Reviewer 1

本文探討了一個重要且迫切的議題：洪水風險評估中動態脆弱性的方法論處理。文章對67篇研究進行了系統性的綜合分析，並提出了一個有用的方法分類系統。此議題對於推動風險研究超越靜態概念化具有重要意義。然而，在本文充分發揮其潛力並正式發表之前，仍有一些方面需要進一步闡明和完善。以下列出一些建議：// Deepl-Translation: This paper examines an important and pressing issue: the methodological treatment of dynamic vulnerability in flood risk assessment. The paper conducts a systematic synthesis of 67 studies and proposes a useful classification system for methodologies. This topic is of significant importance for advancing risk research beyond static conceptualisations. However, before this paper can realise its full potential and be formally published, there are still some aspects that require further clarification and refinement. The following recommendations are outlined below:

We want to thank the reviewers for the reviews provided. We appreciate the time the reviewer took to offer their reflection on the paper. We are glad that the reviewer finds our study relevant and timely. We addressed their feedback to sharpen the paper's scope and narrative. The main changes are the following:

- We added an additional figure and brief discussion of the geographic representation of the studies and the annual cumulated count of studies.
- We added a figure in the methods section to transparently report on the process of identifying the relevant studies.
- We extended the discussion regarding the limitations and opportunities of specific methods for the assessment of vulnerability and refined the conclusion to be more to the point.
- We streamlined terminology and checked in-text citations throughout the manuscript.
- Additionally, we added 6 studies which have been suggested as relevant by an earlier reviewer of this manuscript. These studies do not change the overall narrative or key conclusions drawn and discussed in the originally reviewed draft of this manuscript, but offer more various insights into application contexts and learnings regarding dynamic vulnerability. As a result, the paper now covers 73 studies instead of 67.

As no one on the co-author team was proficient in Chinese to translate/respond to the comments in this reviewer's language, we relied on Deepl, a state-of-the-art online translation tool. We hope that the translations which are provided for reference below capture the nuances and meaning intended by the reviewer and are available to modify further in case of misinterpretation/translations.

Below, we have provided point-by-point responses in blue. When changes to the manuscript were made, we copied the relevant paragraphs and underlined the modified text. If references to lines are provided, they are based on the original manuscript, not the revised version, to facilitate tracking of the context in which changes were implemented.

1. 許多關於洪水脆弱性的綜述文章都明確報告了所評述研究的地理分佈，鑑於脆弱性與具體情境的密切相關性以及全球數據可用性的不均衡，這一點尤為重要。我建議添加一張圖表，概括這67項研究的地理分佈（例如，按洲、國家或收入水平劃分）。這將有助於讀者更好地評估研究的代表性和潛在的區域偏差，並進一步增強文章的說服力。// Deepl-Translation: Many review articles on flood vulnerability explicitly report the geographical distribution of the studies they examine; this is particularly important given the close link between vulnerability and specific contexts, as well as the uneven availability of global data. I recommend adding a figure summarising the geographical distribution of these 67 studies (e.g., by continent, country or income level). This would help readers better assess the representativeness of the studies and any potential regional biases, thereby further strengthening the article's persuasiveness.

R1: We thank the reviewer for this suggestion, and added a new figure and some contextualization paragraphs at the beginning of section 4 as presented in the following:

