

# Reply to the Reviewer

Re: Manuscript ID Preprint egusphere-2025-262

“Review article: *Rethinking Preparedness for Coastal Compound Flooding: Insights from a Systematic Review*”

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## Response to Reviewer 1

We would like to thank Professor Cosmina Albulescu for providing a rigorous and insightful review that helped us identify key areas for improving the focus and conceptual consistency of the manuscript. Each of her comments has been carefully considered, and we describe below how they will be addressed in the revised version.

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## Review Report

The review paper called “*Rethinking Preparedness for Coastal Compound Flooding (CF): Insights from a Systematic Review*” aims to explore how preparedness strategies are growing to be more integrative and how governance and stakeholder collaboration enhance adaptive approaches. The paper can contribute to the literature on coastal compound flooding preparedness upon undergoing some terminology corrections and restructuring. My main concern relates to the unclear differentiation between drivers and hazards, which results in considerable and recurring confusion in the manuscript. This issue may have introduced uncertainty into the search and filtering protocol in the literature review.

I commend the authors on their research efforts. Please find below the review comments aimed at enhancing the clarity and impact of the paper.

We acknowledge that some inconsistencies in wording may have led to confusion between “drivers” and “hazards.” However, the review is conceptually grounded in the typology proposed by Zscheischler et al. [2020], where compound events arise from combinations of multiple climate drivers and/or hazards. In the case of coastal compound flooding, this distinction is operationalized through the interaction of physical drivers (e.g., rainfall, storm surge) that give rise to a hazard (e.g., flooding).

Our study focuses specifically on climatic drivers, given their increasing relevance in the context of climate change and their central role in compound event analysis. As further detailed in a later response, this focus also justifies the exclusion of events such as tsunamis, whose non-climatic origin, limited predictability, and distinct generation mechanisms fall outside the analytical scope and methodological foundation of this review.

Following this framework, our search and filtering protocol was specifically designed to capture the literature addressing the interacting nature of these drivers and their contribution to flood hazard in coastal environments. To improve clarity and avoid ambiguity, we will revise the manuscript to explicitly define these terms early in the Introduction, citing the underlying literature that informs this distinction. Terminology will also be carefully reviewed throughout the manuscript to ensure consistency with this established typology.

## Abstract

- The reader should be provided with the number of reviewed studies, as well as some details about them (time period, spatial scope, for instance).
- The findings noted at lines 13–20 should be reframed to be more coherent, as they currently miss a red thread.

- The aim noted in the Abstract differs from the one stated in the Introduction (“This review explores how preparedness strategies are evolving to integrate technical, environmental, and social dimensions while evaluating the role of governance and collaboration in enhancing adaptive approaches.”). It is unclear to me what type of preparedness (against what) do the authors investigate. Adaptive approaches to what? The framing here is rather vague.
- Line 9: the drivers listed here are actually hazards (except for river discharge, which is not even a driver).
- Line 10: sectoral silos is an unclear term.

The abstract has been revised to include the number of reviewed studies, their spatial and thematic focus, and to ensure consistency with the aim stated in the Introduction. It defines the type of preparedness that we are reviewing—strategies targeting compound flooding in estuarine and coastal areas— and clarifies that adaptive approaches refer to measures addressing interacting climate-related drivers. The distinction between drivers and hazards has been clarified to follow current compound event literature. The findings have been reorganized to improve coherence and narrative flow, and the term “sectoral silos” has been replaced with “limited cross-sectoral coordination”, as referred to in the literature to describe institutional fragmentation that limits integrated responses (e.g., Oseland [2019]; Sakic-Trogrlic and Hochrainer-Stigler [2024]).

The revised version, incorporating these adjustments, now reads as follows:

*Tackling the growing risks of Compound Flooding (CF) requires transformative preparedness strategies, particularly in estuarine and coastal regions, where interaction of climatic drivers such as storm surges, rainfall, and river discharge exacerbates impacts. Despite progress, fragmented governance, limited cross-sectoral coordination, and insufficient integration of scientific insights hinder effective responses. This systematic review draws on 49 studies covering estuarine and coastal regions globally to explore how preparedness strategies are evolving to integrate technical, environmental, and social dimensions while evaluating the role of governance and collaboration in enhancing adaptive approaches. Hybrid early warning systems combining statistical and hydrodynamic models with real-time data are critical for forecast accuracy and timely decision-making. Similarly, balanced implementation of green, blue, and gray infrastructure provides sustainable responses, with nature-based solutions complementing traditional engineering. Our results also show that strengthening governance and communication is essential to improve preparedness. Involving communities in land-use planning, building regulations, and communication ensures measures are both actionable and context-specific. Incorporating psychological and behavioral insights into preparedness frameworks helps translate awareness into proactive, effective actions. Enhanced coordination across sectors and levels of government is also vital to addressing the systemic nature of CF risks, moving beyond siloed, single-hazard responses.*

