


A review of quantitative resilience measurements: Gaps in the operationalisation of agency and diversity in resilience metrics

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Abstract: Resilience is a notably challenging attribute to measure, as it has multiple interpretations and applications, even within specific disciplinary perspectives. Consequently, a wide range of elements and approaches are employed to quantify resilience, including in simulation models. This study aims to identify and categorise the main metrics of resilience across multiple disciplines and the most common approaches to measure resilience in simulation models.

In addition to examining the overall landscape of resilience metrics, our research addresses a critical gap in the incorporation of agency and diversity within these metrics. One prominent critique of resilience applications is their predominant focus on a system-based perspective, analysing system feedback and driving variables, while overlooking the role of actors and their capacity to promote systemic transformation (Cote and Nightingale, 2012). Similarly, although diversity and redundancy have long been recognised as crucial factors in resilience analysis (Elmqvist et al., 2003), our understanding of the literature is that they are neglected in widely used resilience measures. Consequently, our hypothesis is that a limited number of metrics explicitly consider diversity or agency, with even fewer applied in simulation models.

To achieve our objectives, we conducted a systematic review comprising two components. The first component is a meta-review, enabling us to have a comprehensive understanding of how resilience is measured across various disciplines. The second component builds upon the findings from the initial review and focuses specifically on analysing the utilisation of resilience in simulation-based models.

Preliminary results include the classification of resilience metrics into six categories: shape of potential landscape, early-warning signal, performance under disruption, system structure, compound indicator at system level, and compound indicator at individual level. Additionally, we have identified that metrics incorporating diversity and agency are primarily found in compound indicators, which is a category less used in models. Our results indicate that while diversity and agency are often explored in qualitative studies, they are rarely operationalised into the prevailing quantitative resilience metrics. In conclusion, this study provides a comprehensive review for researchers interested in measuring resilience, and we further recommend the development of new resilience metrics that explicitly incorporate agency and diversity.

REFERENCES

- Cote, M. and Nightingale, A.J., 2012. Resilience thinking meets social theory: situating social change in socio-ecological systems (SES) research. *Progress in human geography*, 36(4), 475–489.
- Elmqvist, T., Folke, C., Nyström, M., Peterson, G., Bengtsson, J., Walker, B. and Norberg, J., 2003. Response diversity, ecosystem change, and resilience. *Frontiers in Ecology and the Environment*, 1(9), 488–494.

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