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Beyond the Sendai indicators: Application of a cascading risk lens for the improvement of loss data indicators for slow-onset hazards and small-scale disasters

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ABSTRACT

The implementation of the Sendai Framework offers an opportunity for expanding the global application of standardized loss accounting systems for recording disaster impacts. However, the Sendai indicators and existing global disaster databases offer limited utility in achieving the aims of the Sendai Framework through the creation of a knowledge base relevant for informed risk reduction strategies in varied hazard and vulnerability contexts. Using cascading analyses and systems thinking, this paper explores new approaches for improving methodologies for loss and damage data. It focuses on the subset of small-scale disasters and slow-onset hazards, and demonstrates how a systems approach to cascading risk can improve the utility of disaster databases from reactive and static measures of economic loss, to tools for assessing risk and vulnerability across temporal and spatial scales.

1. Introduction

The introduction of measurable and monitorable targets in the Sendai Framework for Disaster Risk Reduction has spurred a global initiative for more accurate and comprehensive data on the impact of disasters [52]. To demonstrate progress in achieving the goals and targets of the Sendai Framework, countries are required to report on a set of 38 universal indicators demonstrating the reduction of risk and losses over two ten-year periods. The resulting metrics will arguably allow for an assessment of global trends in disaster risk reduction, and facilitate informed decision-making and policy creation at the national level. In order to assist national actors in the development of disaster impact data, the UNISDR has produced technical guidance notes outlining minimum data standards and recommended common data principles and methodologies for the collection, processing, and reporting of statistical data [54]. Additionally, the agency has created the Sendai Monitor, an online database platform that member states can use to submit and store data corresponding with the Sendai indicators.

The efficacy and long-term utility of the proposed indicators in meeting the aims of the Sendai Framework and providing a global overview of disaster risk remains uncertain, not least because historical losses provide only a partial and static snapshot of the risk produced by hazards, exposure and social vulnerability [32]. The structural imperative of databases and indicator systems necessitates rendering disasters as episodic events with temporal, geographical and statistical boundaries, automatically restricting their potential to capture contextualized and fluid risk processes [23,60]. Nonetheless, following the adage that 'you cannot manage what you cannot measure', disaster databases offer a systematized collection of information on disaster impacts that can be useful for understanding vulnerability and guiding risk management strategies [57].

The Sendai indicators draw from and build on models of pre-existing global databases on disaster losses such as EMDAT, NATCAT and DesInventar. While the indicators demonstrate a positive evolution in accurately and comprehensively capturing information on disaster impacts, they nevertheless contain many of the limitations of existing methodologies for representing loss and damage generated by disasters [59]. In addition to loss of human life, information in existing loss databases is largely limited to direct economic losses, predominantly in the housing, infrastructure, and insurance sectors. The bulk of existing data is associated with fast-onset and extreme events, with low inclusion rates for slow onset hazards and sub-national or small-scale disasters [1]. The DesInventar database, implemented in over 80 countries, circumvents some of these limitations by offering a wider inclusion criterion for disaster types, and data categories that can be expanded and tailored to the specific needs of individual countries. Data is georeferenced and collected at various governance scales, but sources rely heavily on unverified news reports and the database is often maintained by diverse national agencies or non-government actors within each country context. It, along with other global loss

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recording mechanisms, suffers from diverging national priorities and approaches to the classification, measurement and statistical processing of data, resulting in metrics that cannot be easily collated or compared across different countries or database systems [1,19,26].

Following the DesInventar model, an effort has been made in the Sendai indicators to capture a wider range of disaster types, impact scales, and data categories that go beyond mortality, affected population, and economic losses, but the coverage of losses in diverse sectors still remains patchy and arbitrary in its scope. Losses in health and agriculture have been given increased attention in the Sendai indicators, but aspects of environmental losses or social impacts such as migration are entirely missing from the indicator set. The framework has taken the bold step of introducing cultural losses in the list of loss indicators, but here too, the loss estimation methodology is limited to a calculation of the direct economic cost of damage to the physical cultural asset. Limited reporting periods and data categories restrict the inclusion of losses generated by hazards such as droughts that produce long gestation, indirect impacts or have weaker attribution chains linking the hazard event with impact. As such, the new indicators perpetuate existing trends of underestimating the true burden of disasters, and represent a lost opportunity in developing a coherent and internationally agreed upon system for the estimation of loss data [13].