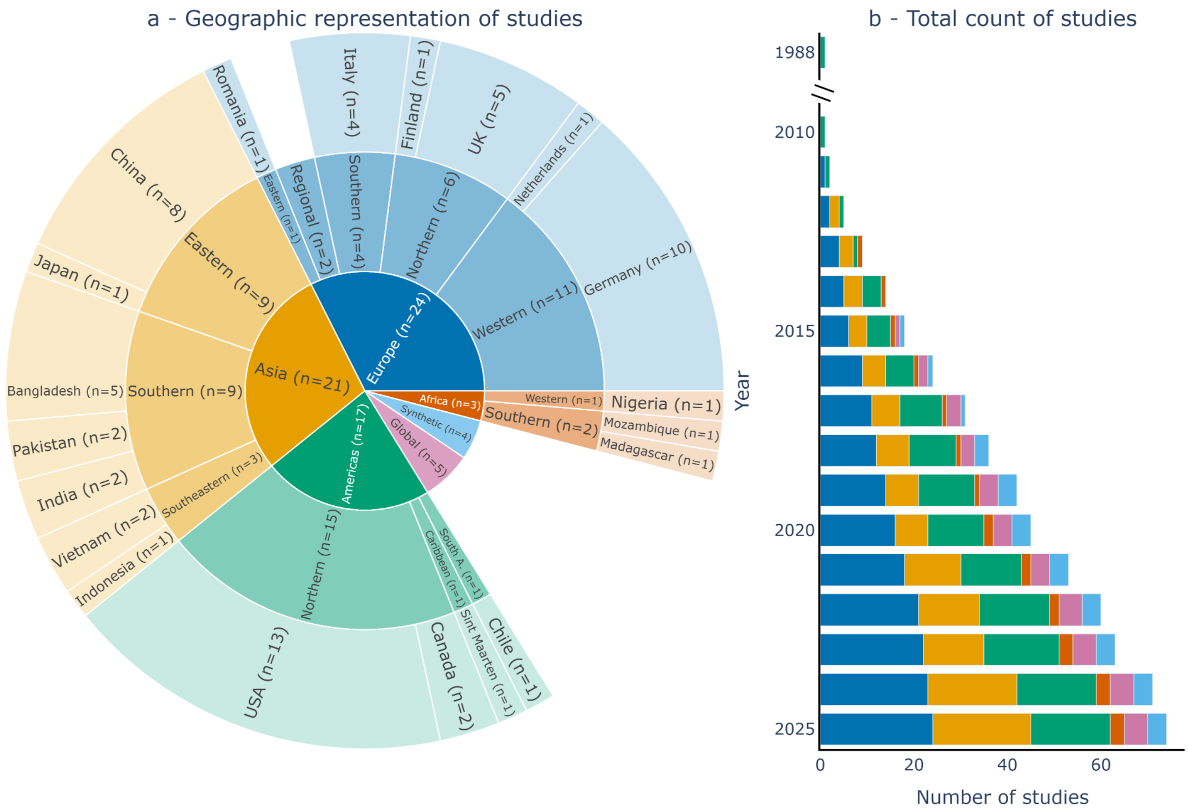
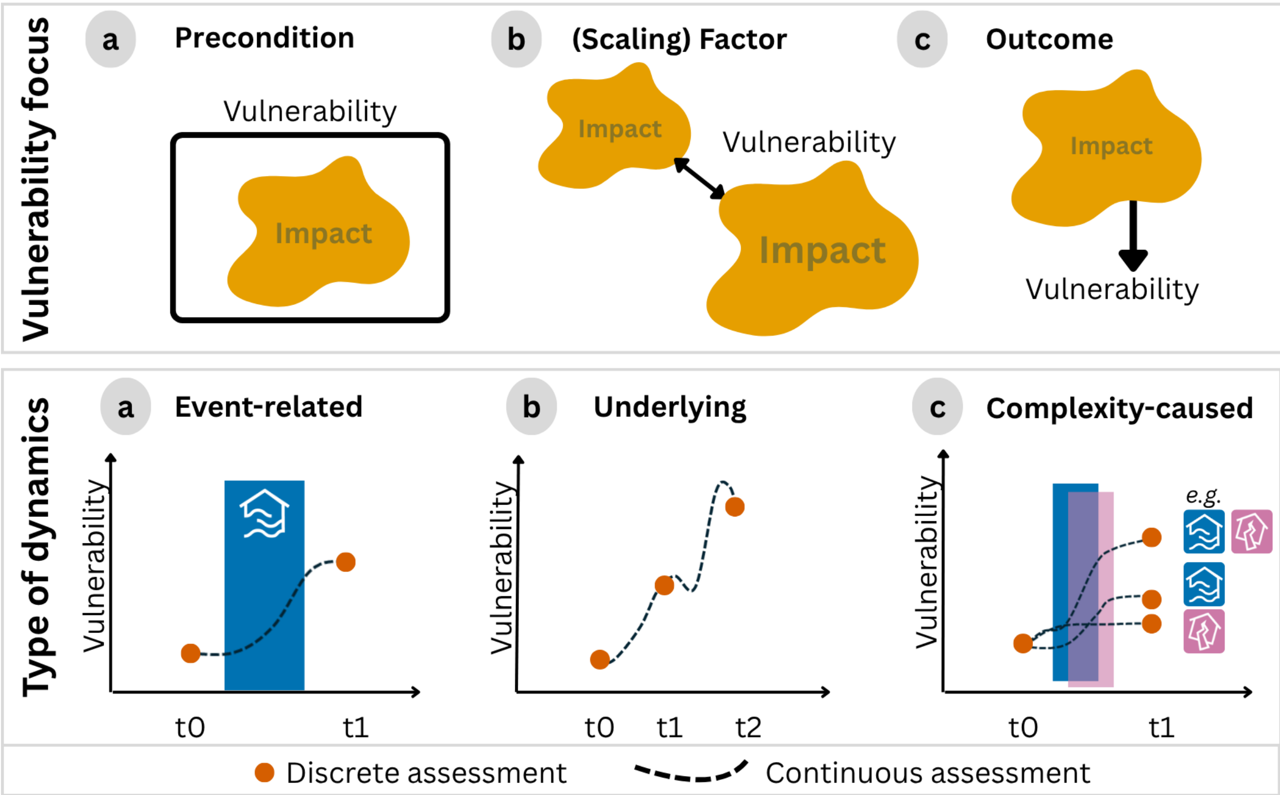


