



Systemic Risk Governance for Disaster Risk Management and Climate Change Adaptation

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Abstract Systemic risks, marked by cascading, interconnected effects across ecological, social, and economic domains, pose unprecedented challenges for climate change adaptation and disaster risk management. Climate change acts as a risk multiplier, intensifying the complexity, uncertainty, and transboundary nature of these risks. This chapter explores how systemic risk governance must evolve to confront these challenges,

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emphasising the need for integrated, anticipatory, and ethically grounded approaches. Drawing on systems thinking, systemic risks are conceptualised as emergent phenomena driven by feedback loops, interdependencies, and tipping points. It is argued that governance should be grounded in reflection, iteration, and deliberation to ensure evidence-based risk analysis, fair decision-making processes, and equitable outcomes. Ethical considerations are central, as risk governance decisions are value-laden and context-dependent. The Horizon Europe project DIRECTED serves as an exemplar, demonstrating how innovations can enhance resilience, bridge local and systemic perspectives, and support continuous learning in risk governance.

Keywords Climate change adaptation • Disaster risk management • Ethics • Risk governance • Systemic risks • Stakeholder engagement • Systems thinking

3.1 INTRODUCTION

Systemic risk, characterised by cascading impacts that spread within and across systems and sectors, presents profound challenges in the context of climate change adaptation. These impacts are transmitted through the movements of people, goods, capital, and information across regions, countries, and continents (Lawrence et al., 2020; Renn et al., 2022). When compounded by underlying vulnerabilities, such as socio-economic inequalities, degraded ecosystems, and fragile infrastructure, these cascading effects can lead to system collapse, with potentially existential consequences over short- and long-term horizons (Centeno et al., 2015; Helbing, 2013; Lawrence et al., 2024).

Climate change acts as a risk multiplier, exacerbating both the frequency and intensity of extreme weather events and stressing critical interdependencies across ecological, economic, technical, and social systems (IPCC, 2023). For example, extreme weather events not only impact food production but also disrupt supply chains, financial markets, and health systems, illustrating the deeply interconnected nature of modern risk landscapes (Carter et al., 2021). Therefore, understanding the root causes and transmission mechanisms of systemic risks, whether biophysical or societal, is imperative for developing adaptation strategies. A systemic risk lens demands that adaptation efforts move beyond isolated interventions towards more integrated and anticipatory approaches

(Boyd & Juhola, 2015). Building resilience thus requires identifying effective leverage points within systems, fostering adaptive capacities across scales, and embedding flexibility into governance mechanisms (Folke et al., 2016; Hynes et al., 2020). This includes enhancing early warning systems, investing in resilient infrastructure, promoting social equity, and encouraging cross-sectoral collaboration. Risk governance frameworks must evolve to accommodate the inherent uncertainty, non-linearity, and transboundary nature of systemic risks (Renn et al., 2022; Schweizer, 2021; Schweizer & Juhola, 2024). Moreover, political and societal responses play a crucial role in either attenuating or amplifying systemic risks (Schweizer et al., 2022). The key drivers of systemic risks spring from the interdependencies and relationships among various actors and elements in a given system, and how the failure or inadequate functioning of one part of the system impacts the entire system. Maladaptive responses, such as protectionist trade measures following climate-induced crop failures, can further entrench vulnerabilities and propagate risks globally (Keohane, 2010; Keohane & Victor, 2016). Therefore, fostering inclusive, transparent, and reflexive governance structures is essential to navigating the complex interactions between climate change adaptation and systemic risk management.

Integrating systemic risk thinking into climate change adaptation strategies is not merely a conceptual refinement, but also a practical necessity. By addressing the interdependencies and cascading effects that characterise contemporary risk landscapes, societies can enhance resilience, safeguard critical systems, and better prepare for an uncertain climatic future.

The chapter proceeds with Sect. 3.2, giving a general overview of systemic risk governance. In so doing, it first explores the relationship between governance and risk, outlining how risk governance has evolved towards including processes of deliberation and participation. The section then links the discussion surrounding risk governance to systems thinking, underscoring how systems thinking is an insightful conceptual lens for the exploration of systemic risks and their governance. In addition, ethical implications of systemic risk governance are highlighted. Sect. 3.3 gives an overview of the Horizon Europe project DIRECTED, wherein the principles and concepts of systemic risk governance laid out in the previous section have been applied to support disaster risk management and climate change adaptation strategies. The conclusion highlights some of the limitations that come with systemic risk governance approaches and points out possible ways forward.

