RESEARCH

Facts: HydroHazards

Managing vulnerabilities to multiple water hazards in Sweden

What risks might cascade from multiple hydrometeorological hazards in Sweden? How will climate change alter the risk of disastrous domino effects? What are the implications for infrastructures and social groups? What measures are needed to reduce vulnerabilities? HydroHazards evaluated the damage that could be caused by multiple water hazards and based on this, provides recommendations of policies and actions for mitigation and adaptation.

HydroHazards was a 5-year project financed by the Swedish Civil Contingencies Agency and FORMAS, starting January 2020 and ending December 2024. The HydroHazards project contributed to Sweden's disaster risk policies by focusing on how to manage multiple hydrometeorological hazards and exploring strategies for reducing and adapting to these risks. The project looked at how exposure to several water hazards at once can have combined or interacting effects on important services and communities. In this way, HydroHazards added valuable insights to the work of the Swedish Civil Contingencies Agency, which aims to address these risks to mitigate their potential impacts on society.

Project Results

HydroHazards implemented interdisciplinary approaches from social and natural sciences to address vulnerabilities at local and regional scales in Sweden, involving stakeholders from multiple societal sectors. The project was executed through three Research Themes:

Research Theme 1: Assessing Hotspots of Multiple Water Hazards and Exposures

How do multiple water hazards combine?

A nation scale analysis looked at flood risks across Sweden by examining coastal flooding, rainfall, and river streamflow, focusing on how these distinct flood risks vary throughout the year. The main results showed that in most areas, extreme river discharge from spring floods usually happen later in the

HYDRO HAZARDS

Project Title

Managing vulnerabilities to multiple water hazards in Sweden (HydroHazards)

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Further reading:
Populärvetenskapliga rapporten

Project website:
www.sei.org/hydrohazards

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Publication number: MSB2553 – september 2025 | Produktion: Advant

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season compared to extreme sea levels. However, in some parts of the west and southeast coast, both types of water hazards can occur around the same time, which is why Halmstad was chosen for a case study.

Additionally, extreme rainfall tends to occur in the summer across the whole country because warmer air holds more moisture. The analysis also found that large sections of the coast experience extreme sea levels during specific weather patterns. Different patterns affect the west, south, and north coasts, but these sea level extremes often happen simultaneously over wide coastal areas. This could make it difficult for nearby municipalities to assist each other during major flooding events.

What are the hotspots and trends of multiple water hazards?

The project also assessed hotspots and trends of heatwaves, droughts, and flood risks using climate indices in Sweden. Results show that heatwaves are becoming more frequent and severe, especially in the most populated areas in the south. Trends suggest flood risks are also becoming more common, especially in southern and northern regions. Although this wetting trend indicates an overall decreasing incidence of droughts, compound analysis showed that droughts have been overlapping with heatwaves, intensifying their impacts. The summers of 2018 and 2022 are recent examples of droughts significantly impacting the Swedish economy.

Research Theme 2: Assessing Differentiated Vulnerabilities

How are the concepts of multiple hazards and cascading effects employed in academic literature and practice?

The findings from literature review show that although scientific methods to assess multiple hazards and their chain reactions are available, local planners rarely use them. This suggests a disconnect between research and practical planning. Current research mainly looks at hazards through technical details, like how severe they are or the direct impact on infrastructure but pays less attention to how these effects spread across different sectors and increase societal risk. New studies should explore how disruptions to infrastructure and services can create new vulnerabilities, rather than only focusing on pre-existing social risks.

How are different social groups exposed and vulnerable to multiple water hazards?

A case study in Halmstad municipality adapted a Social Vulnerability Index to measure flood risks, identifying several key factors that influence vulnerability, such as age, language barriers, health conditions, education, and income. Vulnerable groups include young children, the elderly, foreign-born residents, people with disabilities, low-income households, and single-parent families. Factors like car ownership and housing type also affect flood resilience. The analysis found stark differences in vulnerability across neighbourhoods, with eastern areas having lower socioeconomic status and higher risks compared to more affluent western areas.

The study grouped these variables into three main vulnerability factors. ”House-owners with children” scored high in rural areas with single-family homes, ”People outside the labour force” were most vulnerable in low-income eastern neighbourhoods, and ”Elderly with accumulated wealth” showed lower vulnerability in wealthier coastal areas. Additionally, geographic exposure to flood risks was considered. Overall, 22% of Halmstad’s population lives in the most vulnerable neighbourhoods, highlighting significant socioeconomic disparities in flood risk.

Key concepts

Multiple hydrometeorological hazards are hazardous events that occur simultaneously, cascadingly or cumulatively. In Sweden, these arise mainly from snowmelt and peak river flow, heavy and persistent large-scale rainfall, small scale cloudbursts, and coastal surges.

Differentiated vulnerabilities among social groups or CCSIs are caused by different economic, cultural, and political contexts that cause different impacts depending on for instance age or gender (in the case of social groups).

CSSI is a collective term that encompasses the activities, facilities, nodes, infrastructures and services that are crucial for maintaining important functions in a society. An infrastructure or service is considered of critical importance if a loss of or a serious disruption to its operations in a short period of time can lead to a crisis in society; or if its operations are essential for a crisis to be managed and adverse effects minimized.

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Research Theme 3: Cascading Risk Scenarios from Impacts of Multiple Water Hazards

Based on the HydroHazards framework, a model was created to estimate scenarios of cascading risks in Critical Societal Services and Infrastructure (CSSI). The model maps out how essential services like energy, water, and communications are linked, such as the flow of electricity from power plants to hospitals. By creating a network of infrastructure interdependencies across five layers—energy, water, communication, transportation, and emergency services—the model can measure critical points and vulnerabilities. It was tested in Halmstad, with local stakeholders providing insights on which services are most vital.

How can the interdependencies of essential systems be mapped and assessed to identify critical points of vulnerability?

The results for Halmstad revealed that communication towers, power plants, and water treatment services were the most critical due to their connections to other sectors. Disruption scenarios at these points, particularly from flooding, could trigger widespread failures. For example, a flooded power plant could affect multiple services across the network. Residential, industrial, and educational infrastructure were among the most vulnerable, as they depend heavily on basic services.

What are the most critical infrastructure nodes that need to be protected to prevent cascading failures during flooding events?

This research highlights the value of understanding infrastructure interdependencies to improve urban resilience against multiple flooding hazards. The implemented model serves as a practical tool for local planners to identify systemic vulnerabilities and prioritize climate adaptation investments. An interactive visualization tool was developed for the climate adaptation planner in Halmstad to access the results of the case study.

Publication number: MSB2553 – september 2025 | Produktion: Advant

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