Stockholm Environment Institute

Testing the impact chain model

Exploring social vulnerability to multiple hazards and cascading effects

SEI project brief
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This project brief presents an overview of how the impact chain method can be used to explore social vulnerability to multiple hydrometeorological hazards and their cascading effects, in a case study in Halmstad Municipality, Sweden. A particular focus in this case study was the methodological research and innovation (R&I) area of co-production of knowledge, with lessons learned presented here.

UNCHAIN – Unpacking climate impact chains

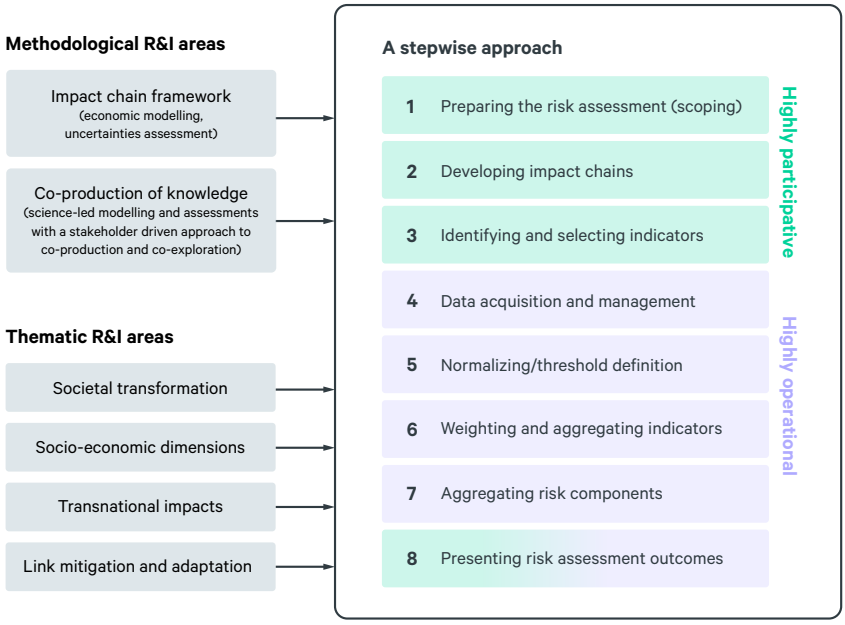
The UNCHAIN project advances climate change risk assessment frameworks aimed at informed decision-making and climate adaptation action. The research approach is based on the concepts of impact chains and co-production of knowledge.

The UNCHAIN approach supports climate change adaptation action by introducing six methodological and thematic research and innovation areas (Figure 1). As laid out in the *Vulnerability Sourcebook* (Fritzsche et al., 2014), the impact chain method considers climate risks in accordance with some of the concepts used in IPCC's Fifth Assessment Report (AR5): hazard, exposure and vulnerability (IPCC, 2014). The method provides practical instructions and guidance for implementing vulnerability and risk assessments based on a step-by-step approach structured around eight modules (Figure 1).

UNCHAIN is centred around 11 case studies in seven countries in Europe to test changes and alterations of the current impact chain model and evaluate its effects. The case study described here is in Sweden.

IMAGE (ABOVE): Halmstad beach

Figure 1. UNCHAIN methodological and thematic research and innovation (R&I) applied in case studies.



Application of the impact chain method in Halmstad

Halmstad Municipality is located on the southwest coast of Sweden, with a population of around 105 000 (of that, the city population is 70 000; SCB, 2022). Its geographical location makes it vulnerable to various natural hazards, including sea level rise, storm surges and flooding, for example (Johansson, 2018).

These hazards can occur at the same time, trigger other hazards, and have cumulative effects – in the words of the IPCC, simultaneously, "cascadingly", or cumulatively. In the worst case, they can cause cascading effects of disruptions across vital societal functions and critical infrastructures.

Little is known regarding which social groups will be affected by these disruptions, and what economic, social and physical factors drive groups' vulnerability. Social groups with known underlying vulnerabilities can be predicted to be more affected than others in the case of a disruptive event. At the same time, other groups may become newly vulnerable due to unforeseen interactions between hazards and previously invisible vulnerabilities (see e.g. Barquet et al., 2022).

The case study of Halmstad Municipality explores impacts on social groups, resulting from multiple hydrometeorological hazards that cause disruptions in vital societal functions and critical infrastructures (for more information on the results, see Englund et al., 2022). Expected outputs and outcomes of the project include a social vulnerability index, spatial vulnerability maps, an impact chain showing emerging vulnerabilities, a process of co-creation and collaborative learning, and methodological insights on the knowledge co-production process with focus on co-produced climate services (Daniels et al., 2020).

Overview of the research process

For the case study of Halmstad, we identified the five most applicable modules of the eight detailed in the impact chain method (Fritzsche et al., 2014). We used these as a basis for structured stakeholder dialogues in the municipality (Figure 2).