3.2 GOVERNANCE FOR SYSTEMIC RISKS

Several challenges for the governance of systemic risks have been identified in the literature. Systemic risks (1) are transboundary or cross-sectoral in the scope of their consequences leading to multiple ripple effects; (2) are highly interconnected and intertwined, leading to complex causal structures, high uncertainty, and major interpretative ambiguities; (3) are non-linear in their cause–effect relationships that come with tipping points; (4) are stochastic in their effect structure, leading to increased uncertainty that is difficult or impossible to characterise by statistical confidence intervals; and (5) tend to have a lag in policymaking which is at least partially due to social processes of risk perception (Renn et al., 2022; Schweizer, 2021; Schweizer & Renn, 2019; Schweizer et al., 2022; Sillmann et al., 2022). Due to the complexity, uncertainty, and ambiguity that characterise systemic risks, an evidence-based approach is essential for guiding effective decision-making including collaborative governance strategies. Such approaches must be guided by ethical considerations, exploring diverse normative frameworks. From these interlinked implications, i.e. procedural, scientific, and normative, arise a set of practical requirements for governing systemic risks.

3.2.1 *Risk Governance*

The catastrophic potential of systemic risks demands urgent action. Yet, complexity, uncertainty, and ambiguity challenge both science and politics, as Chap. 2 pointed out. These challenges raise pressing questions, such as what the goals of governance are, which course of action is appropriate, effective, and efficient, who sets the course and what is their mandate, and what the roles of science, civil society, the economy, etc. are. Governance engages with such questions. Aiming to offer answers by rethinking the concept of governance, this section explores how governance theory and practice have evolved to meet the demands of systemic risk contexts. In this sense, governance reflects the shift in how authority, influence, and coordination are understood. These shifts are ‘conceptualized in three different directions: upward (to the regional, transnational, intergovernmental, and global), downward (to the local, regional, and the metropolitan), and horizontally (to private and civil spheres of authority)’ (Levi-Faur, 2012, p. 7). Thus, governance marks a change in the meaning of government, introducing new processes of governing, altered conditions of ordered rule, and different methods by which society is managed

(Rhodes, 2012). Governance also reflects ideological and cultural shifts, particularly towards individualism and the market as the dominant mechanism for resource allocation (Pierre, 2000). Importantly, as Levi-Faur emphasises, governance is not a unified theory. It is not a single field of study, nor does it provide a comprehensive causal framework for understanding politics, economics, and society (Levi-Faur, 2012). Nonetheless, four general themes are associated with governance: it may be seen as a structure, a process, a mechanism, or a strategy. As Levi-Faur explains: ‘As a structure, governance signifies the architecture of formal and informal institutions; as the process it signifies the dynamics and steering functions involved in lengthy never-ending processes of policymaking; as a mechanism it signifies institutional procedures of decision-making, of compliance and of control (or instruments); finally, as a strategy it signifies the actors’ efforts to govern and manipulate the design of institutions and mechanisms in order to shape choice and preferences’ (Levi-Faur, 2012, p. 8).

This conceptual flexibility allows governance to speak to diverse contexts, particularly in relation to systemic risk and climate risk. Critical reflections of risk discourses have highlighted the importance of including a broader range of societal actors in governance (Fisher, 2012). In this context, risk governance refers to participatory, deliberative processes involving stakeholders and the public (see Chap. 2). These processes become vital sources of democratic legitimacy for risk-related decisions, drawing on extended peer, stakeholder, and public communities (Klinke & Renn, 2012, 2021). Risk governance, therefore, goes beyond simply linking risk analysis, i.e. the systematic process of understanding risk, with risk communication, i.e. the exchange of risk-related information among regulators, stakeholders, media, and the public. Risk governance includes the totality of actors, rules, conventions, processes, and mechanisms concerned with how relevant risk information is collected, analysed and communicated, and how management decisions are taken (IRGC, 2005, 2018).

