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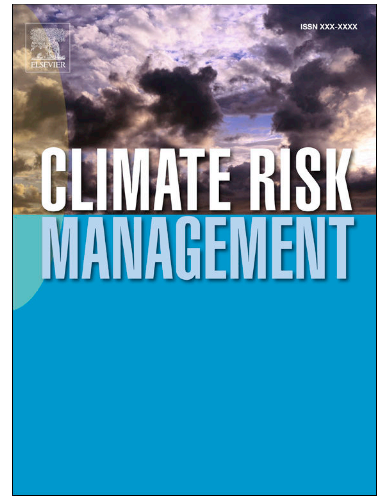

Closing the ‘operationalisation gap‘: Insights from systemic risk research to inform transformational adaptation and risk management

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Title:

Closing the 'operationalisation gap': Insights from systemic risk research to inform transformational adaptation and risk management

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Abstract:

Recent research has shown that adverse risks associated with climate and global change are becoming increasingly systemic with mounting interdependencies that will likely lead to cascading impacts. These impacts are projected to become so intolerable that standard risk management approaches alone will no longer be sufficient. Calls to consider transformational approaches to risk management and adaptation to facilitate a change towards more resilient futures are growing steadily louder. There is, however, a clear gap in terms of translating ambitions for transformational change into interventions and measures that can be directly applied in practice. To bridge this gap and help move forward with operationalising transformation in this context, we suggest harnessing ideas and insights from systemic risk research. Understanding systemic risk usually requires a careful examination of a system's components, leading to a better appreciation of how they and their interactions within a system contribute to systemic risks. Restructuring the connectivity of system elements based on this information represents a transformational change of the system and can lead to a reduction in systemic risk. From this perspective, systemic risk research and transformative risk management are closely connected disciplines, as methodological insights from the field of systemic risk research can benefit the objective of shifting climate risk management interventions towards transformative approaches that facilitate a radical and fundamental change towards more resilient futures The pluralistic views of decision-makers regarding system boundaries and responsibilities can, however, result in forced transformation. An applied systems view can avoid this and guide deliberate transformation coupled with iterative approaches that are able to track the status of such changes and steer developments in the desired direction.

Keywords: transformation, climate change, global change, systemic risk, transformational adaptation, resilience, sustainability

Introduction

There are indications that adverse risks from climate and global change—observed now and expected in the future—are becoming increasingly compound and systemic due to the interactions and enhanced interdependencies among them. Such risks are also likely to have severe cascading impacts (Jongman et al. 2014; Gaupp et al. 2020; Lawrence et al. 2020, IPCC 2022), which will increase the risk burdens on communities and countries. For example, compounding slow- and sudden-onset hazards such as those associated with sea-level rise, wave run-up, salinity, and more frequent storm tides are projected to overwhelm the ability of individuals, governments, and the private sector to adapt before disaster strikes and to cope with losses and damages after disaster has struck (IPCC 2018). As livelihoods become disrupted, displacement and retreat may, in some cases, follow (Desai et al. 2021). There may be significantly increased intensity and frequency of extreme temperatures and droughts, such as those recently experienced in Australia and the USA, and this will have long-lasting socioeconomic and ecological impacts of an existential nature (Handmer et al. 2012, 2020; Grose et al. 2014; Burke et al. 2021).

As risks are becoming more impactful and frequently existential (i.e., threatening the entire future of humankind; see Bostrom 2013) there have been increasingly louder calls for a fundamental shift towards more resilient futures through deliberate transformational approaches to both risk management and adaptation (Kates et al. 2012; Mustelin and Handmer 2013; Feola 2015; Pelling et al. 2015; Gibson et al. 2016; Ajibade and Egge, 2019; Roberts and Pelling 2019; Tabara et al. 2019). However, a clear "operationalisation gap" still remains in terms of translating propositions for transformational change into policy options (Deubelli and Mechler 2021), and there is (with exceptions, see for example Kehrer et al. 2020) little guidance available for designing transformational adaptation and risk management interventions and measures (for a critical discussion see O`Brian 2018; Nightingale et al. 2020; Hellin et al. 2022). To bridge this gap, we suggest ideas and insights that could be harnessed from systemic risk research and indicate ways forward for operationalising transformation in this context.

