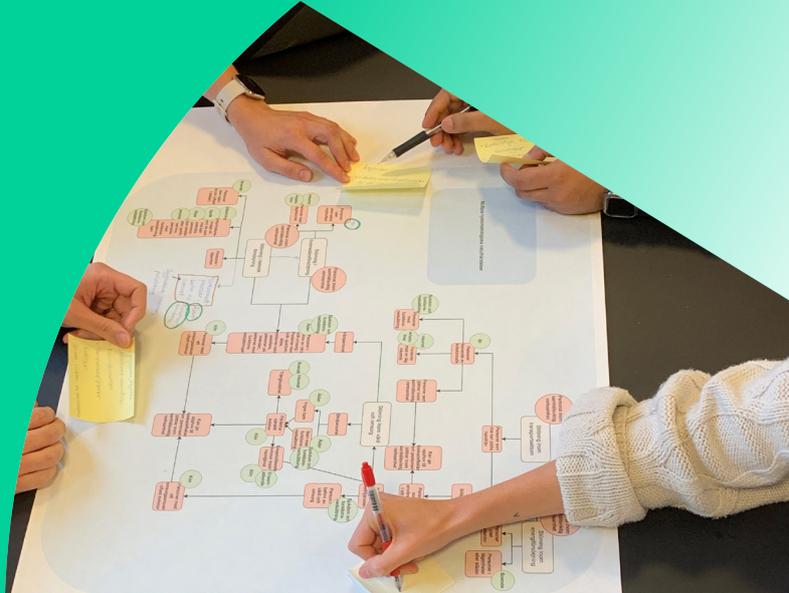


# Weather, wealth and well-being

Cascading effects of water-related hazards  
and social vulnerability in Halmstad, Sweden



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## Key messages

- **Disruptions in critical infrastructure and related vital societal functions are most likely to hit the most vulnerable the hardest; however, their cascading effects can put other social groups at risk that are not initially considered vulnerable.**
- **Local level assessments are needed, as social vulnerability depends on the spatial, temporal and situational context.**
- **Municipalities can use assessments of critical infrastructure and related vital societal functions as a starting point to assess social vulnerability; the impact chain model can support this assessment.**

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## Introduction

As climate changes, Sweden is expected to experience increased risks from water-related hazards, such as heavy rainfall, river flooding, storm surges, and extreme snowfall, as well as droughts and water scarcity (Kjellström et al., 2022). These hazards can at times occur simultaneously, “cascadingly”, or cumulatively. In the worst case, they can cause cascading effects with disruptions across vital societal functions and critical infrastructures (IPCC, 2022).

Which social groups in Sweden will be affected by these disruptions is unclear, as are the economic, social and physical factors that will determine these groups’ coping capacities (Segnestam, 2014). The stable welfare society in Sweden makes the country among the least vulnerable societies in the world to disasters (van Well et al., 2018). However, past disaster events, such as the Covid-19 pandemic (Kelman, 2020; The Public Health Agency of Sweden, 2022) and Cyclone Gudrun in 2005 (Guldåker, 2009), reveal that social vulnerabilities persist.

As in many other countries, Swedish authorities expect individuals to continue to function without any governmental support for at least 72 hours after a societal disturbance (Bergström, 2018). Meanwhile municipalities, which have the primary responsibility for identifying and reducing disaster risk, recognize that disaster preparedness is significantly lacking for some households (Asp, 2015).

Adaptive and coping capacities also differ between different social groups, where some simply lack the capacity, knowledge or resources to take responsibility over their personal safety in the case of a disruption (Sparf, 2015). It is necessary to identify the social groups that lack coping capacity when facing a disruptive event, but also the

IMAGE (ABOVE): Workshop in Halmstad  
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mechanisms that can make people vulnerable. This knowledge can help policymakers to design effective disaster risk reduction strategies and build resilience among the most vulnerable segments of the population.

Municipalities are not obliged by law to assess which social groups may endure negative impacts in the case of a disruptive event (Lindbom et al., 2016). Local risk and vulnerability assessments reflect this, as they generally lack the social dimension (Barquet et al., submitted manuscript). Instead, municipalities focus on assessing the risk of disruptions to critical infrastructure and vital societal functions (MSBFS, 2015).

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### BOX 1. HALMSTAD MUNICIPALITY



Östra Stranden in Halmstad: a tourist haven susceptible to flooding and erosion.

Halmstad is a coastal town located in the southwest of Sweden, with a population of around 105 000. Its geographical location makes Halmstad susceptible to various natural hazards that will be exacerbated by climate change, including sea level rise, surges and floods.