Figure 2 (new): a: Geographic distribution of studies included in the review. Studies are grouped by continent, regions (following the United Nations geoscheme) and country. Some studies were not limited to one specific continent or country and were thus applied on a global or regional scale. A few studies also made use of synthetic cases not rooted in a specific geographic context. b: Total cumulated number of studies on dynamic vulnerability published across years, colored by continent.

- L.207: "We identified 73 relevant studies that explicitly consider dynamic vulnerability, the majority of which (98%) have been published since 2010 (Figure 2b). Study geographies are concentrated in a few, scattered countries. In particular, a large fraction (42%) of studies are focused on cases in the United States of America, Germany and China. As summarized in Figure 2a, our search did not return any studies in many geographical regions, such as Northern, Middle and Eastern Africa, or Central and Western Asia, Central America, or the continent of Oceania. Over the years, both the increase in studies as well as the relative distribution across the continents remained relatively similar (Figure 2b)."

2. 我建議確保圖 1、表 1 和正文在描述脆弱性方面所使用的術語保持一致。主要標題可以統一適用於這些元素，並使用「事前」、「事件中」和「事後」作為子描述來解釋。這將有助於提高文章的連貫性和可讀性。// Deepl-Translation: I recommend ensuring consistency in the terminology used to describe vulnerability across Figure 1, Table 1 and the main text. A common heading could be applied to these elements, with 'pre-event', 'during-event' and 'post-event' used as sub-descriptions to clarify the context. This will help improve the coherence and readability of the article.

R2: We thank the reviewer for the suggestion. As we refer to vulnerability by its effect related to the flood event in the main text much more than to its manifestation relative to the hazard, we prefer to use the terms precondition, factor, and outcome to describe the different conceptual foci of the vulnerability assessment. However, we recognize and appreciate this reviewer's suggestion to improve coherence throughout the manuscript. We therefore updated Figure 1 accordingly.



3. 在第3.3節（動態脆弱性類型）中，雖然文中區分了事件相關、潛在和複雜性所導致的動態脆弱性，但這些類別之間的理論關係仍不夠充分。目前尚不清楚它們是互斥的、層級式的還是重疊的。如果能提供更明確的概念架構或闡明這些關係，將大大增強本文的貢獻。// Deepl-Translation: In Section 3.3 (Dynamic Vulnerabilities), although the text distinguishes between event-related, latent and complexity-induced dynamic vulnerabilities, the theoretical relationships between these categories remain insufficiently explored. It is currently unclear whether they are mutually exclusive, hierarchical or overlapping. Providing a clearer conceptual framework or elucidating these relationships would significantly enhance the contribution of this paper.