Stakeholder and public engagement in risk governance has long been advocated, supported by three primary arguments: (1) substantive, (2) instrumental, and (3) normative (Fiorino, 1990; Stirling, 2006).

1. The substantive argument suggests that including a diversity of perspectives enhances the quality of information and decisions. Stakeholders and the public contribute crucial insights from both scientific and non-scientific knowledge systems (Fischhoff, 1995).

2. The instrumental argument holds that participation can improve the implementation and acceptance of decisions (Beierle, 1999; Slovic, 1993). In this view, governance becomes more effective.
3. The normative argument sees participation as a means to address conflict, build dialogue in polarised contexts, promote fairness, give a voice to the marginalised (Innes & Booher, 2004), and empower citizens (Arnstein, 1969). It can foster social cohesion and trust (National Research Council, 2008).

As a result, stakeholder engagement and public participation are standard features of many risk governance efforts (Webler & Tuler, 2021). Risk governance has become an ‘inclusive and participatory activity that integrates various stakeholder perspectives, engages in the co-generation of practical knowledge, and resolves contingencies by developing discrete scenarios that translate different concerns and positions in negotiable and communicable narratives’ (Klinke & Renn, 2021, p. 3).

This development has led to the concept of inclusive risk governance (Renn & Klinke, 2012; Renn & Schweizer, 2009). Inclusive risk governance integrates extended peer communities, stakeholders, and the public into the decision-making process. It also emphasises the distribution of responsibility among these actors. This approach supports the deliberative and participatory turn in risk governance, where responsibilities are shared and differentiated among those with relevant authority and those directly affected. Participation and deliberation are essential components of this approach.

Unlike traditional models, which rely on decisions made primarily by government agencies or private entities, inclusive risk governance draws its legitimacy and effectiveness from three key sources: (1) the inclusion of diverse types of knowledge, (2) the active involvement of networks and communities, and (3) public deliberation based on open and inclusive discussions about the risk issues (Klinke & Renn, 2021). To address the interconnected and evolving nature of systemic risks, risk governance must thus be supported by analytical approaches capable of capturing complexity, uncertainty, and ambiguity, as well as the integration of stakeholders. Systems thinking provides such a foundation by enabling the structured analysis of interdependencies, feedback loops, and cascading effects.

3.2.2 *Systems Thinking*

Systems thinking provides a structured approach for analysing interdependent, dynamic systems and has become essential for understanding and governing systemic risks (Schweizer, 2021; Schweizer & Juhola, 2024). In the context of systemic risks, systems thinking should be understood as a conceptual lens for exploring relations between interconnected factors from multiple perspectives, rather than as a rigid set of tools and methods (Williams & Hummelbrunner, 2010). Because of its applicability and relevance across practical and scientific domains, systems thinking is inherently inter- and transdisciplinary. The conceptual roots of systems thinking lie in mid-twentieth-century systems theory. Researchers from different disciplinary angles contributed to a more holistic understanding of systems as interdependent, self-organising structures (Mele et al., 2010). As a part of this development, Forrester (1961) developed system dynamics to analyse feedback-driven processes in industrial systems. Sterman (2000) advanced system dynamics for policy design, clarifying how decisions interact with system structures over time. Within system dynamics, causal loop diagrams emerged as qualitative tools to visualise feedback mechanisms and foster shared understanding among stakeholders (Sterman, 2000). Since they make interdependencies visible, causal loop diagrams facilitate the identification of key variables, leverage points, and potential cascading effects. Systems thinking also informs concepts such as resilience and adaptation. Holling (1973) introduced the concept of resilience in ecological systems, defining it as the capacity to absorb disturbances while maintaining core functions and structures. In this context, adaptation contributes to resilience: adaptive measures enhance a system's ability to reorganise under stress, reinforcing its persistence (Folke et al., 2010; Fraccascia et al., 2018). Resilience has since become central to systemic risk analysis, highlighting the importance of coping mechanisms in dynamic, uncertain conditions (Renn et al., 2011).