Understanding systemic risk usually requires a careful examination of a system's components; this can lead to a better understanding of how these, together with their interactions within the system, can contribute to systemic risks themselves. Restructuring the connectivity of system elements based on this information, through changes, for example, in the dependency of important components or the modularisation of the system, can be seen as a transformational change to the system that can subsequently lead to a reduction in systemic risk.. From this perspective, systemic risk research and transformative risk management are closely connected disciplines. Methodological insights from the field of systemic risk research can contribute to the goal of shifting climate risk management interventions towards transformative approaches and these, in turn, can facilitate a radical and fundamental change towards more resilient futures. To set the stage, we first discuss the transformative approaches currently used and relate that discussion to the concept of systemic boundaries.

Understanding systemic boundaries enables transformational adaptation and risk management

Approaches to risk reduction and adaptation that are conducive to transformative resilience can be described along a spectrum of system change, where the two opposite ends of the spectrum can be differentiated by the ratio between continuity and change — from incremental change taking place within a system's existing structures and objectives to profound, deep-rooted — transformational — system changes that challenge a system's status quo. While incremental measures usually entail only moderate changes such as ex post financial outlays for short-term response and recovery or piecemeal grey infrastructure solutions with hard design limits, transformational approaches would go deeper by addressing the underlying, social, cultural, and economic root causes of risk in systems, following a multiple dividend logic (Pelling 2011; Park et al. 2012; Rickards and Howden 2012; Bahadur and Tanner 2014; Feola 2015; Armitage et al. 2017; Bosomworth 2018; Deubelli and Mechler 2021; Deubelli and Venkateswaran 2021). Figure 1 illustrates this ratio and the different aspects involved in transformative approaches to climate risk management. Nevertheless, we should not dismiss the importance of a comprehensive set of context-specific incremental approaches, as these can play a vital role in stabilizing systems and, especially if accrued, may actually transform system dynamics and result in transformational system changes (IPCC, 2018)

