

Security of Supply in Food, Drinking Water, Energy, and Transport Sectors in the Face of Climate-Related Extreme Events

Understanding food, drinking water, energy and transport as interconnected systems

UUniCORN Insight Series

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Summary

This Insight report is an outcome of the UUniCORN catalyst-funded theme "Water, Energy, and Food Security in the Face of Climate Challenges". A research incubator organised within the theme laid the foundation for the work, while UUniCORN catalyst funding subsequently supported parts of the research, leading to the literature review "Försörjningsberedskap för livsmedel, dricksvatten, energi och transporter och dess motståndskraft mot klimat-relaterade extremer – En kunskaps-översikt" for the Swedish Civil Contingencies Agency (MSB).

Based on a scoping review of 140 scientific articles, the report highlights three central insights. First, food, drinking water, energy and transport cannot be treated as separate supply systems: strong interdependencies mean that disruptions in one sector can rapidly cascade into others. Second, current research still captures these interconnected risks only partially, with major gaps concerning compound and cascading events, Nordic conditions, and drinking water systems. Third, strengthening preparedness requires more integrated approaches, including better data and models capable of representing interactions across sectors and multiple simultaneous hazards. Preparedness planning therefore needs to consider both how disruptions spread between critical supply sectors and how measures in one sector can create trade-offs or conflicts in another.

1. Introduction

Water, energy, and food (WEF) are fundamental to human well-being, yet they are increasingly threatened by climate change and extreme weather events. Food security depends on reliable energy and transport systems for production, processing and distribution, while drinking water relies on electricity for treatment and supply. These interdependencies mean that disruptions in one sector can quickly cascade into others. They can also create potential goal conflicts: measures that strengthen preparedness in one sector may increase pressures on another sector or conflict with climate, environmental or economic objectives. As floods, droughts, storms and heatwaves become more frequent and intense, ensuring resilient supply systems has become a major cross-sectoral challenge.

This work grew out of the UUniCORN catalyst-funded theme "WEF Security in the Face of Climate Challenges," which brings together research on supply security, climate-related risks and the interdependencies between critical resource systems. As part of the initiative, a research incubator provided a forum for developing the research questions and collaborations that laid the foundation for this work. UUniCORN catalyst funding subsequently supported parts of the research leading to the literature review presented here.

The literature review for the Swedish Civil Contingencies Agency (MSB) *"Försörjningsberedskap för livsmedel, dricksvatten, energi och transporter och dess motståndskraft mot klimatrelaterade extremer – En kunskapsöversikt"* synthesises current research on how climate-related extreme events affect critical supply systems. While the UUniCORN theme focuses on water, energy and food security, transport is included here as a critical enabling system linking these supply sectors and shaping their resilience to disruptions. Based on a scoping review of 140 scientific articles published since 2015, the study examines vulnerabilities across the food, drinking water, energy and transport sectors. The findings show that supply preparedness cannot be addressed from a single-sector perspective because these systems are tightly interconnected. Food production depends on water, energy and transport; drinking water requires electricity; energy systems rely on water and fuel; and transport depends on electricity and digital infrastructure. Strengthening resilience therefore requires a systems approach that recognises these complex dependencies and improves preparedness for cascading disruptions across interconnected critical infrastructure.

2. Cross-Sectoral Results

The reviewed literature shows that floods and torrential rain are the most frequently studied climate-related extremes, followed by storms and droughts. Heatwaves and wildfires receive less attention, while extreme cold, heavy snowfall, avalanches and landslides are rarely examined. Research also differs by sector: storms dominate transport and energy studies, drought is mainly studied in food and drinking water, while floods and extreme heat are addressed across all sectors.

Although this pattern may reflect actual risks, it also reveals important research gaps. Storms can disrupt not only electricity and transport but also refrigeration, food deliveries, payment systems and water supply. Likewise, droughts negatively affect agriculture, water resources, and hydropower production, and increase the risk of wildfires that may disrupt food production, transport, and the production and distribution of electricity and drinking water. Research focusing on single hazards or sectors may therefore overlook the cascading effects and interdependencies that shape Security of supply.