Systems thinking is essential for the assessment and governance of systemic risks since it provides the conceptual and methodological frame for engaging with complexity. Systemic risks are characterised by non-linear propagation, interdependencies, and cross-sectoral feedback, all of which undermine the predictive capacity of linear models (Renn et al., 2022). Systems thinking enables a structured analysis of these features by mapping feedback mechanisms, identifying critical linkages, and informing governance strategies accordingly (Sterman, 2000). Moreover, identifying

functional roles within a system, their relations and dynamics, needs an integrated approach which helps reveal potential tipping points or vulnerabilities (Otto et al., 2020; Renn et al., 2022). Clarifying these roles is essential for enabling governance to utilise adaptive capacities. By delineating system boundaries and subsystem interactions, systems thinking improves the ability to assess potential impacts of interventions and decisions. Its integrative approach fosters cross-sectoral and cross-scale analysis and coordination, particularly in fields such as disaster risk management and climate change adaptation (Centeno et al., 2015).

Nevertheless, the application of systems thinking to systemic risk analysis is not without limitations, two of which should be explicitly mentioned. First, setting system boundaries, especially in large-scale, interconnected societal systems, can result in marginalisation of cultural, regional, or normative perspectives (Williams & Hummelbrunner, 2010). This raises ethical concerns around who defines the system, and whose perspectives are prioritised. Second, systems thinking often relies on data-informed models, which can inadvertently reproduce existing data biases and overlook marginalised knowledge systems (Carvalho et al., 2025). Furthermore, systems thinking does not inherently address questions of accountability. Accountability, as a value-laden concept, must be defined through legal and procedural frameworks rather than derived from systemic logic alone (Williams & Hummelbrunner, 2010).

To mitigate these limitations, reflexivity should be embedded in systemic risk assessment and governance (Schweizer & Juhola, 2024). Through analytical iteration, systems thinking offers a useful foundation for integrating reflection into modelling processes, encouraging pluralistic perspectives and critical awareness of normative assumptions. In sum, systems thinking is not value-neutral. Rather, it depends on the perspectives, boundaries, and priorities defined by those who apply it. Therefore, ethical considerations must be systematically integrated into the assessment and governance of systemic risks.

3.2.3 *Ethics and Systemic Risk Governance*

Crucial factors for the assessment and evaluation of systemic risk governance measures are the ethical implications that such measure entail. Especially when it comes to the systemic adaptation to climate change and climate risks, questions of justice and equity abound (Byskov et al., 2021; Heyward, 2017). Both the nature of systemic risks and the process of

governing systemic risks lead to normative questions that require deliberation and engagement. Risk itself is by definition a value-laden concept (Hansson, 2013, see also Chap. 2), describing the potential consequence of an action or event for something that people value. Systemic risks further introduce important challenges regarding justice and equity considerations throughout the governance process. In particular, a variety of justice issues arise in the context of governing systemic risks. Following the common distinction between procedural and distributive justice in political philosophy (Rawls, 1999),¹ governing systemic risks needs to account for a fair procedure throughout the decision-making process, as well as an equitable distribution of benefits and burdens in its outcome (Taebi, 2017). Ensuring equitable distribution entails that decision-makers consider how the imposition of risks should be evaluated (Hayenhjelm & Wolff, 2012). From the perspective of systemic risks as continuous, dynamic processes, such an evaluation is complex and requires iterative deliberation (Hofbauer, 2023).

Apart from the governance outcome of systemic risks accounting for justice, the decision-making process itself is also of critical ethical relevance. In line with philosophy and ethics scholarship, procedural justice entails meaningful and equitable participation (Habermas, 2004), and those outcomes are based on fair procedures (Nozick, 1974). Importantly, some strands within the non-ideal tradition of justice thinking, that underscores the importance of accounting for existing injustices in any theoretical undertaking (Valentini, 2012), highlight the need for recognitional approaches and a systemic understanding of societal relationships (Fraser & Honneth, 2003; Young, 2011; Whyte, 2011). These approaches establish the ethical basis for meaningful participation and recognition, stipulating the necessity to account for the historical and systemic discrimination faced by many non-white, Indigenous, low-income, elderly, and other marginalised communities. Such thinking provides insights for the distributional and procedural aspects of systemic risks, especially when it comes to inclusive and participatory governance frameworks (Renn & Schweizer, 2020). Ultimately, what kind of function or purpose the system in question serves, as well as for who it serves that function or purpose for,

¹There are other ways to define and categorise various justice conceptions (Miller, 2025). For the purpose of this brief introduction, however, we believe the procedural/distributional distinction to suffice.

and why a given risk matters to them, sets the empirical basis for a variety of normative deliberations that require meaningful public participation.