We propose using these assessments as a starting point to better understand social vulnerability. They should be expanded to investigate who depends on critical infrastructure and vital societal functions, leading to an exploration of socioeconomic impacts of weather-related disruptions.

We provide here insights on social vulnerabilities in a Swedish context. Drawing from previous research (Kuran et al., 2020), we recognize that social vulnerability has spatial, temporal and situational dimensions and therefore varies between different contexts. Therefore, we limit our focus to the social groups that are suspected to be vulnerable in the event of multiple simultaneous water-related hazards that cause cascading effects, disrupting infrastructure services in Halmstad (Box 1).

We identified critical factors that may produce or reinforce social vulnerability at the local level. Unpacking the characteristics of vulnerable groups is essential when designing and implementing risk strategies to ensure that no one is left behind.

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## Method

Insights gathered from the projects HydroHazards and UNCHAIN, both of which collaborated with the Municipality of Halmstad, provide the basis of this work (Barquet et al., 2022; André et al., 2022). To structure the case study, we applied the impact chain model (Fritzsche et al., 2014; Schneiderbauer et al., 2013; Zebisch et al., 2017, 2021), which visualizes climate risks in cause-effect chains in accordance with the IPCC concepts of hazard, exposure and vulnerability (IPCC, 2014, 2022). For definitions of key concepts, see Box 2.

The impact chain was structured as follows: multiple water-related hazards occur; these events interact with pre-existing vulnerabilities in the infrastructure system and population, and they then cause cascading effects in these societal systems that in the end generate new vulnerabilities. To develop the impact chain, we reviewed available documentation and academic literature, and we engaged key stakeholders representing Halmstad Municipality in a co-production process that included workshops, surveys, interviews and focus group discussions (André et al., 2022).

Due to limitations in historical data, we applied a forward-looking scenario-based approach. Different scenarios were co-constructed, drawing on the Halmstad Municipality adaptation plan (Halmstad Municipality, 2021a,b) combined with stakeholder preferences. The scenarios encompassed disruptions in the water supply, energy sector, health and care services, food supply chain, municipal technical services, and the transportation network. For each sector, stakeholders were asked to identify and discuss which social groups might be affected or need support in case of a disruption of services.

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## BOX 2. KEY CONCEPTS

**Impact chains:** “Impact chains are conceptual models describing climate impact as cause-effect relationships within a socio-ecological system” (Zebisch et al., 2021, p. 40).

**Multi-hazard:** “means (1) the selection of multiple major hazards that the country faces, and (2) the specific contexts where hazardous events may occur simultaneously, cascadingly or cumulatively over time, and taking into account the potential interrelated effects” (UNDRR, 2020, p. 53).

**Cascading effects:** A disruption in one type of infrastructure that causes a failure in a second or several or a disruption of services, potentially spreading to other systems as well (Espada et al., 2015; Eusgeld et al., 2011; Hasan & Foliente, 2015).

**Vulnerability:** “The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards” (UNDRR, 2020, p. 55).

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We thereafter compiled the data into an impact chain to visualize the cause-effect relationship between different components. The impact chain was validated by stakeholders during a workshop. After constructing the impact chain, we searched for cross-cutting themes that could explain physical, social, economic and environmental drivers of social vulnerability. We then grouped the vulnerability factors into five categories, described below: underlying vulnerability, livelihood strategies, infrastructure dependency, cascading effects, and so-called erosive coping, where the disaster response makes the situation worse.

## Social vulnerabilities in Halmstad

The social groups identified as vulnerable are comprised of a diverse set of individuals with access to different resources, skills and opportunities. In this vein, social vulnerability is often the result of multiple intersecting variables (Sparf, 2015). The following five categories illustrate this point,

based on the results from the above co-created processes with stakeholders. Below, stakeholders’ perspectives are described in each category.

### 1. Underlying vulnerability

Individual characteristics, social standing, resources and skills can create underlying vulnerability. Social and demographic characteristics differentiate vulnerability across groups, making some individuals more vulnerable than others, when multiple hazards trigger cascading effects across the infrastructure system. The academic literature (for example, Cutter et al., 2003) identifies many attributes that shape social vulnerability, of which nine were considered relevant in the case of Halmstad:

- **Age:** Children are dependent on others for security and tend to struggle with accessing information on their own. Elderly people are more likely to have mobility constraints or other health problems, which makes them dependent on others in the event of a crisis (Fekete, 2010; Welle et al., 2014).
- **Language:** Some people might lack access to crisis information due to language barriers (Garbutt et al., 2015; Koks et al., 2015).
- **Illness and disability:** People with significant mobility impairments, developmental disabilities, and intellectual disabilities are dependent on others for information and evacuation (Kazmierczak et al., 2015; Sayers et al., 2018).
- **Educational attainment:** Less-educated people are more likely to struggle with accessing information and knowing their rights and obligations in a crisis. In general, those with low educational attainment have less income (Tapsell et al., 2010; Thieken et al., 2007).
- **Single parent households:** Some single parents may have less access to social networks while having to support other dependents, which increases caring responsibilities and enhances dependency on childcare services or the school system (Garbutt et al., 2015; Sayers et al., 2018).