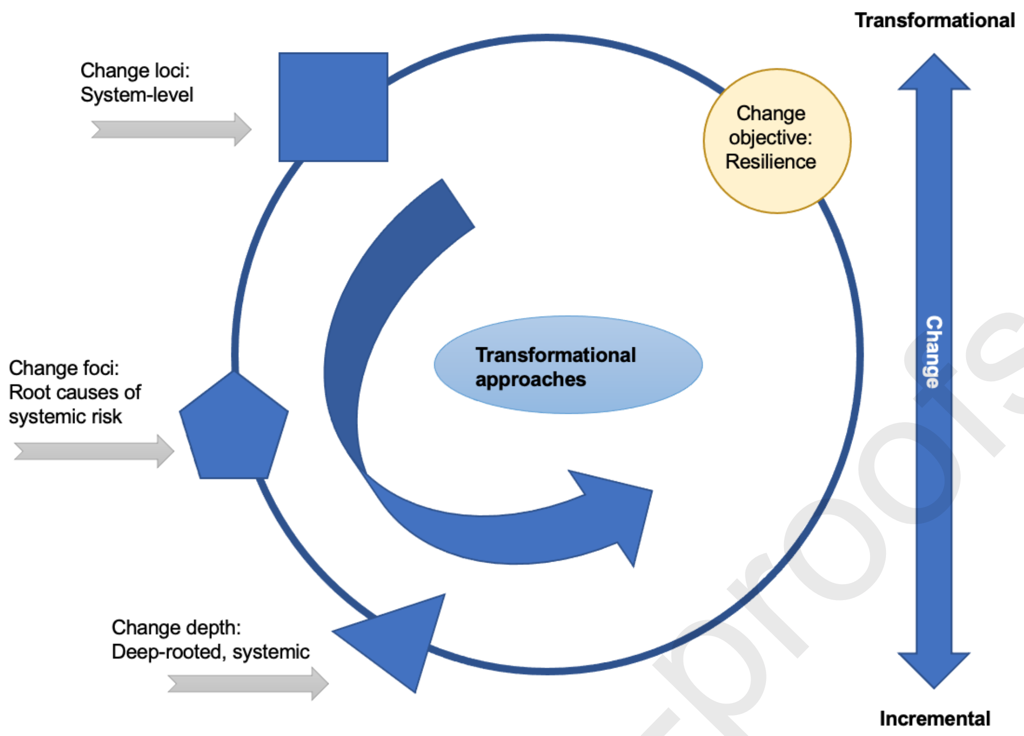

Figure 1 *Transformation in the context of resilience-building: Delivering deep-rooted, systemic change towards sustainable futures* (Deubelli & Mechler, 2021; Deubelli & Venkateswaran, 2021)

In this context, 'transformative' is frequently used to describe the change process (e.g., transformative climate risk management and adaptation), while "transformational" tends to be used to refer to the outcome of the change process itself— the system transformation—which constitutes a deep-rooted, qualitative shift towards a more resilient state (Vermeulen et al. 2018; Deubelli and Mechler 2021). As indicated above, transformative approaches entail changes in the system that are profound enough to challenge its status quo (Park et al. 2012; Armitage et al. 2017). However, a review of the literature reveals the lack of a clear definition as to what constitutes the system in question and what are its explicit boundaries and interdependencies. A clear definition of system boundaries has proved to be useful in many other instances where complexity is a main feature of the system being examined, for example in the following disciplines: Ecology (Varela and Maturan 1984 and the Autopoiesis concept); Sociology (Luhmann 2010 and the distinction between system and environment)' Cybernetics (computer- and brain-related considerations; see Härdle 2018); and Systemic Risk (see, e.g., Helbing 2010 regarding financial systems).

Building on this, we suggest that enabling transformational actions hinges on explicitly defining the system of interest, understanding the most relevant interdependencies and interconnections within it and among neighbouring systems, and identifying the systemic risk it faces (Park et al. 2012; Armitage et al. 2017). Drawing on the understanding that transformational change most commonly takes place at the system level (see, e.g., Kates et al. 2012; O'Brien 2012; Park et al. 2012; Feola 2015; IPCC 2019) delineating the loci of change within their defining system boundary and clarifying which of them are inside or outside the system are key steps in the design and implementation of climate risk management actions that have the potential to unleash transformational change towards more resilient and sustainable futures (Folke et al. 2010; Pelling 2011; Faldi and Macchi 2017; Bosomworth 2018). Importantly, when a specific system is confronted with risks that could render it unsustainable, for example systemic risks within one of its subsystems (Figure 2), understanding where these risks may materialise and what their potential impact is, is key information with respect to designing transformative interventions that reduce the root causes of such risk and build resilience (see, e.g., Park et al. 2012; Armitage et al. 2017) as depicted in Figure 1.

Considering interactions: Delineating the loci of change and transformation capacity

After defining the clear boundaries of a given system, we suggest focusing in a next step on the effects of interaction among the elements in the system—a major focus in systemic risk research—by investigating the system's network dynamics (i.e., the interaction among the system's elements) (Haldane and May 2011; Levin 2012; Thurner 2019). By following this approach, we propose to define a system as a set of interconnected and—to some extent—interdependent elements.

A system definition of this kind allows diverse system types to be examined, together with their capacity to undergo transformation based on different geographical areas, heterogeneous decision-makers, and multiple risk drivers, and this enables possible entry points to be identified. More importantly, system elements can again be defined as systems—so-called subsystems—comprising interconnected and interdependent elements with multiple functions, operations, databases, costs, and stakeholders, resulting in complex systems of systems or networks of networks (Collin et al. 2010; Haimes 2017). Different main interaction channels can be assumed to be of primary importance at a given agency and governance level and with respect to different risks (e.g., asset and consumption losses, effects on GDP, and global stock losses) and to systemic risk (global system collapse, country default); this forms the basis for considering diverse transformative pathways and processes which focus on creating systemic shifts that challenge underlying vulnerabilities and governance gaps (Deubelli & Venkateswaran, 2021). The middle part of Figure 2 illustrates a country as one possible conceptual representation of a system of systems, with the boundaries being the political borders and the household level being the smallest subsystem level assumed (see Agency).