R3: We thank the reviewer for this suggestion. We provide clear definitions for the three types of dynamics in lines 166-172. Using an example we show that the definitions are not strictly exclusive. At the same time, we believe it is beyond the scope of this study to offer a comprehensive set of definitions. Instead, we also recognize the challenge and the need for clear, distinct conceptual definitions as part of the discussion (see lines 439-443). Here, we added an additional reflection as to how the lack of consistent definitions could be addressed in future work. We suggest that such definitions should be developed which are valid for vulnerability research across different hazard-disciplines.

- L. 167-172: “We distinguish between the following types of dynamics: event-related dynamics, underlying dynamics, and complexity dynamics (Figure 1). Event-related dynamics focus on vulnerability dynamics regarding one specific event, usually comparing vulnerability before and after the event (e.g., vulnerability changes due to experiencing a flood event(s)). Underlying dynamics focus on how vulnerability changes at multiple points over an extended period, without explicit consideration of how multiple factors contribute to these changes. Complexity dynamics focuses on how vulnerability changes explicitly due to the joint effects of multiple factors. These definitions are not strictly exclusive. For example, a study could focus on analyzing the various impact chains resulting in combined, complex factors affecting the vulnerability dynamics in the context of one specific flood event. In that case, the study would be categorized as focusing on complexity dynamics because the emphasis lies on the interacting factors rather than the specific event."

- L.441: "This dual role blurs the boundaries between categories. It highlights the need for a more explicit framework for categorizing the vulnerability focus in dynamic vulnerability research, especially in the context of multi-hazard events. A similar observation was made regarding the conceptualization of different types of dynamics. Future work could formulate such conceptual definitions based on the integrated insights from various hazard disciplines. This would allow defining vulnerability dynamics following terminology that is comparable and applicable across different hazard contexts.

4. 在討論中，與其孤立地提及驗證、可轉移性和不確定性處理等局限性，不如係統地綜合分析不同方法論如何解決這些問題，這將更有益。對不同方法進行更全面的比較，將有助於提升論文的分析深度。 // Deepl-Translation: In the discussion, rather than mentioning limitations such as validation, transferability and uncertainty handling in isolation, it would be more beneficial to conduct a systematic and comprehensive analysis of how different methodologies address these issues. A more thorough comparison of the various approaches would help to enhance the analytical depth of the paper.

R4: In Table 3, we summarize key limitations per method based on what has been reported in the results section in detail. In the accompanying text, we pick and discuss (briefly) the key limitation relevant for vulnerability dynamics. We offer suggestions on how this could be addressed in the future, either based on good practice or based on ideas that the co-author team identified based on the reviews across methods. Based on the reviews we also added reflections on how some of the limitations could be overcome e.g. by leveraging new data sources and methods. We made the following changes:

- L. 250: "Commonly, these studies acknowledge the lack of calibration and validation data for the flood impact models. A short-term solution to overcome this lack of calibration data could be the use of alternative data sources such as crowdsourcing (Ponukumati & Regonda, 2025; Assumpcao et al. 2018). Another promising development is that global and regional flood impact datasets are getting created or updated using new sources of information offering a wider temporal coverage or spatial detail (e.g. Veigel et al., 2025; Bruijn et al. 2019 or Paprotny et al. 2024). "

Bruijn, Jens A. de; Moel, Hans de; Jongman, Brenden; Ruiter, Marleen C. de; Wagemaker, Jurjen; Aerts, Jeroen C. J. H. (2019): A global database of historic and real-time flood events based on social media. In Scientific data 6 (1), p. 311. DOI: 10.1038/s41597-019-0326-9.

Paprotny, Dominik; Terefenko, Paweł; Śledziowski, Jakub (2024): HANZE v2.1: an improved database of flood impacts in Europe from 1870 to 2020. In Earth Syst. Sci. Data 16 (11), pp. 5145–5170. DOI: 10.5194/essd-16-5145-2024.