3.3 SYSTEMIC RISK GOVERNANCE, DISASTER RISK MANAGEMENT, AND CLIMATE CHANGE ADAPTATION: LESSONS FROM THE DIRECTED PROJECT

While systems thinking provides the conceptual tools to analyse complexity, and ethical reflection addresses the normative implications of systemic risks, these insights must be translated into practical governance approaches. Effective governance of systemic risks requires the integration of systems thinking and ethical reflection into practical, inclusive strategies. Systemic risks, associated with complexity, uncertainty, and cascading effects, often resemble *black swan* events that are difficult to anticipate or fully understand (Taleb, 2010). Addressing these risks demands ongoing reflection, adaptability, and resilience, as well as a governance approach that evolves with new evidence and shifting priorities. Systems thinking provides tools to analyse interconnections and feedback loops within dynamic systems, helping identify leverage points for intervention. However, it must be applied reflectively, as it can reinforce biases through too narrow system boundaries. Ethical considerations in governance emphasise distributive and procedural justice, inclusivity, and recognition of historically disadvantaged groups. Furthermore, systemic risk governance calls for multi-level, participatory, and deliberative processes. Public engagement and stakeholder participation are essential for building legitimacy, ensuring fairness, and supporting effective decision-making. Systemic risks increasingly shape the global risk landscape, and climate-induced disasters have become emblematic of the urgent need for integrated and adaptive governance approaches (Sillmann et al., 2022; World Economic Forum, 2024). With extreme weather events on the rise, disaster risk management as well as climate change adaptation strategies become a focal point for the investigation and governance of systemic risks.

Climate-induced disasters, whether sudden-onset events like hurricanes and floods, or slow-onset phenomena like drought and sea-level rise, are increasingly interconnected through complex feedbacks across social, environmental, and technological systems (IPCC, 2023; Lawrence et al., 2024). Disasters are no longer isolated events but are capable of triggering cascading failures across critical infrastructures, economies, and governance systems (Gill & Malamud, 2016; Groundstroem & Juhola, 2021;

Helbing, 2013; Lawrence et al., 2020). The Fukushima Daiichi nuclear disaster (2011), triggered by an earthquake and tsunami, exemplifies how a single geophysical event can evolve into a multi-sector systemic crisis (Aven & Renn, 2020). Similarly, climate-amplified wildfires not only destroy ecosystems but also degrade air quality, disrupt energy supplies, and cause displacement (Ducros et al., 2024; Lucas, 2022).

3.3.1 *The DIRECTED Project: A Brief Overview*

Building on the insight that systemic risk governance requires broad and meaningful participation, the Risk-Tandem Framework (Parviainen et al., 2025) outlines a transferable and scalable approach towards disaster risk management as well as climate change adaptation. The approach was developed in the context of the Horizon Europe project DIRECTED, funded by the European Commission. DIRECTED aims to reduce vulnerability to extreme weather events and foster disaster-resilient societies by promoting interoperability between disaster risk management and climate change adaptation. At its core, DIRECTED aims to assess, improve, and, where possible, integrate various disaster risk management and climate change adaptation processes throughout Europe. The DIRECTED project deploys a Real-World Laboratory approach for facilitating co-production and applying its key innovations, the Risk-Tandem Framework and the Data Fabric. These innovations are put into practice in four European regions, namely, the Emilia Romagna region in Italy, the Capital Region of Denmark, the Rhine-Erft region in Germany, and the Danube region, which covers multiple countries, e.g., Austria and Hungary (Schröter et al., 2024). The DIRECTED Real-World Laboratories are composed of local stakeholders, governance and administrative practitioners, scientists, and Real-World Laboratory hosts, i.e. project partners who serve as intermediaries between the DIRECTED consortium and the local communities. This setup allows for continuous engagement and learning, both for consortium members and for hosts and stakeholders (Cumiskey et al., 2025). The project uses a co-creative methodology, wherein the research questions as well as the methods are co-developed alongside the affected stakeholders and practitioners (Bharwani et al., 2024). This ensures that the outcomes of the project are solution-oriented and tailored to address the real-world problems of stakeholders.