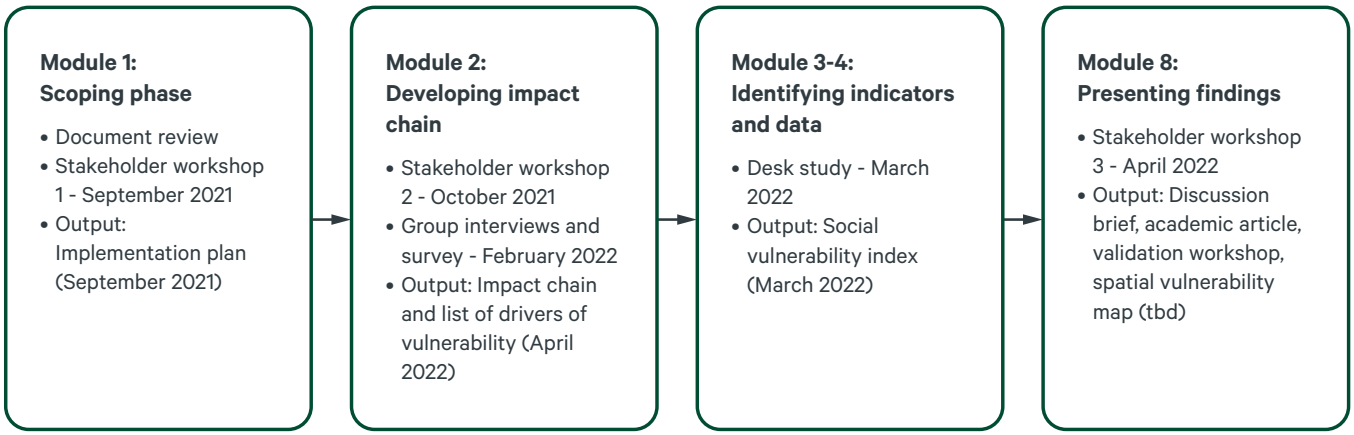
We gathered a diverse group of stakeholders representing different areas of the municipality's provision of critical services, which include climate adaptation, water services, social services, risk management, urban planning, and environmental protection. We engaged the municipality representatives in a participatory process guided by the five selected modules.

For Module 1, the scoping phase included several steps to further specify aims and research questions and to inform the design of the case study and the participatory process. We held meetings at different stages, conducted a document review on climate risks and adaptation in Halmstad Municipality and the broader academic literature on social vulnerability to flooding. An online stakeholder workshop set the scene for the project, established collaboration, discussed capacity needs, and discussed scope and context for the risk assessment.

Module 2 developed the impact chain: due to the low frequency of hazardous events in Sweden, data are lacking. Therefore, we applied a scenario-based approach in which stakeholders co-designed scenarios using their local knowledge and sectorial expertise. Scenarios were co-constructed drawing on the Halmstad Municipality adaptation plan and stakeholder preferences. First we explored cascading effects of disrupted water supply, and later in the process, other sectors such as as energy, health and care services, food supply chain, municipal technical services, and transportation network. For details, see Englund et al. (2022).

Modules 3 and 4, identifying and selecting indicators and gathering data, led us to select indicators for the underlying vulnerabilities identified in the impact chain in Halmstad. No data were available for the variables that constituted emerging vulnerabilities, that are to be explored in the next stage of our research. We noted the "direction" and magnitude of change for each indicator, positive or negative for an increase or decrease in vulnerability, respectively.

Figure 2. Overview of the research process and the five selected modules.



Data for the indicators were then downloaded from Statistics Sweden and Delmos. Only "open" data were used. Indicators covered demographic statistical areas (DeSO) with 700 to 2700 inhabitants in each location, which allowed for comparisons between different neighbourhoods in the municipality.

The last step, Module 8, was presenting outcomes. Stakeholders were invited to a third workshop that was held in person in Halmstad, to validate and continue building the impact chain. At the workshop, preliminary findings on indicators, underlying and emerging vulnerabilities were presented in the form of a map and narrative for further discussion with the stakeholders. Going forward, we will share the findings with the involved stakeholders in the format of their preference. Planned outputs include presentations, journal articles, and user-friendly reports.

Methodological innovation and emerging results

The impact chain method was initially designed to understand the cause-effect relationship of climate risks (Figure 3). In our case study, we sought to capture the multidimensional, time dependent, and situational factors that shape social vulnerabilities (e.g., Kuran et al., 2020).

