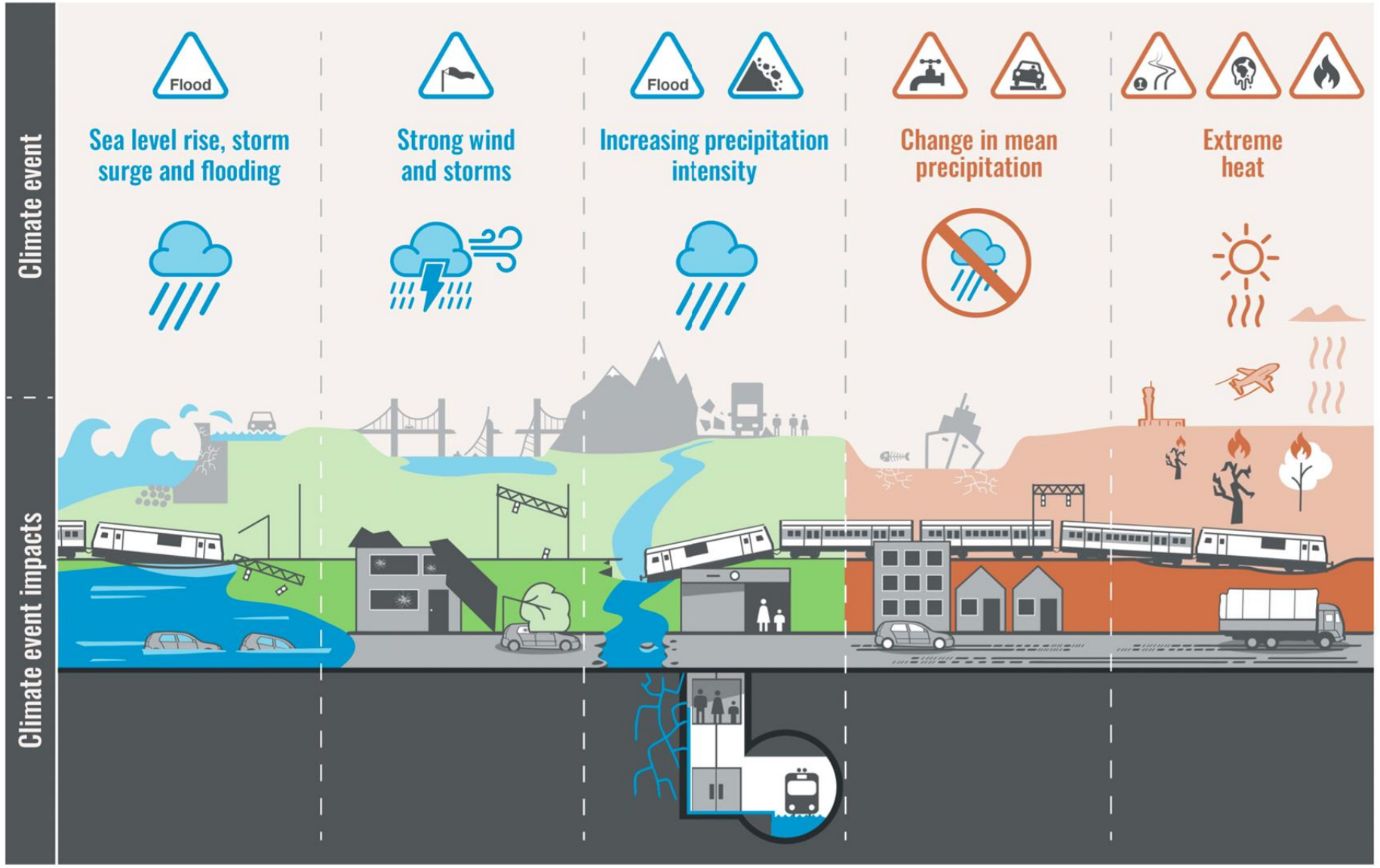
Navigating Climate Risks in Rail Transport: Weather Impacts, Governance Challenges, and Adaptation Measures