3.3.2 Merging Systemic Risk Governance, Disaster Risk Management, and Climate Change Adaptation Through the DIRECTED Risk-Tandem Framework

Conventional disaster risk management often relies on historical data and risk maps based on past disaster events. However, systemic risks necessitate anticipatory reflection on emerging hazards, novel threat combinations, and new vulnerabilities increased by climate change impacts, socio-technical transformations, and financial mechanisms (UNDRR, 2019, 2023, 2025). Scenario planning, foresight exercises, and stress testing of critical systems have increasingly become standard practices to explore complex, low-probability, high-impact risks (Abdelhakim et al., 2024; Bourgeois et al., 2017; Döll & Romero-Lankao, 2017). With an ever-changing risk landscape, it is crucial to ensure a continuous learning process that can be adapted to changing circumstances. Accounting for this dynamism, the disaster risk management and climate change adaptation strategies that are explored and sought to be improved in the DIRECTED project via the Risk-Tandem Framework are built around reflection, iteration, and deliberation (Parviainen et al., 2025).

Reflection is crucial due to the unpredictable nature of systemic risks, which often involve tipping points and cascading effects that are difficult to anticipate. This implies that the governance process must be designed and implemented in a way that explicitly acknowledges and critically assesses the conceptual and methodological tools on which it relies, as well as the inherent uncertainties associated with extreme weather events. For example, the Risk-Tandem Framework draws on a number of existing approaches, combining societal vulnerability with risk finance tools, as well as co-creation and modelling approaches. Such a variety of tools results in a substantially rich picture of potential systemic risks, supporting more effective disaster risk management and climate change adaptation. At the same time, the diverse concepts underlying this framework need to be brought together through a shared conceptual language. For example, insights from a social vulnerability analysis may conflict with recommendations from a risk financing perspective.

With the reflective dimension in mind, governing systemic risks in the disaster risk management and climate change adaptation context also requires iteration in order to allow for the continuous restructuring of the management strategies. Iteration is crucial, since it makes room for the fine-tuning of a given disaster risk management and climate change

adaptation strategy. The needs of stakeholders and affected people vary across regions, and the local context is paramount for the efficient and sustainable handling of systemic risks. Accordingly, the Risk-Tandem Framework is applied iteratively, explicitly allowing for a consistent monitoring, evaluation, and learning process (Parviainen et al., 2025).

Iteration offers a segue into deliberation. Deliberative, inclusive governance is essential for systemic risk management, ensuring that diverse perspectives, local knowledge, and vulnerable voices inform disaster risk management strategies (Klinke & Renn, 2021; Nalau et al., 2021). Participation enhances legitimacy, equity, and the substantive quality of decisions (Fiorino, 1990; Arnstein, 1969). In the context of systemic risk governance, inclusion is essential for both epistemic and ethical reasons. Epistemically, involving a broad range of stakeholders, e.g. through participatory governance frameworks, brings in more diverse perspectives, leading to richer and more comprehensive information. Ethically, inclusive governance is grounded in the premise that all those affected by a decision should have a say in the governance process leading towards decisions. This means ensuring meaningful participation in decision-making processes. The Risk-Tandem Framework addresses this by emphasising co-creation in both risk governance and agenda setting. It also emphasises the importance of transparent communication of uncertainties, cascading effects, and potential trade-offs. While uncertainty cannot be eliminated, it can be navigated by participation and deliberation, enhancing trust and informed decision-making (van der Sluijs et al., 2005; Renn, 2008).

Within the Risk-Tandem Framework, continuous stakeholder engagement, e.g. by through collaboration on key research questions, ensures the building and maintaining of a trusting relationship. Crucially, this collaboration is not just a unidirectional sharing of information but rather framed as a communal effort to build a strong, locally relevant research project. By default, this approach necessitates open communication between researchers and local actors to come to a shared understanding of the issue. Among stakeholders, the Risk-Tandem Framework further helps institutionalising communication platforms and shared knowledge repositories to enable interested community members to track the decision-making process regarding disaster risk management and climate change adaptation in their region.