Veigel, Nadja; Kreibich, Heidi; Bruijn, Jens A. de; Aerts, Jeroen C. J. H.; Cominola, Andrea (2025): Content analysis of multi-annual time series of flood-related Twitter (X) data. In Nat. Hazards Earth Syst. Sci. 25 (2), pp. 879–891. DOI: 10.5194/nhess-25-879-2025.

- L.298: "Across ABM studies, a recurring limitation is the lack of empirical data for parameterizing agent behavior, and a focus on select dynamics, which constrains model realism (e.g., Abebe et al., 2019; Ciullo et al., 2017; Haer et al., 2019). Text-mining of social media or newspapers can uncover direct and indirect impact patterns related to flood events (e.g. Bruijn et al., 2019; de Brito et al. 2025) which can be used to improve the parametrization of simulation models. Similarly, ABMs are a widely used method across application contexts. Insights from behavioral economic studies in the context of financial impacts from floods could provide additional ideas for model parameterization, for example by means of micro-experiments or the use of evolutionary algorithms to match model outputs with observations (Axtell et al. 2025; Taberna et al. 2020)."

Axtell, Robert L.; Farmer, J. Doyne (2025): Agent-Based Modeling in Economics and Finance: Past, Present, and Future. In Journal of Economic Literature 63 (1), pp. 197–287. DOI: 10.1257/jel.20221319.

Brito, Mariana Madruga de; Sodoge, Jan; Kreibich, Heidi; Kuhlicke, Christian (2025): Comprehensive Assessment of Flood Socioeconomic Impacts Through Text-Mining. In Water Resources Research 61 (1), Article e2024WR037813. DOI: 10.1029/2024WR037813.

Taberna, A.; Filatova, T.; Roy, D.; Noll, B. (2020): Tracing resilience, social dynamics and behavioral change: a review of agent-based flood risk models. In 2663-3027. Available online at https://opus.lib.uts.edu.au/handle/10453/146588.

5. 在第520行，稿件提到需要統一的多重災害事件資料。為了讓這項建議更加具體，最好能明確指出哪些類型的資料（例如，災害影響範圍、暴露軌跡、復原時間表、行為資料）最迫切需要。// Deepl-Translation: On line 520, the manuscript mentions the need for harmonised multi-hazard event data. To make this recommendation more specific, it would be preferable to clearly identify which types of data (e.g., disaster impact areas, exposure trajectories, recovery timelines, behavioural data) are most urgently required.

R5: Thanks for the suggestion. We added a specification of the type of harmonized data in line 520 as follows:

- L.520: "More harmonized data are needed on multi-hazard events, like impact data, exposure trajectories, and other complex processes, as well as the processes that follow such events, particularly in terms of hazard, exposure, and vulnerability characteristics (Sakic Trogrlic et al., 2024). Efforts have been undertaken in this regard, such as trying to better identify multi-hazard events in disaster loss datasets (Lee et al., 2024; Jäger et al., 2025), developing multi-hazard event footprints based on past single hazard event datasets using the MYRIAD-HESA algorithm (Claassen et al., 2023), and using statistical approaches to produce stochastic multi-hazard event sets, such as MYRIAD-SIM (Claassen et al., 2025). "

Lee, R., White, C. J., Adnan, M. S. G., Douglas, J., Mahecha, M. D., O'Loughlin, F. E., ... & Zscheischler, J. (2024). Reclassifying historical disasters: From single to multi-hazards. Science of the Total Environment, 912, 169120.

Jäger, W. S., de Ruiter, M. C., Tiggeloven, T., & Ward, P. J. (2025). What can we learn about multi-hazard impacts from global disaster records?. Natural Hazards and Earth System Sciences, 25(8), 2751-2769.

Claassen, J. N., Ward, P. J., Daniell, J., Koks, E. E., Tiggeloven, T., & de Ruiter, M. C. (2023). A new method to compile global multi-hazard event sets. Scientific Reports, 13(1), 13808.