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- **Vehicle ownership:** Owning one's own vehicle reduces social vulnerability as it can facilitate emergency evacuation (Kazmierczak et al., 2015; Vink et al., 2014).
  - **Housing:** People living in single-family houses are considered vulnerable, as they have greater responsibilities for implementing disaster risk reduction measures in comparison to those living in apartments (Lindley et al., 2011; Thieken et al., 2007).
  - **Income:** Households with incomes below average have less capacity to cope in the case of a crisis, as they have smaller amounts of financial resources to invest in efforts towards disaster risk reduction (Fekete, 2010; Vink et al., 2014).
  - **Unemployment:** Unemployed people are more likely to spend time alone in their residences; hence, they may have to handle the initial phase of a crisis on their own. In addition, they are more likely to have less financial resources (Sayers et al., 2018; Tapsell et al., 2010).

Examples of how stakeholders perceived these attributes to play out include the following. Low-income households are assumed to be more vulnerable to disruptions to the food supply chain because they are less likely to have emergency food storage and so have less coping capacity in the case of high and volatile food prices. In the case of disabilities, people may be disproportionately affected in the case of disruption in transportation services, for example if they rely on public transport or disability transportation services for mobility, as their disability inhibits access to other modes of transportation such as cycling or walking.

## 2. Livelihood strategies

Livelihood strategies determine exposure to multiple hazards and their cascading effects, as well as shape capacity to cope and adapt. Some parts of the workforce are not able to work remotely, including those involved in emergency response, who are also particularly exposed to risk. For example, vulnerability can increase among operational personnel restoring infrastructure following a disruptive event – repairing telephone and electricity lines, for example.

To meet this demand, operational personnel at times expose themselves to significant risk. Occupational accidents may occur, as happened in the 2005 Cyclone Gudrun, when 11 people perished during the storm clean-up (Holmström, 2006).

Healthcare staff, social workers, caregivers, support workers, and similar caring roles represent other vulnerable occupations. Such workers might have a strong sense of professional duty and personal obligation that persists, despite experiencing barriers imposed by multiple hazards and their cascading effects. Caregivers and emergency personnel must be able to reach their patients even in the direst circumstances, which can result in risk-taking behavior. For example, stakeholders noted that when a large snowstorm hit Halmstad in 2021, home care providers continued to travel to their patients. Some were stranded in their cars due to the poor road conditions from the snowstorm.

## 3. Infrastructure dependency

Society depends on infrastructure services daily, and disruptions can generate new groups of disadvantaged individuals. Infrastructure disruptions and their impacts on people are shaped by redundancy – the extent to which system components or services are substitutable (Bruneau et al., 2003).

For example, households with only one accessible grocery store may suffer worse impacts in the case of a disruption in the food supply chain, according to the

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discussions with stakeholders in Halmstad Municipality. Members of rural households tend to travel longer distances in a disruption, to find another grocery store than the one they usually visit.

According to stakeholders, people with certain disabilities may have fewer alternatives when it comes to grocery stores, as few physical stores are adapted to special needs, such as wheelchair access. Vulnerability also may arise if a person does not receive assistance from the municipality prior to a disruption and is living “under the radar”.

A non-weather-related example revealed some of these vulnerabilities: in 2021, a cyberattack targeted the Swedish food store chain Coop, forcing most of the stores to close for several days. Most residents in Halmstad probably managed the disruption by simply shopping at other grocery stores, whereas others might have experienced a more severe impact if Coop was the only nearby store adapted to their needs or within reach.

For water resources, the opposite situation for rural and urban dwellers may hold true: households located in rural areas are more likely to own a well, which makes them less dependent on the municipal water supply in the case of a water outage. Some rural households may also live close to a lake from which they can collect water. In comparison, urban residents living in apartments are less likely to have access to an alternative water source.