3.3.3 *Managing Information Through the Data Fabric*

While striving for reflection, iteration, and deliberation is crucial for sustainable and effective systemic risk governance, it requires a thorough and cohesive data management strategy to facilitate data and modelling interoperability. Thus, apart from the immediate governance dimensions expressed in the Risk-Tandem Framework, the DIRECTED project also develops a framework for the interoperability of datasets and models to improve decision-making on systemic risks. The Data Fabric is a reference framework that accommodates the diversity of datasets and modelling approaches used throughout different organisations and across multiple national boundaries. It provides a data infrastructure to enable stakeholders to consolidate and connect relevant data sources, models, and information products across disaster risk management and climate change adaptation application domains and institutional operating systems and languages (Schröter et al., 2024). The Data Fabric plays a key complementary role to the governance and institutional leverage points identified by means of the Risk-Tandem Framework. It offers the modelling expertise needed to support well-informed and verifiable decisions. At the same time, the Data Fabric relies on the dynamic, solution-oriented processes of the Risk-Tandem Framework to ensure it focuses on societally relevant questions.

Combining the strategies of the Risk-Tandem Framework and the Data Fabric also accounts for the volatility of systemic risks. Systemic risks evolve dynamically, making fixed, one-off disaster risk management plans obsolete. Iterative governance emphasises continuous learning, allowing disaster policies and actions to adapt to changing knowledge, conditions, and social values (Folke et al., 2005; Kuhlmann et al., 2019). Accordingly, adaptation that seeks to build resilience in a multi-risk context of high uncertainty needs to rebuild, adjust, and learn post-event. A way of ensuring that these rebuilding efforts are sustainable in the long run is by tapping into local knowledge and building on community feedback, as well as continuously updating and integrating climate data.

3.4 CONCLUSION

The systemic nature of climate risks calls for governance approaches grounded in reflection, iteration, and deliberation. By integrating disaster risk management and climate change adaptation through systemic risk thinking, policymakers and practitioners can enhance societal resilience,

anticipate cascading failures, and craft adaptive strategies capable of navigating the uncertainties of a rapidly changing climate. In doing so, disaster risk management and climate change adaptation become not just mechanisms for crisis response but cornerstones of proactive, sustainable, and inclusive climate change adaptation.

Through the DIRECTED project and its Risk-Tandem Framework, this chapter illustrates how reflection, iteration, and deliberation can support more adaptive and inclusive approaches to risk governance. Systems thinking provides tools for mapping interdependencies, anticipating tipping points, and identifying leverage points for intervention. Ethical reflection ensures that governance processes account for distributive and procedural justice, recognise marginalised perspectives, and navigate the value-laden nature of risk.

Nonetheless, while systemic risk governance is a crucial addition to the toolkit of managing growing risks through extreme weather events driven by climate change, it also has important caveats that require careful consideration and reflection, e.g. regarding sensitivity to contextual parameters when applied at scale. As analytical approaches are scaled up, marginalised needs and perspectives of vulnerable groups may become obscured by the increasing emphasis on generalisability at larger scales. This chapter accordingly emphasises the need for the integration of ethical reflection and normative decision-making into the process of systemic risk analysis, to avoid the reification of existing inequities.

A similar drawback can be noted concerning participation. The approaches laid out here are steered towards being normatively reflective, taking social justice issues and equity procedurally into account. However, given the reliance and immediate relationship with local needs, issues of equity and inclusion might slip into the background due to other priorities. At the same time, participation might be turned into a window dressing exercise, wherein ensuring that everyone's voice is heard is more akin to ticking a box rather than having meaningful impact. For this reason, it is necessary to set procedural guardrails, including ethical discourse as an integral piece to the application of deliberative systemic risk governance.

These critical reflections are only two examples of the issues that might arise in the context of systemic risk governance and the application of its principles. This highlights the need for more methodological work, developing means to account for the structurally owed risks that drive existing systemic risks. Importantly, risk scholars in the field need to grapple with the socio-political implications of building resilient and adaptive

communities. Adaptation to climate change is not a politically neutral undertaking. With this in mind, the approach and concepts presented here should pave the way to further invigorate and inspire the conversation surrounding disaster risk management and climate change adaptation.

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