MICHELLE OCHSNER – LUND UNIVERSITY & K2

KAJT HÖSTSEMINARIUM – 27.11.25

Introduction & Background

Impacts of Weather & Climate Change on Transport Infrastructure



Greenham et al. (2022) Climate-Resilient Transport: A Policy Guide

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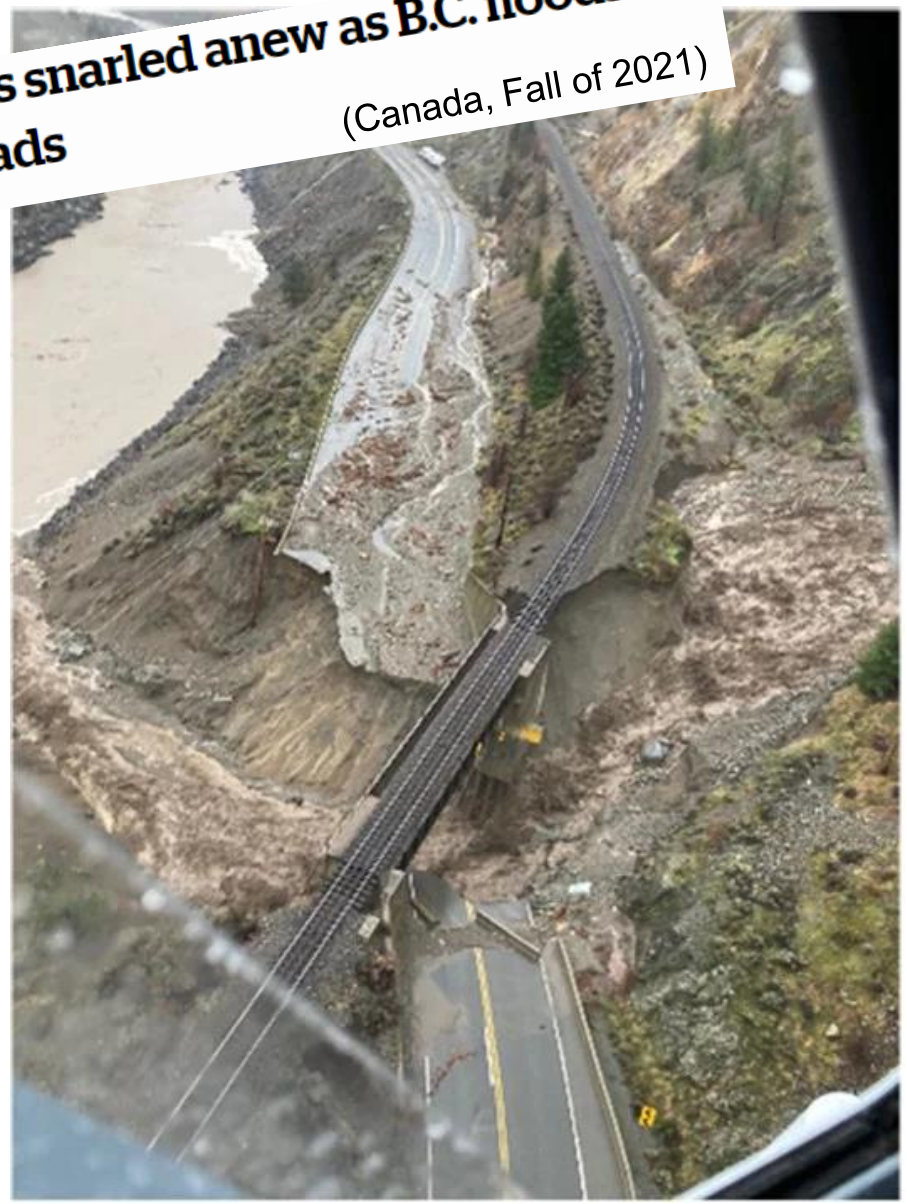
Stressed supply chains snarled anew as B.C. floods wash out rail lines, roads