The indicators of the Sendai Framework also remain exclusively focused on the assessment of direct economic losses, defined in the technical guidance notes as losses that 'happen during the event or within the first few hours after the event and are often assessed soon after the event to estimate recovery cost and claim insurance payments' [54]. The availability of data, and the burden of continuous data reporting on national and local governments is often cited as a justification for limiting loss calculations to direct economic losses within disaster databases, including the Sendai indicators. However, as evidenced by the Sendai Framework Data Readiness Review conducted by the UNISDR, most reviewed countries already collect information on the majority of indicators, although this information currently exists in disparate forms and locations [53]. Building on the same logic, it can be argued that information on several indirect costs and impacts exists or can be estimated using pre-existing data sources. For example, data on migration or environmental indicators is being compiled by several national and international agencies, including the Internal Displacement and Migration Centre (IDMC) and the Organization for Economic Cooperation and Development (OECD), and indirect impacts such as loss of tourist revenue due to damaged cultural assets can be calculated using existing economic and sector-specific data. In the context of loss reporting systems, what is required instead is the elucidation of expanded data categories and attribution methodologies to assist countries in drawing a link between a hazard event and its potential impacts. The improved recognition of extreme heat as a cause of death in mortality registers for several European countries after the 2003 heat wave event is an example of how improving information on attribution linkages can result in more accurate procedures of accounting for disaster losses [38,62].

The partial and inconsistent coverage of losses across scale, hazard types, impact categories, and event severities points to inherent weaknesses of the Sendai indicators and other loss accounting mechanisms to capture loss and vulnerability across the disaster process. Conceptual and empirical progress in the field of disaster risk has not necessarily translated into developments in the content and methodologies employed by indicator systems and databases to provide comprehensive risk information. In an attempt to address this gap, this paper explores the potential utility of employing a cascading risk lens to improve basic data infrastructure for disaster loss calculations. It explores the methodological tools offered by cascading risk analysis and the overlapping fields of compound and interacting risk for unraveling interdependencies and chains of disruption and amplification that produce complex and divergent disaster impacts. Specifically, it examines the characteristics of extensive risk and slow onset events, and using heat wave impacts as an example, discusses how conceptualizing such disasters as a series of cascades can help in the development of standardized approaches for their quantification in loss data systems.

2. Compound, interacting and cascading risk

Analysis of disaster interdependencies has been widely addressed in the contiguous literature on compound, interacting and interconnected risk. Compound risk commonly refers to the interaction of multiple hazards or events that combine to produce extreme disasters capable of generating widespread losses [23,27,60]. Spurred by the IPCC SREX definition of compound events, works have focused on the processes whereby a single climate or weather variable can, directly or indirectly, interact with other variables to generate single, secondary or concurrent disaster events that are extreme in their impact. Models of statistical dependence between multiple, connected climate variables are developed to analyze, predict and prevent the impact risk of climate extremes [33]. The discussion of compound hazards is principally located in the fields of hazard science, technological systems, and climate change studies, but recent iterations have evolved beyond natural hazards to encompass subjects such as conflicts and urbanization [16,56].

The concept of compound events overlaps significantly with the literature on interacting and interconnected risk, which adopts a systems theory approach to earth sciences. Both fields emphasize environmental factors as the primary triggers of extreme events, but the latter elucidates the role of physical networks and causal chains to a greater extent. For example, Gill and Malamud [20] describe networks of hazard interaction as composed of three main hazard and process groups (natural hazards, anthropogenic processes, and technological hazards/disasters) whose interaction is governed by either triggering relationships, increased-probability relationships, or catalysis/impedance relationships. Variations in spatial and temporal extent, frequency, and impact of networks produce diverse outcomes in different contexts, but a visualization of connections can assist in producing multi-hazard risk assessments and management strategies. Here, anthropogenic processes are primarily defined as human interactions with natural systems that result in environmental and ecological change.

Cascading risk studies adopt a broader and more process oriented approach to interconnected risk systems. A cascade is understood as a chain of causality that emerges when hazards, risk and accumulated vulnerabilities connect across multiple scales to produce a disaster [45]. The attention to sequential cause-effect relationships in cascading risk makes it a robust tool for analyzing interlinked systems and networks. This explains why, in the context of disaster studies, the approach has been widely applied to understanding disaster vulnerability and potential weak points in technological sectors such as energy, transportation and telecommunications [21,39,47]. As highlighted by the 2011 Japanese earthquake and the resulting crisis at the Fukushima Daiichi nuclear power plant, increasingly interdependent socio-technical systems have resulted in complex functional dependencies that can produce or amplify disaster losses in diverse sectors. In the context of increased risk of climate change and augmented exposure, governments and critical service providers are using a cascading crisis framework to understand vulnerability nodes and potential escalation points that cause cross-sector breakdowns when triggered by hazard events [29].

Subsequently, much of the initial analysis of cascading risks focused heavily on the nature and form of triggering events such as the natural hazard or the loss of function of a physical component of critical infrastructure. In its simplest form, the chain of causality is often described as a 'toppling domino effect', where a sudden shock to the system generates uncontrolled chain losses down the line of connected systems [44]. The tendency to view cascading events as a linear chain of pre-existing vulnerability points assumes the presence of a predictable sequence of dependence, where the degree of causality or 'coupling' between two or several points can be measured [34]. Recent consideration of a more diverse range of sectors, including emergency