Claassen, J. N., Koks, E. E., De Ruiter, M. C., Ward, P. J., & Jäger, W. S. (2025). A Synthetic European Weather Dataset Based on Spatiotemporal Vine Copulas. Scientific Data, 12(1), 1734.

6. 稿件結構清晰且切合時宜，但結論部分可以更明確、更有力地闡述本綜述相對於以往綜述的獨特貢獻（例如，本文新增了哪些方法論見解、比較結構或可操作的優先事項）。加強這方面的闡述將有助於提升稿件的清晰度和引用潛力。// The structure of the manuscript is clear and timely, but the conclusion could articulate the unique contributions of this review relative to previous reviews more clearly and forcefully (e.g., what new methodological insights, comparative frameworks, or actionable priorities this paper introduces). Strengthening this aspect will help enhance the clarity and citation potential of the manuscript.

R6: We thank the reviewer for the suggestion to refine and sharpen the conclusion. We reworked the conclusion substantially to address the reviewer's comments. The revised paragraphs are included below.

- L. 530-549: "<u>This review provides the first methodological comparison of approaches used to capture vulnerability dynamics in the context of flood risk - an aspect that previous reviews have addressed only implicitly.</u> We <u>compared</u> how common assessment methods have been used or adapted to capture vulnerability dynamics, with an explicit focus on the types of dynamics they aim to capture. Our findings <u>offer researchers a basis for identifying promising methods for assessing vulnerability dynamics and can serve as a starting point for discussions on their opportunities and limitations.</u>

  Across the <u>73 analyzed</u> studies, we identified five main methodological approaches: curve-based, dynamic simulation, indicator-based, qualitative, and statistical, each with distinct strengths and limitations. Most of these methods draw on a combination of data sources, although remote sensing and workshop-derived inputs appear to be relatively uncommon. Furthermore, we found that event-related dynamics dominate the field, with underlying and complexity-related changes receiving less attention. Social vulnerability dimensions such as economic, cultural/behavioural, and governance aspects are commonly included, while the physical dimension is often reduced to urban assets and critical infrastructure.

  <u>Looking ahead, three priorities stand out. Methodologically, the field would benefit from closer attention to:1) developing and testing methods that allow identifying causal pathways for vulnerability dynamics, 2) learning across the various disciplines that study dynamic system responses, and 3) combining the complementary strengths of different techniques in mixed-methods approaches. As an example of the latter, researchers could use statistical methods to extract recovery patterns for a specific case study or, more broadly, across contexts, to infer more accurate behavioral rules for agents in simulation models. Such results can then be combined with qualitative forensic analysis, which may offer additional insights, for instance regarding installed risk mitigation measures and their effects.</u>

  As the field develops, applying these approaches across various hazards, integrating different methods, paying closer attention to causal pathways, and conducting meta-analyses of findings regarding changes in vulnerability <u>may improve both the understanding of vulnerability dynamics and the ability to manage their complexities</u>."

Additional revision: During a review process of an earlier version of this manuscript (https://egusphere.copernicus.org/preprints/2025/egusphere-2025-850/), the reviewers had suggested a set of six studies that are also relevant. They all apply statistical methods regarding (sub-)dimensions of vulnerability and reflect a similar pattern across methods, data, vulnerability focus, and type of dynamics. We decided to include these 6 studies summarized below for sake of completeness and added diversity in terms methods used, purpose of the analysis and the learnings:

- Bubeck, P., Berghäuser, L., Hudson, P., & Thieken, A. H. (2020). Using panel data to understand the dynamics of human behavior in response to flooding. Risk Analysis, 40(11), 2340-2359.
- Bubeck, P., Botzen, W. J., Kreibich, H., & Aerts, J. C. (2013). Detailed insights into the influence of flood-coping appraisals on mitigation behaviour. Global environmental change, 23(5), 1327-1338.
- Gallagher, J. (2014). Learning about an infrequent event: Evidence from flood insurance take-up in the United States. American Economic Journal: Applied Economics, 206-233
- Kousky, C. (2017). Disasters as learning experiences or disasters as policy opportunities? Examining flood insurance purchases after hurricanes. Risk analysis, 37(3), 517-530
- Deryugina, Tatyana, Laura Kawano, and Steven Levitt. 2018. "The Economic Impact of Hurricane Katrina on Its Victims: Evidence from Individual Tax Returns." American Economic Journal: Applied Economics 10 (2): 202–33.
- Davlasheridze, Meri, Karen Fisher-Vanden, and H. Allen Klaiber. "The effects of adaptation measures on hurricane induced property losses: Which FEMA investments have the highest returns?." Journal of Environmental Economics and Management 81 (2017): 93- 114.