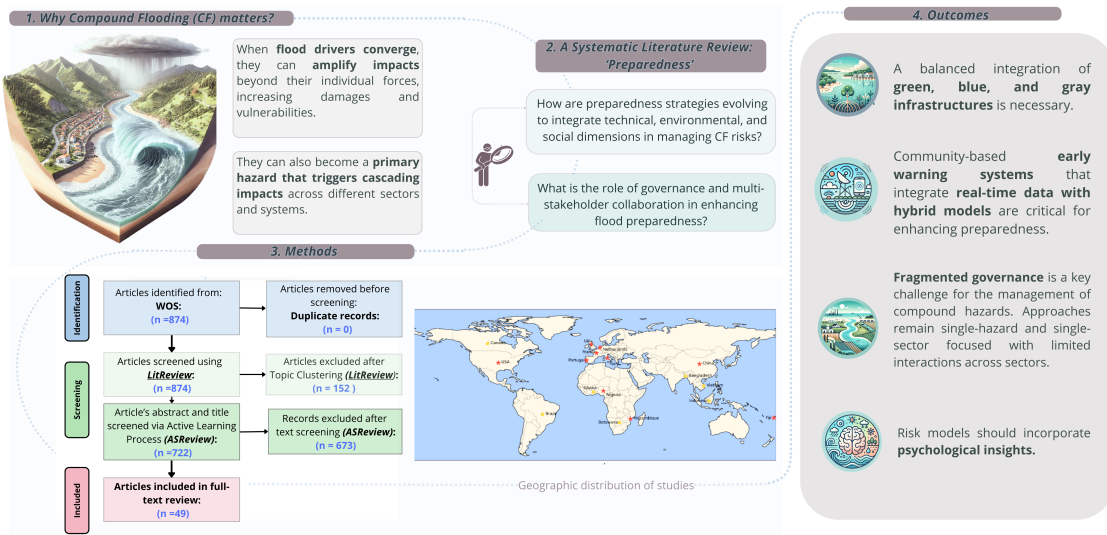
## Graphical abstract

- What do the authors mean by “a primary hazard that triggers ripple effects”? Isn’t this phrasing redundant with cascading impacts?
- I recommend reordering the outcomes based on their importance. The current order seems rather random.

The expression “a primary hazard that triggers ripple effects” has been revised to avoid redundancy with the concept of cascading impacts and to improve terminological precision.

While we acknowledge the suggestion regarding the ordering of outcomes, we consider these elements to represent interdependent pillars of preparedness rather than a strict hierarchy of importance. Nevertheless, minor adjustments have been made to improve narrative flow and thematic coherence in the graphical abstract, as shown below:

# Rethinking Preparedness for Coastal Compound Flooding: Insights from a Systematic Review



## Introduction

- Line 26 (“The greatest risks from a changing climate may not come from individual impacts”) contains a logical error considering the terminology of impact and disaster risk as proposed by UNDRR. Please revise the definitions of these terms and modify accordingly.

We have revised the sentence to align with the terminology used in the UNDRR framework and in recent compound event literature (e.g., Zscheischler et al. [2020]), which emphasizes the interaction of multiple drivers and/or hazards.

The updated version reads:

*“The greatest risks from a changing climate may not arise from single hazards, but from the interaction of multiple climatic drivers or hazards that challenge existing response capacities.”*

- Line 27: What are intersectional vulnerabilities? The term is rather confusing in this context.

The use of the term “intersectional vulnerabilities” follows the framing adopted by Simpson et al. [2023], where risks from a changing climate are described as emerging from the nexus between compound hazards, exposures, and overlapping forms of vulnerability. In this context, “intersectional” does not refer to a specific theory or framework, but rather captures the way in which multiple social, economic, and geopolitical factors combine to shape differentiated levels of risk. We use the term to emphasize that vulnerability to compound flooding is not evenly distributed, but is often amplified for those at the intersection of disadvantage. Given that the phrasing is directly aligned with the cited source and captures a key dimension of risk complexity, we consider its inclusion appropriate and meaningful in this context.

