply] Thank you for your comment. We apologize for any confusion regarding the origin of the figure. We would like to clarify that the figure was developed by the authors based on the existing literature in the field. To ensure proper attribution, we have added references to the description of the figure in the text. This allows readers to understand the sources that informed our conceptualization and representation. The updated description paragraphs reads as follows:

"In an ideal recovery process, the intensity of physical reconstruction and socio-economic recovery activity remains at their maximum level during the recovery time to maximise the functional recovery zone. However, this would be very challenging. As will be discussed in Sect. 2.2, resource allocation and concentration on the disaster area will not remain constant during the whole recovery period. External support would decline, and the intensity of reconstruction activities could decrease (Choi et al., 2019). Nevertheless, because socioeconomic recovery is dependent on physical structure (Barakat and Zyck, 2011; Mitsova et al., 2019), the intensity of related recovery activities may be raised with the repair of some of the damaged facilities, while at the initial stage of the recovery, it might not be so high due to the damaged structures and infrastructures.

As shown in panel (b) of Fig. 1, by increasing the intensity of socio-economic recovery activities, the common zone (functional recovery) could be preserved or even increased during the recovery period. Furthermore, the intensity of socio-economic recovery activities could be increased without external support in a disaster-struck community (Alifa and Nugroho, 2019). These cooperatively evolving activities enable people to take part in the restoration of their communities independently (Nigg, 1995; Talbot et al., 2020; Perce, 2007). For instance, as more enterprises of all sizes become involved in the economy, people will be more capable of actively participating in the economic recovery of their community (Freeman, 2004). Setting this balance between physical reconstruction and socioeconomic recovery would be possible if the disaster area needs assessment (see Sect. 4.13) is considered."

(C.14) P9 L229: The fact that the phases should be separate. This could be problematic – please see my comment above on the criticism on the DRM cycle.

[Authors reply] We agree that phases cannot always be easily separated and that in some cases it can be necessary to adopt a more fuzzy approach compared to the traditional DRM cycle with consecutive, well-defined, and separate phases. Nevertheless, understanding the relationship between them still remains crucial, specifically considering the relationship between short-term response actions and long-term recovery efforts (see Sect. 2.2, L. 230-233: *“However, it should be noted that experience indicates that addressing the short-term requirements of affected populations during the response phase has an influence on meeting the needs of the population during long-term recovery and addressing these two types of needs should be done in an integrated way (Garnett and Moore, 2010)”*)

Nevertheless, we agree that the sentence reported at L229 was misleading and we eliminated it from the manuscript.

Moreover, in line with this perspective, we also changed the title of one of the ten final key challenges (Challenge number 5) discussed in Sect. 5., replacing the word “distinction” with “relationship”:

5. The current literature does not establish a clear relationship between the response and recovery phases.

(C.15) General: The paper has a lot of very long paragraphs that sometimes make the reading a bit challenging. I suggest editing this throughout the paper, shortening and separating thoughts per paragraphs where possible.

[Authors reply] To improve the flow of the text, we checked the overall manuscript and reorganized the sentences into coherent paragraphs, avoiding having too small or too long paragraphs.

(C.16) P13 L350-355 Really interesting! Any further explanation on why? Perhaps do reflect on the literature on the role of politics and electoral cycles- even with a reference or two.

[Authors reply] Thank you for your suggestion. We have carefully considered your comment and have added the following paragraph to address the issue of the electoral cycle in decision-making regarding the recovery process:

“During an electoral cycle, politicians often display a tendency to prioritize physical reconstruction efforts over socio-economic recovery. This preference entails a stronger focus on rebuilding infrastructure and physical structures, driven by political motivations

to demonstrate tangible progress and garner public support (Masiero and Santarossa, 2021)."

We believe that this addition enhances the discussion by addressing the role of the electoral cycle in decision-making during the recovery process. Thank you for bringing this important aspect to our attention.

(C.17) P13 L366 on community involvement – I truly enjoyed reading this part of the paper. However, what I miss is mentioning the need for community involvement in pre-disaster planning, also getting input and community priorities into the recovery and reconstruction plans.

[Authors reply] Thank you for your positive feedback. We appreciate your recognition of the importance of community involvement in recovery planning during the pre-disaster period. We agree that this is a crucial aspect that deserves attention. We have made the following additions to highlight its significance, and to exemplify the significance of community involvement in the pre-disaster we present a real-life case study of the aftermath of Hurricane María in Puerto Rico.

"Pre-disaster community involvement in recovery planning and social organization plays a pivotal role in enhancing the community's capability to leverage its capacities, particularly its social capacity, to effectively address challenges in the aftermath of a disaster and actively engage in the recovery process. Social organization through the involvement of different stakeholders in pre-disaster planning significantly contributes to the successful implementation of recovery plans and facilitates the realization of post-disaster recovery efforts (Delilah Roque et al., 2020).