In the initial submission version we had not included these six studies. As such we made minor modifications throughout the manuscript (e.g. updating the number of studies considered), and particularly made the following adjustments:

- L.207-l.224: "We identified 73 relevant studies that explicitly consider dynamic vulnerability in their assessments. Figure 2 summarises the distribution of methodological approaches, conceptual foci, types of dynamics, physical and social vulnerability categories, and data sources considered. Overall, the main methodological approaches are relatively evenly represented. Most studies (n = 49) address vulnerability dynamics as the outcome of a flood event. A smaller subset (n = 19) applies dynamic vulnerability in multiple ways, for example, treating it both as a precondition to hazard impact and as an outcome of the event. Across the sample, there is a modest bias toward event-related dynamics (n = 38), while complexity-related dynamics are least represented (n = 13).

  In terms of vulnerability dimensions, several recur across multiple studies. Economic factors and cultural/behavioural aspects are most often considered, alongside awareness and information, demographic characteristics, and governance or institutional features. Most studies address multiple aspects of social vulnerability, while physical vulnerability dimensions are more narrowly represented. Here, there is a clear bias toward exposed urban assets (n = 41) and critical infrastructure (n = 23), which are often the sole physical characteristics analysed. [...]"

- Section 4.5 (l.370 - l.415): "Eighteen studies employ statistical approaches, which differ mainly in whether they analyse vulnerability as an outcome of events or as a precondition influencing outcomes. As shown in Figure 2, no study conceptualizes vulnerability as a factor in their analysis. In our sample set, we do not find any studies that investigate vulnerability dynamics due to the complexity of interacting processes. Instead, most studies employ an event-related assessment approach, utilizing various data sources and focusing on different vulnerability components. A key distinguishing element is whether they approached vulnerability solely as an outcome or as both a precondition and an outcome.

The first group primarily applies an outcome-focused approach (Bubeck et al., 2012, 2013, 2020; Deryugina et al., 2018; Gallagher, 2014; Gallagher and Hartley, 2017; Kienzler et al., 2015; Köhler et al., 2023; Kousky, 2016; Phifer et al., 1988). Bubeck et al. (2012, 2013, 2020), Kienzler et al. (2015) and Köhler et al. (2023) investigate explicit correlations between past flood experiences and future flood preparedness or mitigation efforts, while Phifer et al. (1988) investigate relations to the health in the elderly. Gallagher (2014) and Kousky (2016) investigate the temporal evolution of insurance take-up following flood events while Deryugina et al. (2018) and Gallagher and Hartley (2017) investigate tax return patterns and debt patterns (regarding loans and credit cards) respectively in the recovery process from flood events.

Some studies rely primarily on interview data and apply descriptive statistical approaches in their analysis (Bubeck et al., 2012, 2013, 2020; Köhler et al., 2023; Phifer et al., 1988). Gallagher and Hartley (2017) and Deryugina et al. (2018) use a difference-in-difference approach comparing census blocks that were affected by the flood with those that were not, using modeled flood data and census information, along with field monitoring data regarding the debt development. Kousky (2016) and Gallagher (2014) use panel data from insurance claims for their analysis.

Phifer et al. (1988) find that flood vulnerability extends beyond immediate damage, as health effects persist over time, particularly among those who experience both personal and community-wide destruction. Similarly, Köhler et al. (2023) identify a paradox where individuals with more flood experience tend to take more precautionary measures but simultaneously feel less resilient. These findings underscore the role of psychological and social dynamics in vulnerability.