- The authors should clarify from the beginning what they call a driver. Is this term interchangeably used with hazard, as shown at lines 29 and 40? I do not recommend using them as synonyms, but to always clearly specify if they refer to a hazard or the driver (of what, of CF as a hazard)?

As Prof. Abulescu rightly points out, it is essential to distinguish between drivers and hazards. Following the terminology proposed by Zscheischler et al. [2020], we will clarify in the revised manuscript that our work focuses on climatic *drivers*, as the underlying meteorological, hydrological, or oceanographic conditions—such as heavy rainfall, storm surge, and river discharge—that may act independently or in

combination to give rise to a hazard. *Hazards*, in contrast, are the resulting events with the potential to cause damage—such as compound flooding in coastal and estuarine areas, where the multiple climatic drivers interact and exceed natural or built drainage capacities.

Coastal areas encompass a wide range of geomorphological settings, including beaches, cliffs, estuaries, and deltas—zones where both marine and terrestrial processes converge. In such environments, the occurrence of flooding is not solely driven by marine conditions (e.g., storm surge or high tide), but also by land-based contributions such as river discharge.

We will include this distinction early in the manuscript and ensure consistent terminology throughout.

- **I recommend rephrasing the research questions in a clearer way (1st question – dimensions of what?; 2nd question is rather blurred and it is not a question per se). Reaching the Methodology section, I see that the questions are clearly formulated here, but they should also be written like this in the Introduction.**

We appreciate Prof. Abulescu’s observation regarding the formulation of the research questions. In the revised version, we will reword the questions in the Introduction to reflect the more precise and structured version already presented in the Methodology. The first question will explicitly state which dimensions are being addressed, and the second will be reshaped into a proper interrogative form with a more defined scope. These changes will contribute to a more consistent and well-structured narrative throughout the manuscript.

The updated paragraph in the Introduction will read as follows:

*This paper conducts a systematic literature review to critically examine how climate risk management practices are evolving to address the intricate challenges of compound flooding in coastal areas—regions where the interplay of vulnerabilities and flood drivers increases risks. The analysis centers on two guiding research questions:*

- i) How are preparedness strategies evolving to integrate technical, environmental, and social dimensions in managing compound flood risks?*
- ii) What is the role of governance and multi-stakeholder collaboration in enhancing flood preparedness?*

*By addressing these key issues, this study seeks to contribute to the development of adaptive frameworks that strengthen resilience and improve preparedness in the face of complex and evolving CF risks.*

- **The authors do not specify how gaining answers to the 2 proposed research questions will contribute to the development of adaptive frameworks: “By addressing these critical issues, this study seeks to contribute to the development of adaptive frameworks that strengthen resilience and enhance preparedness in the face of complex and evolving CF risks”.**

To address this point, the revised manuscript will include a brief paragraph specifying how the two research questions contribute to the development of adaptive frameworks. The analysis sheds light on the operational, institutional, and socio-environmental conditions that influence preparedness efforts across coastal contexts. By examining how these dimensions are addressed (RQ1) and how governance and collaboration mechanisms support them (RQ2), the study identifies gaps, enabling factors, and practices that inform the evolution of preparedness. Instead of proposing a universal model, the contribution lies in highlighting the key elements that shape adaptive strategies and in offering insights to support more flexible, integrative, and context-sensitive approaches to compound flood risk.

## Methodology

- **Line 163–164: “By examining these integrations, we assess how well they address the complex and compounding risks associated with multiple flood drivers.” – what does this assessment involve? Is there a clear framework for assessing the degree to which the listed elements address the CF risk involving multiple flood drivers?**

The revised manuscript will specify that the assessment is interpretive in nature, based on a close examination of how each study approaches the integration of technical, environmental, and social components in relation to compound flood risk. Rather than applying a predefined framework, the analysis builds on recurring patterns and tensions across the literature to explore how integration is framed, where it is advanced, and where it remains limited or implicit.