3. Sector-Specific Results

Food

The food supply chain is susceptible to disruptions at every stage from production to consumption. Drought and heat can reduce crop yields, lower food quality and nutritional value, increase livestock illnesses and mortality, reduce milk production, and create feed shortages. In Sweden, where over 90% of agriculture depends on rainfall, changing precipitation patterns pose a significant risk. Floods can destroy crops, degrade soils, contaminate water sources, and damage agricultural infrastructure, while wildfires and storms threaten livestock, disrupt electricity, telecommunications, and the delivery of essential supplies.

Food processing, cold storage, transport and retail all rely on stable electricity and fuel supplies. Disruptions to roads, railways or ports can quickly lead to empty grocery store shelves. Studies show that storm-affected stores may experience supply shortages for up to ten days, with rising food prices disproportionately affecting lower-income households.

Transport

Transport systems, including roads, railways, ports and fuel distribution, are essential for maintaining supply chains. Storms, floods, and landslides can damage infrastructure and isolate communities, while extreme heat can deform railway tracks. Where alternative routes are limited, disruptions last longer and increase transport costs. Damage to major ports can also affect national and international trade.

Fuel shortages present another critical vulnerability. Extreme weather conditions can increase fuel demand during evacuations, emergency response and power outages, especially when fuel-powered generators are widely used. At the same time, many fuel stations rely on electricity to operate pumps and payment systems. These combined pressures can quickly reduce fuel availability, making reliable fuel supplies essential for transport resilience and overall supply security.

Energy

Electricity is a critical infrastructure for all sectors of society. Power systems are increasingly vulnerable to climate-related extremes, including floods, storms, droughts and extreme temperatures. Storms and floods can damage grids and substations, while drought reduces hydropower generation and limits cooling water for power plants. Heatwaves increase electricity demand while reducing cooling efficiency, and increases the risk of wildfires, and extreme cold can damage power lines and create demand that exceeds grid capacity.

Climate-related extreme events also threaten fuel supplies. Floods and droughts reduce biofuel production, cold temperatures affect fuel quality, and power outages can disable petrol pumps and payment systems. Fuel shortages further disrupt backup generators, transport and electricity production, increasing risks to supply security.

Drinking water

Drinking water has received limited research attention, with studies focusing mainly on water contamination and supply shortages caused by climate-related extremes. Droughts can lead to local water shortages, while floods may disrupt water supplies by damaging treatment plants and flooding infrastructure. Extreme temperatures can also affect drinking water systems by damaging pipes or causing power outages that interrupt treatment and distribution. Flooding is the most common hazard affecting water quality, as it mobilises pathogens and other contaminants. Wildfires can further degrade water quality by spreading ash and debris into water sources. Together, these impacts increase the vulnerability of households and communities to interruptions in safe drinking water supplies.

4. Dependencies and Cascading Effects

Interconnected systems and cascading effects make disaster preparedness increasingly complex. Climate-related extreme events can trigger disruptions that rapidly spread across food, drinking water, energy and transport systems. Because these sectors are closely interconnected, failures in one system often create widespread and sometimes unexpected cascading effects.

The food sector, for example, illustrates these dependencies. Food production, processing, storage and distribution rely on functioning transport, electricity and water, among many other systems. Transport is essential for delivering raw materials, fuel and feed at the production stage, while electricity powers production, refrigeration and irrigation. Drought and flooding can reduce water availability and disrupt hydropower generation, a major source of electricity in Sweden. Transport networks are also critical for repairing

damaged infrastructure and maintaining access to isolated communities. As many grocery stores operate with limited inventories, even short-term transport disruptions can quickly affect food availability.

The four illustrative cases below show how climate-related extreme events can disrupt interconnected systems and cause cascading effects. Disruptions in one sector can quickly cascade through interconnected systems.

- **Wildfire:** Extreme heat can trigger a wildfire, leaving soil vulnerable to erosion. When there is no vegetation left it makes the soil more prone to flush away during floods or heavy rain. Heavy rainfall can then lead to landslides and flash floods, causing damage to roads and railways.
- **Heatwave:** Heat stress can reduce dairy production, leading to lower milk and cheese supplies, higher food prices and economic losses across the food sector.
- **Flood:** Flooding can disrupt transport networks and delay food deliveries. Panic buying further amplifies shortages, even when food supplies remain adequate.
- **Storm:** Storm damage can disrupt fuel deliveries and cause power outages. Increased demand for fuel to power backup generators further strain limited supplies.