Key to enabling the necessary stakeholder support and buy-in is an understanding of the interaction effects—including the negative and positive feedbacks of transformative interventions—among the elements within a system and across systems (right-hand side of Figure 2). Given the divergent views of decision-makers regarding system boundaries and interactions, along with the profound and sometimes radical change that such transformative interventions may entail for stakeholders within the system and its subsystems (and also across interconnected and interdependent systems), insights from systemic risk research can help provide an actionable decision-making base (left-hand side of Figure 2).

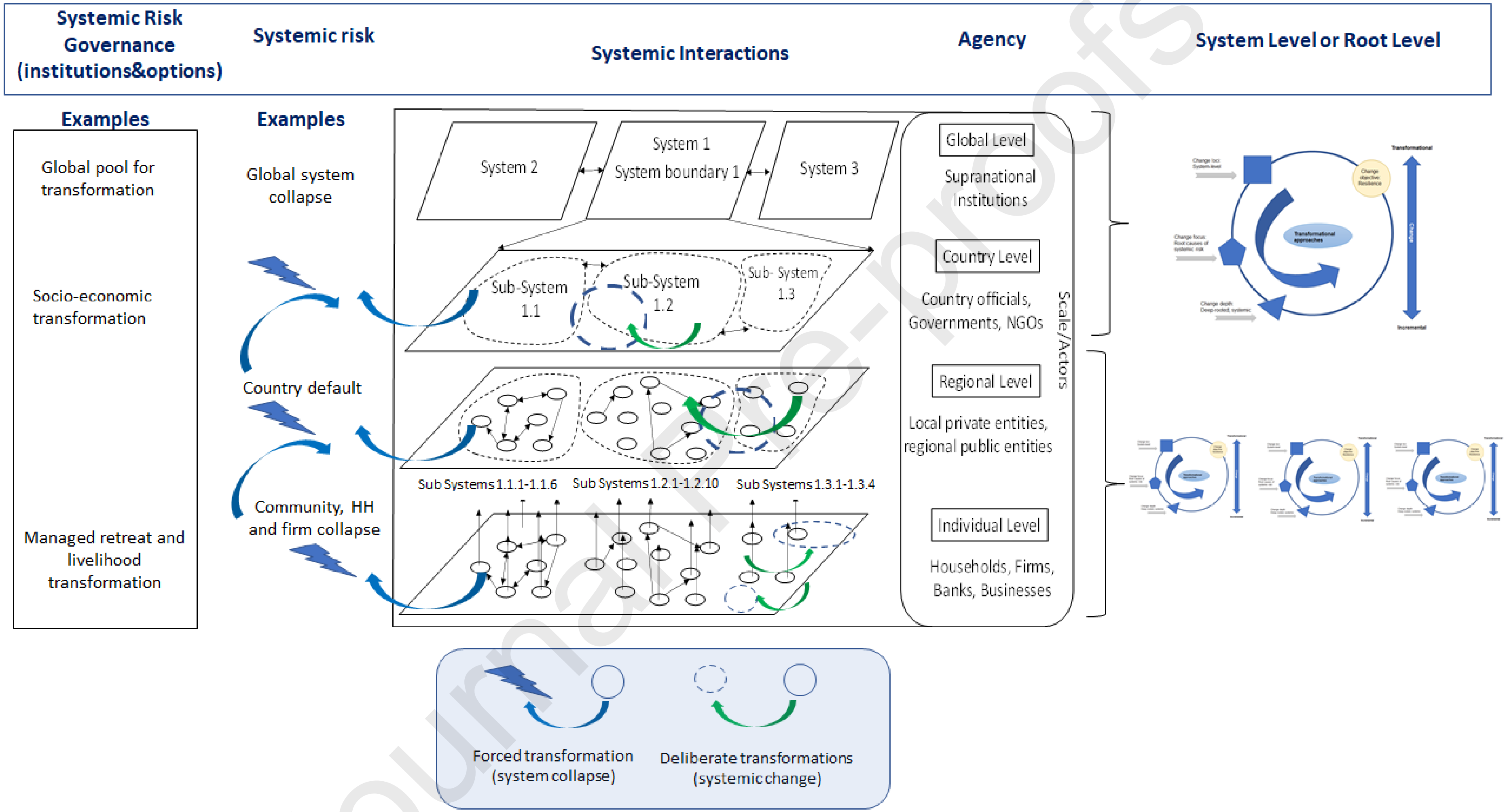

Figure 2 *Systems of systems approach based on system boundaries and possible spatial scales and actors.*