- **Upon reading section 3.1., it is unclear to me the time period targeted by this literature review.**

We acknowledge that the time period covered by the review was not clearly stated. The search did not impose a restriction on the starting year; all records available in the Web of Science (WoS) database up to September 2024 were considered. In the revised manuscript, this will be made explicit in Section 3.1. The paragraph will now read:

*“... To identify relevant studies, we carried out a systematic search in the Web of Science (WoS) database, applying a multi-layered strategy aimed at capturing research related to preparedness for compound flooding in coastal areas, with a particular focus on community resilience and risk management. This approach was informed by previous reviews on similar topics (Kuhlicke et al., 2023; Sun et al., 2024). No lower date limit was applied; all records available in the WoS database up to September 2024 were included in the review. The search was organized ...”*

- **Please check Table 1 for typos.**

Table 1 will be carefully reviewed, and any typos or inconsistencies will be corrected in the revised version.

- **Why were studies on tsunamis (“disasters such as tsunamis and earthquakes, which were beyond the scope of this work”) beyond the scope of this work, if they related to preparedness for such hazards?**

The updated document will make explicit that studies on tsunamis were excluded because they are not aligned with the analytical scope of this review. As noted by Hendry [2021], tsunamis are of geophysical origin and do not result from the interaction of climate-driven processes, which is the core focus of compound flooding events considered here. Their exclusion is not based on relevance to preparedness in general, but on the need for conceptual consistency: the review targets flood risks arising from the conjunction of meteorological, hydrological, and oceanographic drivers linked to climate variability and change. Including tsunamis would compromise the coherence of the framework and the comparability of the selected studies.

- **Is the exclusion process described at lines 205–210 mainstream for literature reviews in flood preparedness? Is this method sound enough to correctly identify the papers that did not align with the objectives of the review? To me, the procedure sounds rather inconsistent and relevant studies may have been removed from the pool. Perhaps list this as a methodological limitation.**

We will provide a more explicit and robust justification of the exclusion process. This procedure combined topic modeling with expert judgment to refine the initial pool of articles. Using the Python-based tool Litstudy for trend visualization, we generated word clouds to identify prominent terms across the dataset. This helped us pinpoint thematic clusters that, despite matching the search strings, were conceptually misaligned with the scope of the review. For example, terms such as “oil” and “surfactant” were associated with studies on petroleum extraction, while others like “seed bank” and “germination” pertained to plant physiology research in coastal ecosystems. Upon further inspection, these studies were excluded as they did not address compound flooding or preparedness strategies.

To ensure transparency, the revised manuscript will include the complete refined search query along with the terms that were excluded. The following terms were removed from the search in the Topics (TS) field due to their lack of relevance to the review’s objectives:

*earthquake, species, tsunami, seed bank, habitat, germination, mangrove, irrigation, lake, soil, bank, food insecurity, organic matter, trees, sediment, dam, ice jam, drought, groundwater, energy*

The exclusion process will be acknowledged as a methodological limitation, as it involved some interpretive judgment. However, we believe that tools like Litstudy are extremely useful when dealing with large amounts of bibliographic data. These tools help identify patterns and inconsistencies that might not be easily detected through manual screening alone. This approach ensures that the analysis stays focused on the key topics of compound flooding risks and preparedness strategies.

- **What were the relevant and irrelevant records that served as the foundation for training the first machine learning model?**

The relevant and irrelevant records used to train the first machine learning model in ASReview were initially identified through random selection, as provided by the tool itself. For the training phase, 34 records were manually labeled by the researchers, with classification based solely on the abstracts. Only the abstracts were presented, while the titles were withheld, ensuring that the classification process was based on more comprehensive information rather than potentially misleading or incomplete titles.

Once the initial set of records was labeled, the machine learning model began automatically selecting and presenting additional records for classification. As the researcher labeled more records, the model iteratively improved its ability to identify relevant studies, progressively focusing on the most pertinent literature. In total, approximately 40% of the articles retrieved from Web of Science were screened through this process.

## Results

- **Line 261: Social Sciences should also be written with capital letters.**

Thank you for pointing that out. *Social Sciences* will be corrected to uppercase in line 261.

- **Figure 3: I recommend replacing this polar chart with another type of representation. Such charts are harder to read, and the same information can be conveyed in more classical and clearer ways.**

The figure has been revised to replace the polar chart with a clearer representation. The updated version, shown below, presents the same information in a more straightforward and readable format to enhance clarity.

- **I would like to see a more extensive explanation of this point: “This notable growth in scientific attention after 2012 aligns with a broader shift in natural hazard research paradigms, particularly following significant developments in climate risk frameworks.”**

In response to the reviewer’s request, the revised manuscript will expand on how scientific focus shifted after 2012, particularly with the introduction of “compound events” in the IPCC’s 2012 SREX report. This shift reflects broader changes in natural hazard research and climate risk frameworks.