(Canada, Fall of 2021)



https://www.cbc.ca/news/business/bc-floods-rail-impact-1.6250554

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(UK, Summer of 2022)

https://www.bbc.com/news/uk-england-gloucestershire-62199856

Two Swiss trains derail in strong winds, several injured

(Switzerland, spring 2023)

https://www.swissinfo.ch/eng/two-swiss-trains-derail-in-strong-winds--several-injured/48409580

 https://www.euronews.com/2023/08/08/three-injured-after-train-derails-in-sweden-as-storms-cause-havoc-across-northern-europe

https://www.dn.se/sverige/tagstopp-i-norr-hart-slag-mot-industrin/

Research Gap

- Climate adaptation research for transport, especially railway, has received less attention compared to other sectors.
- Two streams of literature:
  - Quantification of weather and climate change impacts.
  - Climate change adaptation strategies and decision making.
- Few studies combine these.

Train Street, Hanoi, Vietnam, 2023. Source: Own photo

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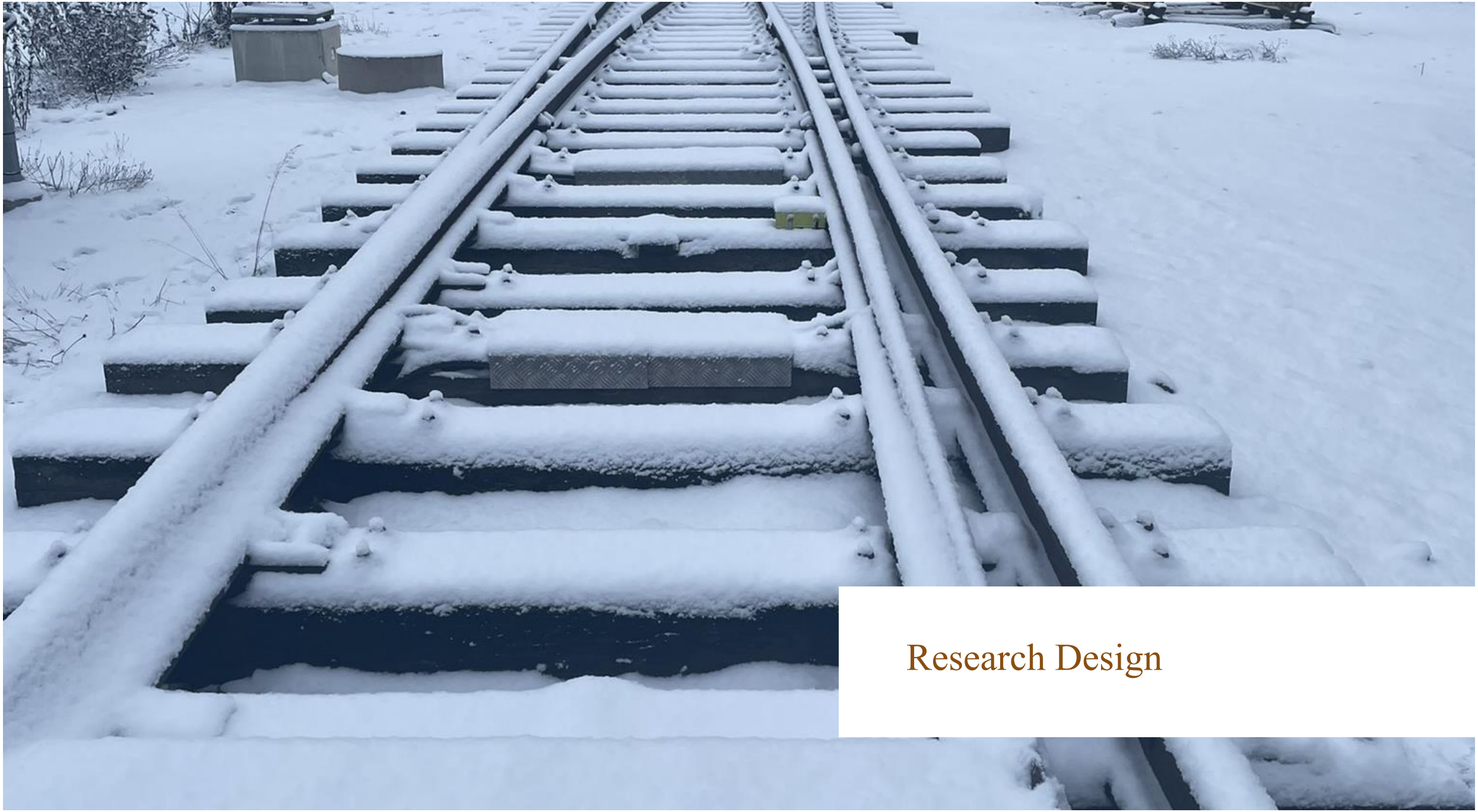