#### **4. Cascading effects**

As with infrastructure systems, impacts on a social group can trigger cascading effects on the provision of services and, in the end, generate new vulnerable groups. For Halmstad and other municipalities, this was particularly evident in the Covid-19 pandemic; although a different type of event than multiple water-related hazards, it provides important lessons.

For example, longer disruptions in the educational system affect children and their families, despite remote learning being a viable option for some. Young children cannot be home alone but require their parents’ supervision. Some disabilities can make children less capable of remote learning, as is the case with children with neuropsychiatric disabilities who struggled with transitioning to remote learning.

According to the discussions with stakeholders, women are more likely to stay at home with their children. In addition, single parents are heavily affected, as caring responsibilities cannot be shared. Many single mothers work within the healthcare sector in Halmstad increasing the likelihood of cascading effects on healthcare provision if they are forced to stay home with their children instead of going to work.

#### **5. Erosive coping**

Erosive coping refers to the disaster management strategies that result in an increase rather than a decrease in vulnerability. Erosive coping as a term refers to the short-term strategies following disruptive events, in contrast to the term maladaptation, which refers to the negative consequences that arise when adapting to long-term changes and future disruptions (Juhola et al., 2016; Warner et al., 2012).

The Covid-19 pandemic provides an example of erosive coping across Sweden, where some crisis communication efforts reinforced social vulnerabilities by amplifying differential access to information. Similar patterns are expected in the case of multiple weather-related hazards that trigger cascading effects. In Halmstad, access to information depends on various factors, in particular language skills; educational attainment; age; and illnesses and disabilities. People without access to information

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sources via mobile phones, television or radio may also struggle to get information, whether because they do not own these devices or do not speak the language broadcast to them.

When risk strategies for coping with crises leave the responsibility to an individual or household, existing social inequalities can be reinforced, as shown during the Covid-19 societal shutdown at a global scale. As in most parts of the world, homeschooling meant that families in Halmstad with higher education and better financial means had an advantage in ensuring their children's continued education, as well as providing meals or equipment. Thus, the factors that made these families particularly vulnerable before the pandemic were amplified through the coping strategies during the pandemic.

## Implications for disaster risk reduction

Using Halmstad as an example, we illustrate that social vulnerabilities are situational and contextual, a finding that is in line with previous research (Kuran et al., 2020). Social vulnerability is dependent on pre-existing structural factors and processes, as well as how a disruptive event unfolds. Multiple hazards and their cascading effects can cement existing or create new vulnerabilities, temporarily or in the long-term.

We recommend that local authorities expand their local risk and vulnerability assessments to include the social dimension and which social groups that might become vulnerable during a water-related hazard, as well as potential cascading effects from such events. By identifying who might be in need of support today, local authorities can design appropriate response mechanisms that target the most vulnerable in time for future events. Urban planners and risk managers can elaborate on their ongoing work assessing infrastructure risk by asking which social groups depend on these functions and who, therefore, might suffer from the potential impacts in the case of a disruption.

To this end, we consider the impact chain model useful for studying emerging vulnerabilities. The impact chain model provides practical guidance on how to assess risk and vulnerability systematically, comprehensively and contextually. As demonstrated, the impact chain model can describe important links between natural hazards, infrastructure disruptions and vulnerability, thus providing an understanding of the multidimensional, time-dependent and situational factors that shape social vulnerability. The impact chain model can be used to identify potential solutions, as well as monitor their impact to avoid maladaptive outcomes (e.g. Zebisch et al., 2021). Further testing is, however, needed.

Moving forward, we recommend that research continue to support decision-makers and practitioners by identifying viable adaptation options for reducing social vulnerability. A number of gaps exist in the available knowledge and practice for developing adaptation measures that address social vulnerability. To be effective, adaptation measures must target root causes of social vulnerability (Schipper, 2020). An analysis beyond social factors is needed, in which the focus should be on formal rules, laws and regulations, as well as on informal norms, traditions and value systems, in order to understand root causes of vulnerability.

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#### 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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UNCHAIN is a cooperation between 10 research partners, led by the Western Norway Research Institute and Ramboll Group. UNCHAIN aims to develop and improve the impact chain model, first introduced by Schneiderbauer et al. (2013) and catalysed by Fritzsche et al. (2014; 2017), by introducing six methodological and thematic research and innovation areas through 11 case studies around Europe. UNCHAIN is funded through a collaboration between the EU funding mechanisms "Joint Programming Initiative" (JPI) and "Assessment of Cross (X)-sectoral climate impacts and pathways for Sustainable transformation" (AXIS). Sweden's contribution is financed by FORMAS with co-financing from the European Union (Grant No 776608). The project is active from September 2019 until March 2023.