5. Methods and Models

Of the 140 articles reviewed, 39 used or introduced models and methods to assess the impacts of climate-related extreme events on critical supply systems.

Most focused on transport (64%), followed by food (31%), energy (23%), and drinking water (15%). Floods were the most commonly studied extreme (49%), followed by storms (26%) and droughts (26%).

Most studies use simulations, often combined with case studies or scenario-based analyses. However, they largely focus on current conditions: only 10% examine historical events, and just 8% consider possible future events. Existing approaches also tend to focus on individual sectors and hazards, leaving important gaps in representing compound events, cascading effects, and changing socioeconomic conditions.

6. Knowledge Gaps and Research Priorities

The review identifies four areas that need further research: cascading effects and complex dependencies, linked crises or polycrises, improved data and models, and the role of households and inclusion. Addressing these gaps is important for understanding how climate-related extremes affect supply systems and for strengthening future preparedness.

Cascading Effects and Complex Dependencies

Future research should focus on the complex dependencies and cascading effects linking critical supply systems. As food, drinking water, energy and transport become increasingly interconnected, disruptions in one sector can rapidly spread to others. Understanding these interactions is essential to improve preparedness and strengthen security of supply.

Linked Crisis or Polycrises

Eighty-seven per cent of the reviewed studies did not address linked crises or polycrisis. This is an important gap, as climate-related extremes may occur alongside other disruptions or interact with multiple simultaneous events. Future risk assessments therefore need to better capture how interconnected crises can amplify impacts across supply systems.

More Data and Models

There is a need for more specific and higher-quality data to improve supply security and climate risk modelling. Research coverage is geographically uneven, with major gaps in climate-sensitive and vulnerable regions with limited data availability, including a clear lack of studies from the Nordic region. In the Nordic context, drinking water systems, food supply chains, and storm impacts on agriculture are particularly understudied. Many existing models rely on limited data, focus on specific sectors, and use assumptions that fail to capture real-world behaviours, such as panic buying or changing transport conditions. Many models also focus on single hazards, overlooking compound events, cascading effects and interactions between critical sectors. Developing integrated models and datasets tailored to Nordic conditions is therefore essential for improving preparedness and resilience.

Role of Households and Inclusion

The role of individuals and households remains understudied. Many existing models assume rational behaviour during crises, yet responses such as panic buying can worsen food shortages. More research is needed on household preparedness, including topics such as food storage, food literacy, and the ability to cope with prolonged power outages. Researchers also emphasise the importance of addressing vulnerability, equity and inclusive risk communication to ensure that preparedness measures reach all demographic groups. Risk communication should better reflect everyday motivations of households and improve outreach to rural communities, which are often overlooked in national preparedness campaigns.

7. Conclusions

Climate-related extreme events can disrupt food supply, drinking water, energy, and transport systems in ways that extend far beyond the initially affected sector. Because these systems depend on one another, preparedness needs to account for how disruptions can cascade across critical infrastructure and supply chains.

For research, the main gaps concern compound and cascading risks, linked crises, Nordic conditions, and the limited representation of future events and human behaviour in existing models. Better data and more integrated modelling approaches are needed to understand how multiple hazards and sectoral dependencies interact, and to identify where vulnerabilities are likely to emerge.

For preparedness, this means looking beyond individual sectors. Planning needs to consider not only how disruptions spread across food, water, energy, and transport systems, but also how measures to strengthen resilience in one sector may create pressures, trade-offs, or goal conflicts in another. Such a cross-sectoral perspective can support more robust decisions under increasingly uncertain climate conditions.

References

Albrecht, F., Koivisto, J., & Teutschbein, C. (2025). Försörjningsberedskap för livsmedel, dricksvatten, energi och transporter och dess motståndskraft mot klimatrelaterade extremer: en kunskapsöversikt. Swedish Defence University Report Series 2025:1. https://doi.org/10.62061/tzxi9045

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About UUniCORN

Uppsala University Conflicting Objectives Research Nexus (UUniCORN) is the first of Uppsala University's Future Institutes (UUniFI), dedicated to advancing worldleading research on complex societal challenges through a transdisciplinary lens. UUniCORN seeks to initiate, facilitate and conduct research on goal conflicts in sustainability transformations, and to contribute to societal transition through collaborative action.