Research Design

Research Aim

- Advance the understanding of climate adaptation processes, using the railway sector in the Swedish context as a lens to examine how adaptation is approached & implemented in practice.
- This is done by:
  - Exploring how weather affects railway operations and infrastructure.
  - How governance structures and planning approaches shape the ability to adapt to climate change.

Mitlödi, Switzerland, 2024. Source: Own photo

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Included Papers

I. The effects of flooding on railway infrastructure: A literature review.

II. Weather and Train Disruptions in Sweden, 2011-2019.

III. The impacts of weather on railway infrastructure in Sweden.

IV. Barriers and Opportunities for Dynamic Adaptation of Coastal Railways.

V. Barriers to Climate Change Adaptation in Swedish Railway Infrastructure.

VI. On Track to Climate Resilience? Insights from Japanese Railways.

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Research Questions

- **Research Question 1:** What are the impacts of weather on railway operations and infrastructure in Sweden?
- **Research Question 2:** What are the challenges to adapting the railway sector to climate change within current governance structures in Sweden?
- **Research Question 3:** What lessons can be drawn from different strategies and planning frameworks to inform climate resilience in Swedish railways?

	Paper Number					
Research Questions	I.	II.	III.	IV.	V.	VI.
RQ 1.	X	X	X			
RQ 2.				X	X	
RQ 3.	X			X		X

Research Design

- Philosophical underpinnings
  - Wicked problems (Rittel & Webber, 1973)
  - Situated knowledges (Haraway, 1988)
  - Plural epistemologies (Nightingale, 2003; 2016)
- Mixed methods & interdisciplinary approach

	Paper Number					
Method Approach	I.	II.	III.	IV.	V.	VI.
Quantitative		X	X			
Qualitative	X			X	X	X

Data Sources

Quantitative

Qualitative

Weather Data
SMHI

Operations Data
Swedish Transport Administration

Infrastructure Fault Data
Swedish Transport Administration

Climate Zone Data
Beck et al. (2018)
Köppen-Geiger

Workshop Data
Fieldwork

Interviews Data
Fieldwork

Literature
Scopus
Experts
Websites

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Methods of Analysis

Literature Review
Paper I & IV

Visual Graphical Analysis
Paper II & III

Fault Rate Analysis
Paper III

Thematic Analysis
Paper IV – VI

Answering the Research Questions

Research Question 1:

What are the impacts of weather on railway operations and infrastructure in Sweden?

Papers I – III

Overview of weather-related susceptibilities. ‘X’ indicates a determined relationship

	Operations	Switches	Signals	Tracks	Catenaries
Snow Depth	X	X		X	
Temperature	X	X		X	X
Precipitation	X			X	X
Wind Speed	X			X	X

- Snow depth, temperature, precipitation, and wind speed all impact railway operations but to varying degrees.
- Track assets are the most vulnerable assets to all types of weather while signals are the most resilient.
- When comparing two climate zones, notable differences were observed for track assets.
- Swedish railways are most vulnerable to winter-related weather conditions:
  - High snow depths
  - Low temperatures
  - High wind speeds

Research Question 2:

What are the challenges to adapting the railway sector to climate change within current governance structures in Sweden?