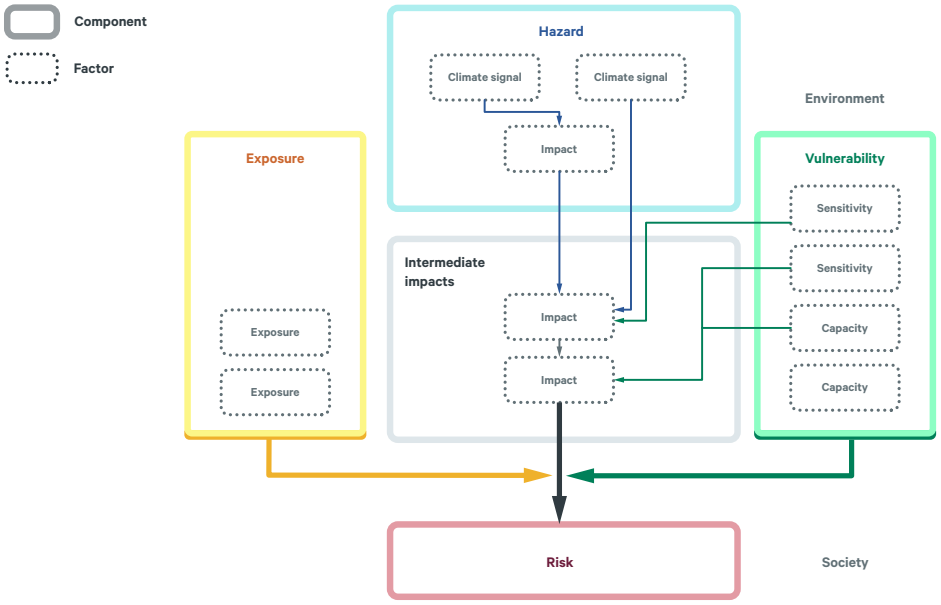
As a result, we further developed the impact chain and adapted it to the structure illustrated in Figure 4: a climate signal causes multiple hazards to occur, which, in interaction with pre-existing vulnerabilities in the infrastructure system and population, cause cascading effects that eventually generate new vulnerable groups. This demonstrates that the impact chain model is flexible, and that it can be adapted to fit many objectives and stakeholder needs.

In addition to generating insights on social vulnerabilities in Halmstad, the case study also focused on the UNCHAIN methodological innovation of knowledge co-production. Knowledge co-production is gaining prominence in the climate adaptation discourse (Bremer & Meisch, 2017). In brief, co-production engages researchers and decision-makers across disciplinary boundaries in a collaborative research process, in order to produce relevant, contextual and timely knowledge (Norström et al., 2020).

To further advance climate services, we built on the existing impact chain model by applying a related framework for co-designed transdisciplinary knowledge integration processes, notably the Tandem framework (Daniels et al., 2020). The combination of the impact chain model and other collaborative and process-oriented frameworks enabled us to adopt an iterative, process-driven approach that fostered collaboration between researchers and relevant stakeholders throughout the research process. The research design was adapted as new information emerged from stakeholder inputs to ensure contextual relevance.

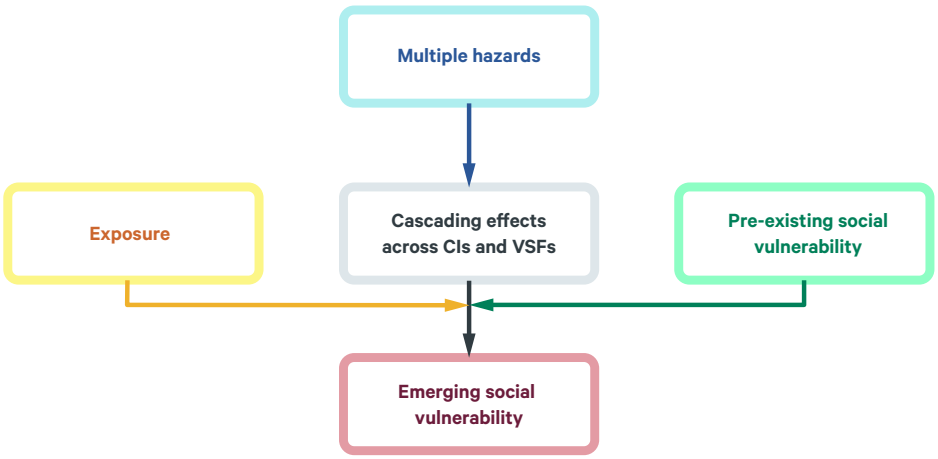
The results still need to be evaluated together with the stakeholders. Our preliminary assessment is that this approach stimulated exchange of knowledge and collaborative learning, as lessons learned could be incorporated in subsequent data collection activities, ultimately improving the research process while also contributing to increasing stakeholders' knowledge base.

Figure 3. Structure of an impact chain



Source: Zebisch et al. (2017), p. 28.

Figure 4. Adjusted impact chain for the Halmstad Municipality case study (CIs refers to Critical Infrastructures and VSFs refers to Vital Societal Functions).



Further reading

UNCHAIN: https://www.vestforsk.no/en/project/unpacking-climate-impact-chains-new-generation-action-and-user-oriented-climate-change-risk

HydroHazards: https://www.sei.org/projects-and-tools/projects/hydrohazards/

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