Note: *Deliberate transformation in the form of systemic change usually happens inside a system's boundaries or across system boundaries, although a full reconstruction of any given system at hand may be a viable option (e.g,. in the case of managed retreat due to existential risk).*

Plural System Perspectives and System Dynamics: Prioritising entry points and identifying transformation potential

An in-depth analysis of a system, its subsystems and interconnected and interdependent systems, and the interactions and feedback loops across the diverse elements of a system can serve as a basis for identifying the root causes and drivers of risk and their complex linkages; and this enables more targeted and effective design of transformative risk management interventions in the long run. Ultimately, however, which components will be prioritised also depends—to some extent—on the diverse perspectives, values, and worldviews of those designing the interventions (Scolobig et al. 2016), such as whether they take a project planner's top-down perspective or a stakeholder's bottom-up perspective—in other words the plurality of system perspectives. Structuring stakeholder views through an analytical–deliberative process can help achieve a compromise with regard to which entry points the transformation will focus on and which measures and interventions need to be prioritised. Using systemic risk research also offers opportunities for incorporating divergent views and perspectives, for example based on rational thinking or plural rationality, when deriving a desired, transformed system state (Sider et al. 2014).

The reasons for prioritising transformational interventions and measures that aim to manage intolerable risk are case-specific and can be of a political, ethical, moral, economic, or social dimension; it thus makes sense to harness the opportunities linked to a multiple lines of evidence approach (Hochrainer-Stigler et al. 2019). For example, models incorporate assumptions that may be critical for system performance but cannot be incorporated into the specific setup, for example, using a CGE (Computable General Equilibrium) or ABM (Agent Based) model; moreover, stakeholder perception may vary significantly and may need to be included via different means of analysis, for example, focusing on equality aspects or distributional justice in the context of climate change. Established quantitative measures in systemic risk research, such as DebtRank, which focus on understanding the system elements that may cause systemic risk to materialise can also provide ways of prioritising entry points for reducing risk of this type (Poledna and Thurner 2016), for example through a focus on elements or subsystems that are too big to fail or too interconnected to fail. As transformation of a system can have quite dramatic consequences for the elements within the system, subsystem, or interconnected systems, for instance in the case of migration and retreat due to existential risk, assessing and considering these before engaging in the design of transformative interventions helps ensure their effectiveness and thus stakeholder support down the road.

Similarly, the specific design of a transformational intervention or measure is also influenced by whether the transformation is the result of a deliberate transformational change process (Mechler et al. 2014; Feola 2015; Colloff et al. 2017; Few et al. 2017; Fazey et al. 2018) or results from 'forced' processes in reaction to a breach of hard physical adaptation limits (Kates et al. 2012; Mechler and Schinko 2016), such as sea-level rise challenging some islands' very existence (Nunn 2013). Given the interconnections between systems and system elements, such 'forced' transformations may also trigger voluntary transformation in neighbouring, interconnected systems that are affected by spill-over effects from the forced transformation, for example in the case of retreat from one locality to another. Understanding where risks, and in particular intolerable risks, are likely to show up and what consequences they might have is key for assessing transformation potential, as, too, is a system's readiness to learn, innovate, and take risks in implementing large-scale, novel responses to create a fundamentally new system or process (Dowd et al., 2014).