Papers IV – V

Challenge Area

Legislation

Resources

Prioritisation

Knowledge

Challenge Area	
Legislation	Fragmented governance; unclear mandates; misaligned policies; siloed responsibilities; contested funding; complex land-use laws
Resources	
Prioritisation	
Knowledge	

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Legislation	Fragmented governance; unclear mandates; misaligned policies; siloed responsibilities; contested funding; complex land-use laws
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Prioritisation	
Knowledge	

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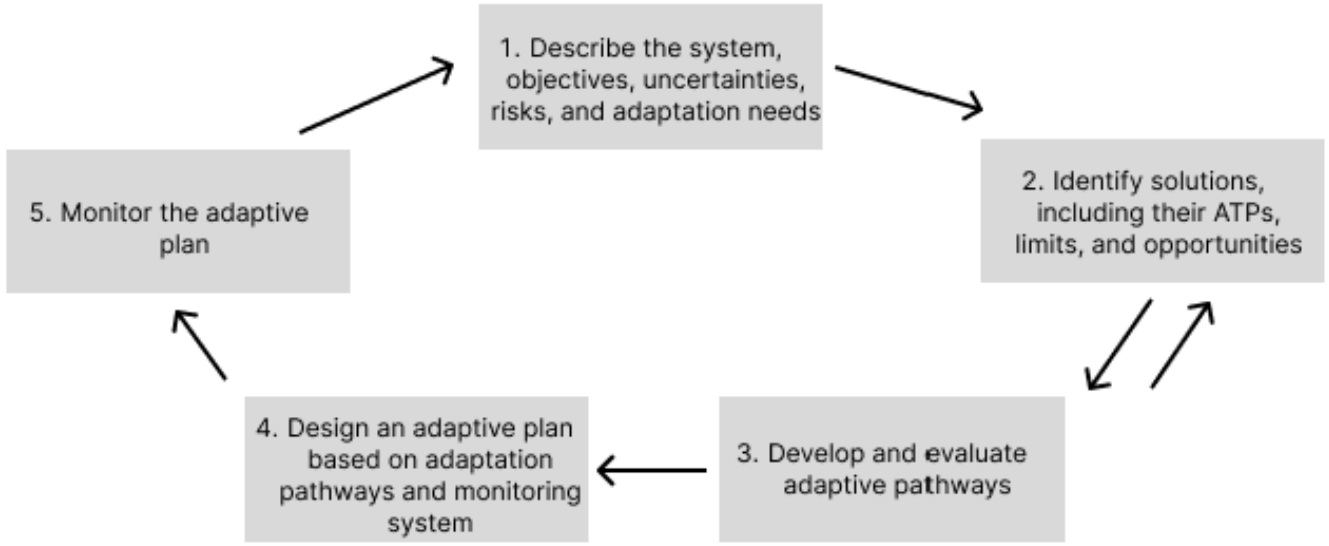
Prioritisation	Climate adaptation seen as future issue; slow investment processes; political cycles; rigid planning
Knowledge	Varying understanding of climate adaptation; gaps in climate modelling and risk assessment; confusion between climate adaptation and climate mitigation

Research Question 3:

What lessons can be drawn from different strategies and planning frameworks to inform climate resilience in Swedish railways?

Papers I, IV, VI

Adopting Dynamic Approaches



Dynamic Adaptive Pathways Planning (Paper IV)

- Enables flexible, long-term decision-making by identifying adaptation tipping points and adaptation pathways.
- Enables reflections on current plans, highlights lock-ins, and promotes collaboration.