An illustrative example of the significance of social organizations can be observed in the aftermath of Hurricane María in Puerto Rico. During this time, social organizations played a crucial role in coordinating and addressing the comprehensive needs of the community. Despite the island-wide power outage, these organizations became vital hubs where community members could come together to organize, support one another, and address the challenges faced. Their pre-disaster planning efforts and established networks allowed for effective coping mechanisms and resource allocation, even in the absence of immediate access to personal finances held in banks (Delilah Roque et al., 2020)."

(C.18) Table 3: it mentions seven publications in the table title, while four are listed.

[Authors reply] Thank you for pointing out the mistake in reporting the number of publications in the manuscript text. We apologize for the error and have made the necessary correction.

(C.19) Section 5: Which of these are specific to urban areas and which in general to recovery and reconstruction?

[Authors reply] The present research addresses the recovery issues associated with multi-hazard events in urban environments, taking into account the complexity of urban systems, their diverse goals and perspectives, and the heterogeneous stakeholder involvement. The final section of the manuscript integrates and summarizes the challenges discussed throughout the paper. This serves as a background for identifying future research needs in the field, providing the key findings and take-home messages of the current study. As a result, it can be claimed that the urban system could be affected by all of the challenges outlined, and all of the challenges are associated with urban areas. Nevertheless, it is important to note that while all the challenges outlined primarily pertain to urban areas, some of them could also be applicable to the recovery processes in other contexts, such as rural settlements. Specifically, certain challenges directly highlight urban aspects, such as challenge number 7, which emphasizes the need to view disasters as opportunities to enhance the resilience of *"urban systems"*. Additionally, challenge number 10 underscores the significance of understanding the socioeconomics and interdependencies among various *"urban assets"* or sectors within the *"urban system"*. In challenge number 2, the term *"urban area"* is added to emphasize the heterogeneity of the stakeholder groups involved in *"urban systems"*.

We highlighted this concept in the conclusions adding the following sentence:

"The outcomes of this critical literature can set the basis to outline the key research directions in the field of multi-risk disaster recovery and urban resilience. Nevertheless, it is important to note that while all the challenges outlined primarily pertain to urban areas, some of them could also be applicable to the recovery processes in other contexts, such as rural settlements."

Annex 1

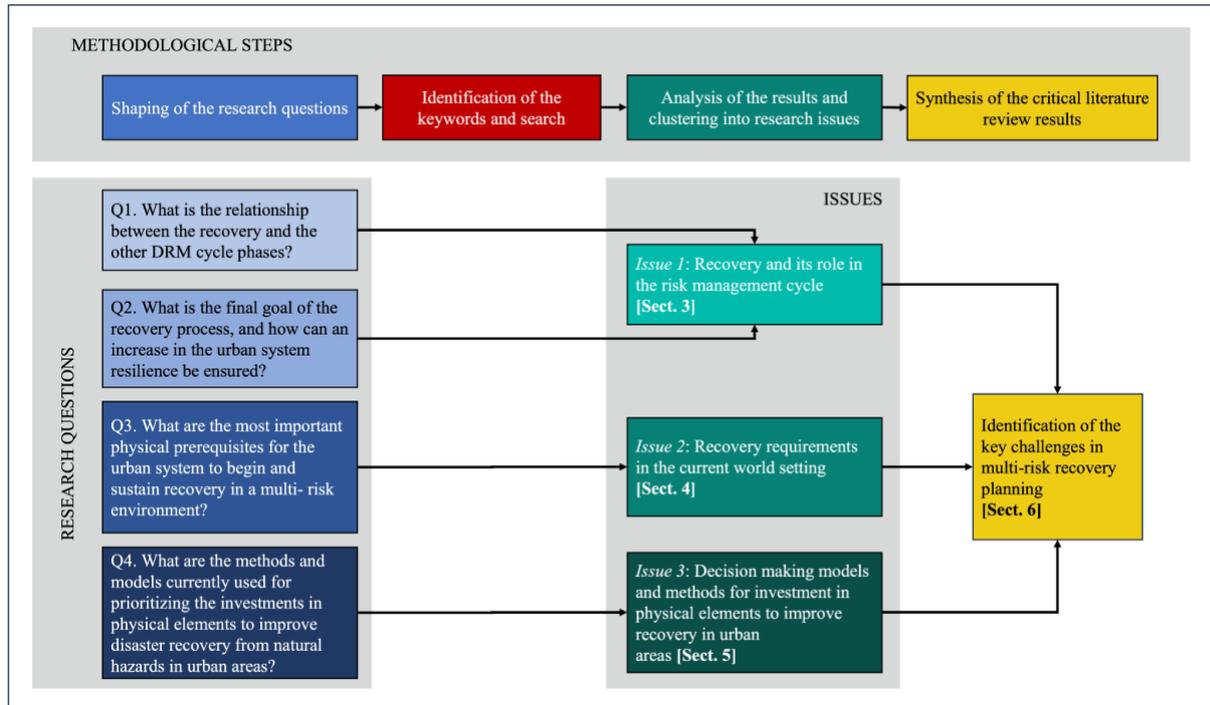


Figure 1. Graphical representation of the methodological steps implemented to perform the critical literature review on multi-risk recovery planning, highlighting the relationship between the guiding Research Questions and the multi-risk recovery planning Issues