- **“The surge in publications, particularly after 2015, coincides with the growing recognition of the need for integrated approaches that address the complexities of compound flooding and other interconnected hazards” – this can be linked with the Sendai Framework.**

Thank you for your comment. The surge in publications since 2015 is indeed linked to the growing recognition of the need for integrated approaches to complex hazards like compound flooding. This fact aligns with the Sendai Framework for Disaster Risk Reduction (2015-2030), which emphasizes multi-hazard strategies. We will explicitly highlight this connection in the revised manuscript.

- **I advise the authors to draw another timeline figure identifying the key trends discussed in section 4.1. The 0x is temporal, and the rest includes the emergence of key trends (start and end points). This figure can help the reader identify the diversification tendencies and the**

introduction of new terms (e.g., compound events, compound effects, multi-hazard) more readily, and it would make a valuable addition to the already rich and high-quality material in this paper. The figure can also include a similar design for the details in sections 4.2.

A timeline figure will be included to show how key concepts discussed in section 4.1 have emerged and evolved over time, including shifts in terminology and focus. A second panel will reflect the main research directions outlined in section 4.2.

- **Table 2: there is no need to separately provide the year. The reference alone looks neater. I also think the caption of the table should provide some details on the methodology of eliciting the key topics.**

The inclusion of the year in the reference format was an oversight and will be corrected to reflect the proper reference style. Additionally, the caption of Table 2 will be revised to include a more detailed description of the methodology used to elicit the key topics.

- **Figure 6: I recommend replacing the pie chart with another type of chart. It is well known that pie charts are misleading and harder to read for most people. Also, on the bar chart, please replace the Count on Y with a more appropriate label.**

We will replace the pie chart with a more suitable visualization. Additionally, the Y-axis label on the bar chart will be updated to more accurately reflect the data.

- **Figure 7: Please improve the readability of the text in this picture. Providing some contrasting background for the text would be beneficial to the reader.**

In response to the comment, we will also increase the font size and adjust the text formatting to further enhance readability. Additionally, we will make sure that the text is clear and well-contrasted against the background.

## Conclusions

- **What is understood here by systemic vulnerability and systemic risk? The authors should clearly define these terms (also used in the Conclusions and throughout the text) in the introductory part.**

The concepts of systemic vulnerability and systemic risk will be explicitly defined in the revised introduction. In line with Weir et al. [2024], systemic vulnerability refers to the susceptibility of interconnected systems to disruption under external stress, driven by interdependencies among their components, while systemic risk captures the potential for such disruptions to propagate across systems, triggering cascading and large-scale impacts. Armaş et al. [2025] further conceptualize systemic vulnerability as the enduring core of vulnerability that persists across time and space, regardless of mitigation efforts, and has the potential to reinforce future impacts or obstruct adaptation processes. These definitions will be used consistently throughout the manuscript to clarify their relevance in multi-hazard and dynamic risk contexts.

- **Line 551: complex interactions of what?**

The sentence has been revised to specify the meaning of "complex interactions," now framed as the interplay among physical processes, socio-institutional dynamics, and evolving conditions within coupled human–natural systems.

Revised sentence (line 551):

*Cascading impacts, non-linear climate feedback, and systemic vulnerabilities demand adaptive frameworks capable of anticipating complex interactions among physical systems and socio-institutional structures.*

## Additional comments

I recommend adding a dedicated Reflections section to consolidate the paper’s key contributions. It can be placed after Results. This section should include clear answers to the two research questions and compare insights on CF preparedness with preparedness for other hazards influenced by climate change (in terms of frequency, intensity). By critically discussing these findings, this section would serve as the intellectual “heart” of the paper.

As suggested, the revised manuscript will include a Reflections section after the Results. This section will revisit the two guiding research questions and draw together the main insights from the review, while also acknowledging the uncertainties, tensions, and limitations that persist in the field of compound flood preparedness. Rather than offering definitive answers, it will propose a set of considerations that may help inform future research and practice—such as the importance of addressing governance fragmentation, incorporating behavioral dimensions, and exploring ways to make integrative strategies more actionable across diverse contexts. The aim is to close the manuscript with a structured synthesis that consolidates the findings and suggests potential directions for further work.

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