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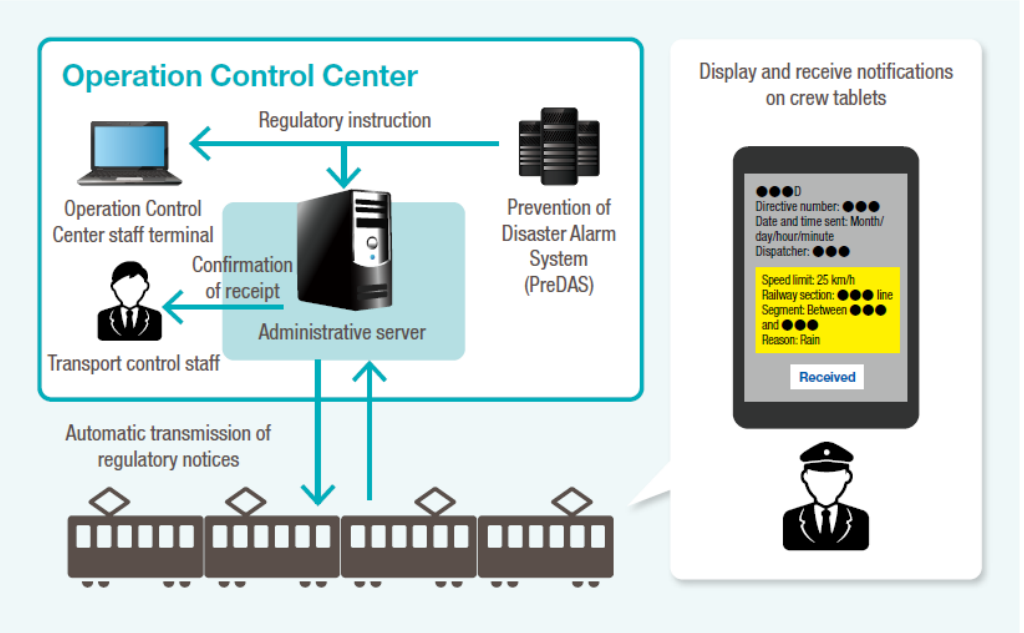
Real-Time Monitoring & Early Warning Systems



JR East, 2023

- Supports proactive decision-making, such as when to suspend services or activate structural measures.
- Helps to understand the weather conditions at specific railway assets to take into account microclimate.