This also relates to system dynamics, an important focus within systemic risk research that works to identify feedback loops inherent to a system and to cross-check tabled policies and interventions for reducing risk in the system (Morecroft 1988; Gray and Shahidi 2011); it thus offers an opportunity to identify systems with the most pronounced transformative potential and those with intolerable risk (risk that may render it unsustainable in the long run). For example, in the Indian region of Tamil Nadu, where smallholders are exposed to compounding systemic risk, system dynamics has offered a useful approach to identifying actions for farming households to contain increasing coastal flood risks.[1] This includes the option for farmers to

[1] For more information on this GIZ-lead project see: https://www.giz.de/en/downloads/giz2021-en-climate-related-risk.pdf

keep their land uncultivated; this could eventually lead to migration with potential major effects at the regional level, as the number of people seeking alternative livelihoods increases: such effects could be people moving to larger cities for work, which would trigger feedback loops at higher levels (see conceptually forced and deliberative transformation within Figure 2 and options for systemic risk management). Consequently, if a shock propagates upscale or not is not only dependent on the interconnectedness of the sub-system with higher order systems but also if the shock can be dampened or controlled within the local sub-system (either through transformational or incremental interventions, see Figure 2, right hand side).

Conclusion

While there is increasing consensus on the need for a step-change in climate risk management and adaptation, there is no practical guidance for closing the 'operationalisation gap' in terms of translating ambitions for transformational change into tangible interventions and measures (Deubelli and Mechler 2021) . Drawing on the understanding that transformational change most commonly takes place at the system level (see, e.g., Kates et al. 2012; O'Brien 2012; Park et al. 2012; Feola 2015; IPCC 2019), we argue that the capacity to harness opportunities to operationalise ambitions for transformational change in the context of climate risk management hinges on delineating a system's scope, interconnections, and interdependencies with a view to understanding the root causes of systemic risk. In that regard, systemic risk research and transformational adaptation and risk management are closely connected disciplines: we find that transforming a system from its status quo towards a more resilient state relies on explicitly defining the system of interest and understanding the most relevant interdependencies and interconnections within it and among neighboring systems (Park et al. 2012; Armitage et al. 2017).

We suggest a systemic risk research perspective be used that focuses on the system or elements of the system (which would again be viewed as systems) to delineate the loci of change within a system's defining boundary and to clarify what is both inside and outside the system as a key step towards designing and implementing transformational interventions and measures (Folke et al. 2010; Pelling 2011; Faldi and Macchi 2017; Bosomworth 2018). Due to the complex nature of transformational change, we suggest that opportunities linked to a multiple line of evidence approach be harnessed—this will ensure that varying perceptions of the importance of system elements or subsystems within the system are considered (Pratt et al. 2015; IPCC 2018).

Bringing to light these avenues for inducing and guiding cascading risks in complex systems of systems provides decision-makers with a tangible means of enabling, and to some extent, managing transformational change in the context of climate risk management. While the results hinge on context-specific data availability and epistemic uncertainties, the pathways resulting from analysis based on the tools of systemic risk research—which in this context currently are still largely untapped—offer actionable opportunities for informing the operationalisation of transformational ambitions in the context of adaptation and risk management. In that regard, systemic risk research and the concepts of transformation are closely connected, and methodological insights from the field of systemic risk research can help shift interventions towards transformative approaches that, in turn, facilitate a radical and fundamental change towards more resilient futures.

This does not necessarily mean that such fundamental change needs to be forced via (potentially disruptive) top-down interventions but can also include incremental changes on the very local level which may finally lead to a transformation on the system level as well. We indicated that systemic risk only realizes due to failure of element(s) in a system that can spread through the system due to dependencies between the system elements. Hence, both, the (local) system elements as well as the system level have its own distinct role and advantages in regards how to steer transformational adaptation processes in their context (Handmer et al. 2020). This also means, as both are intrinsically related, that cooperation, learning and understanding between different “strategies of change” (Kehrer et al. 2020) is needed and essentially requires transdisciplinary collaboration (Cundill et al. 2018). A toolbox-based approach which emphasize the multiple realities and entry points for transformational adaptation and governance within complex systems (Schweizer 2021) may be a promising way forward as it could contribute to a shift in emphasis and appreciation of the multi-faceted problem and multitude of approaches and methodologies that exist (Hellin et al. 2022).

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Declaration of interests

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