While Bubeck et al. (2012) demonstrate that flood events trigger accelerated mitigation efforts and preparedness improvements, Kienzler et al. (2015) show that these improvements are inconsistent across cases. Bubeck et al. (2020) find empirical evidence for - amongst other things - a decline in perceived flood risk and risk mitigation intentions with a weak to medium effect 18 months after a flood event. Bubeck et al. (2013) dive deeper into the specific factors, such as ways to cope with flood impacts, that shape the recovery processes and find that a postponement attitude tends to have a significant negative effect on the installment of risk mitigation measures, while socioeconomic aspects seem to play less of a role. Gallagher (2014) finds that insurance uptake increases after flood events, while Kousky (2016) concludes that insurance uptake increased directly after flood events, died down after about three years, and that insurance uptake is also correlated with governmental disaster relief grants. Gallagher and Hartley (2017) find that the debt decreased after an event in correlation with the payout of flood insurance money used to pay back loans instead of rebuilding. They hypothesize on possible reasons, both a demand-driven process (paying off loans and moving) and a lender-driven process (required to pay off mortgages on houses where house value was used as collateral). Finally, Deryugina et al. (2018) find various patterns including temporarily increased unemployment, relocation, increased marriage probabilities and withdrawals from retirement accounts in the aftermath of flood impacts.

Similar to studies employing other methodological approaches, multiple studies acknowledge the challenges associated with input data completeness, accuracy and aggregation level (e.g., Bubeck et al. 2020; Gallager, 2014; Gallagher and Hartley, 2017; Köhler et al., 2023). Bubeck et al. (2012) note some specific challenges relating to dynamic vulnerability with regards to the timing of flood events considered, which is not resolved in enough detail to derive conclusions about overlapping processes of recovery and risk reduction/mitigation efforts. Deryugina et al. (2018) note that for the difference-in-difference method it is particularly challenging to find a credible comparison group that can serve as the benchmark and counterfactual to the flood impacted area. They also note that especially urban areas in the surrounding region might also be affected by cascading effects on the labor market, which makes unimpacted cities in the vicinity less suitable.

Studies combining precondition–outcome perspectives include Atiqul Haq et al. (2024), Biswas et al. (2024), Dalvasheridze et al. (2017), Jamshed et al. (2021), Jiang et al. (2023), Houston et al. (2021) and Salvucci and Santos (2020). These studies examine how flood exposure affects broader vulnerability characteristics, including fertility, birth weight, mobility, and consumption. They also investigate which vulnerability sub-dimensions are correlated with the changes. For example, Biswas et al. (2024) investigate which socioeconomic factors are generally correlated more strongly with low birth weights in combination with potential flood exposure. Dalvasheridze et al. (2017), use data on ex-ante long-term mitigation investments and ex-post spendings on recovery and clean-up, as well as building damages, to investigate the damage reduction effects. They find that ex-ante investments primarily reduce the probability of damage, while ex-post investments mainly result in loss reduction. Jamshed et al. (2021) investigate how the mobility patterns between rural and urban settlements vary depending on factors including the age of the household head and economic situation, and Jiang et al. (2023) explore how recovery patterns in terms of credit use are affected by the wealth of the impacted household (Contreras and Torres-Machi, 2025, do the same for travel characteristics). They use various data sources for their analysis and apply several different methods of inference analysis including bivariate, multivariate or multinomial regression analysis (e.g., Atiqul Haq et al., 2024; Biswas et al., 2024; Jamshed et al., 2021), Autoregressive Integrated Moving Average model for time-series data (e.g., Atiqul Haq et al., 2024) and Moran's I statistics for spatial correlation analysis (e.g., Biswas et al., 2024), difference-in-difference to compare changes in affected regions in comparison to unaffected places (Salvucci and Tarp, 2021), and descriptive statistics (Jamshed et al., 2021; Jiang et al., 2023; Houston et al., 2021). Biswas et al. (2024) note that a key limitation in the inability to establish causality is due to input/measurement data constraints. [...]"