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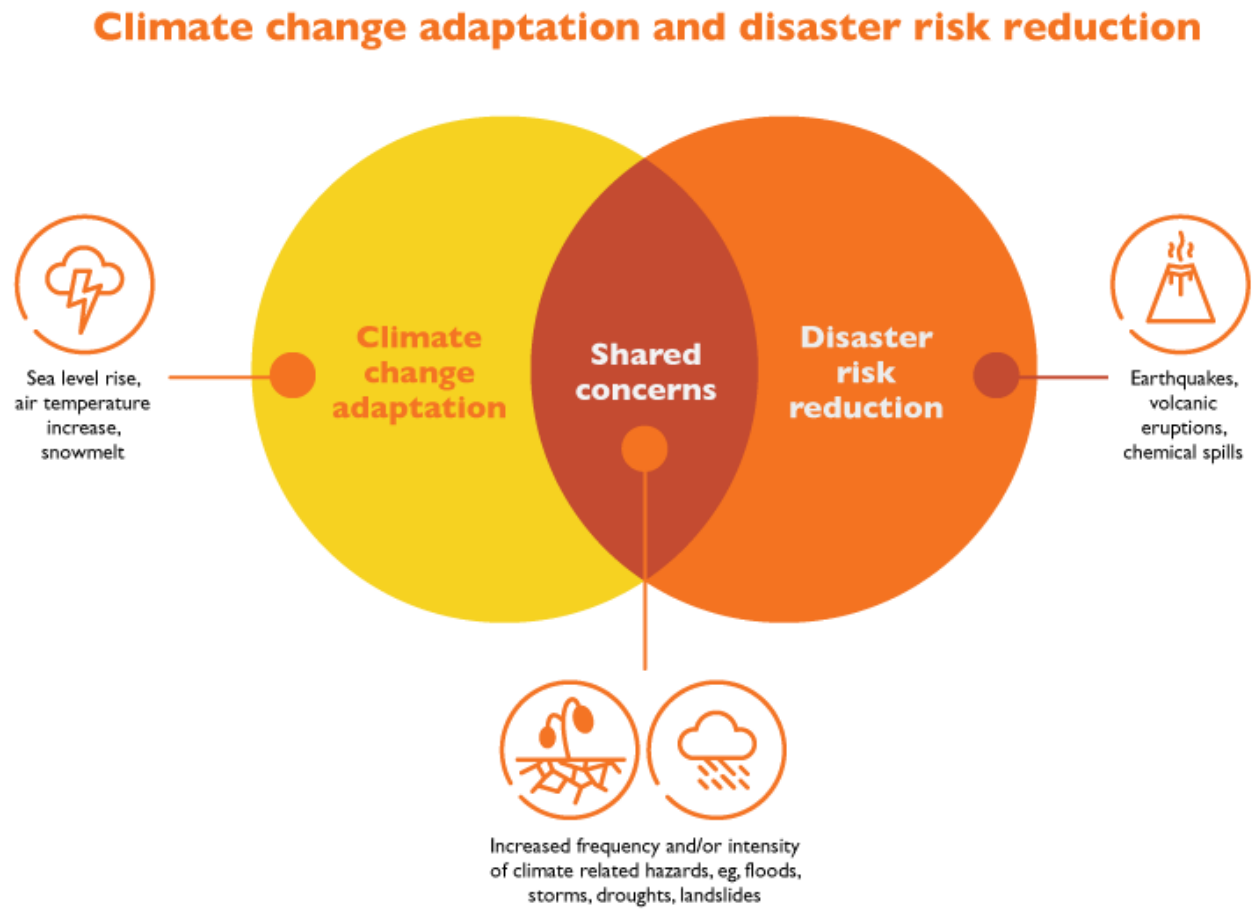
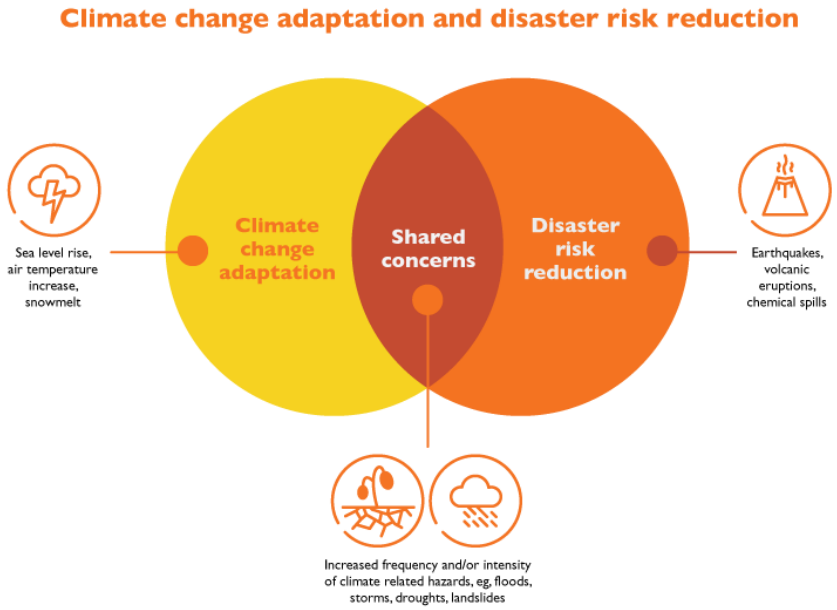
Lessons from Disaster Risk Reduction



https://www.worldvision.com.au/global-issues/work-we-do/climate-change/climate-change-adaptation-and-disaster-risk-reduction
(based on Turnbull et al., 2013)

Lessons from Disaster Risk Reduction



- Climate adaptation is a new concept to Japanese railway operators.
- Japanese railway operators are coping.
- Disaster Risk Reduction can offer a foundation for Climate Change Adaptation.

https://www.worldvision.com.au/global-issues/work-we-do/climate-change/climate-change-adaptation-and-disaster-risk-reduction
(based on Turnbull et al., 2013)

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Integration of Structural and Non-Structural Measures

https://www.andemagazine.jp/2023/07/27/infrastructure-maintenance-jreast-02.html

- Strong focus on structural measures in both the Swedish and Japanese contexts.
- Further integration of the two in order to account for uncertainties with climate change.

Source: own photo

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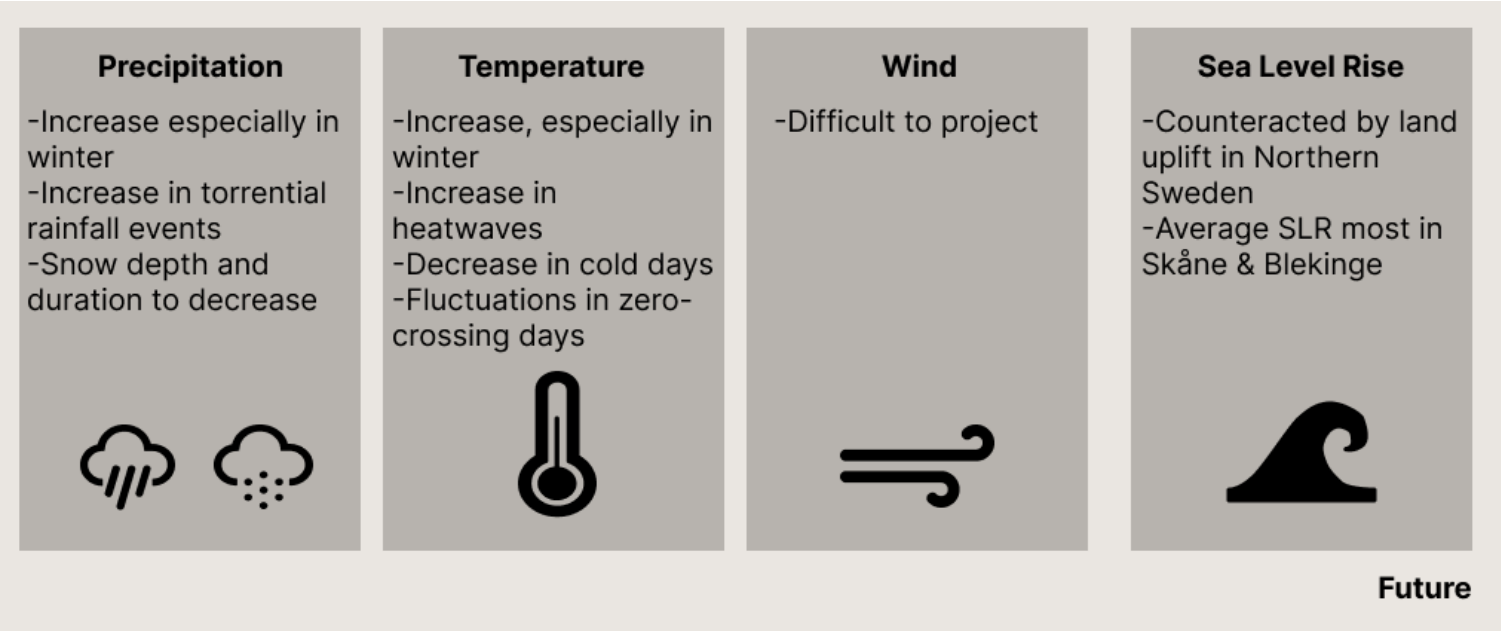
The implementation of these approaches are still dependent on current governance structures and financing/funding opportunities.

Göteborg, Sweden. Source: Own photo

Implications and Conclusion

Future Implications



Based on Sjökvist et al. (2025)

Future Implications

- No one size fits all
  - Adaptation is locally dependent/context specific.
- Adaptation leads to enhanced resilience.
- Many solutions exist to transition towards more flexible and dynamic adaptation approaches.
  - The transition is hindered by challenges within governance structures.
- Climate adaptation in the railway sector cannot be looked at in isolation but is intertwined with other surrounding governance structures.

Arita, Japan, 2025. Source: Own photo

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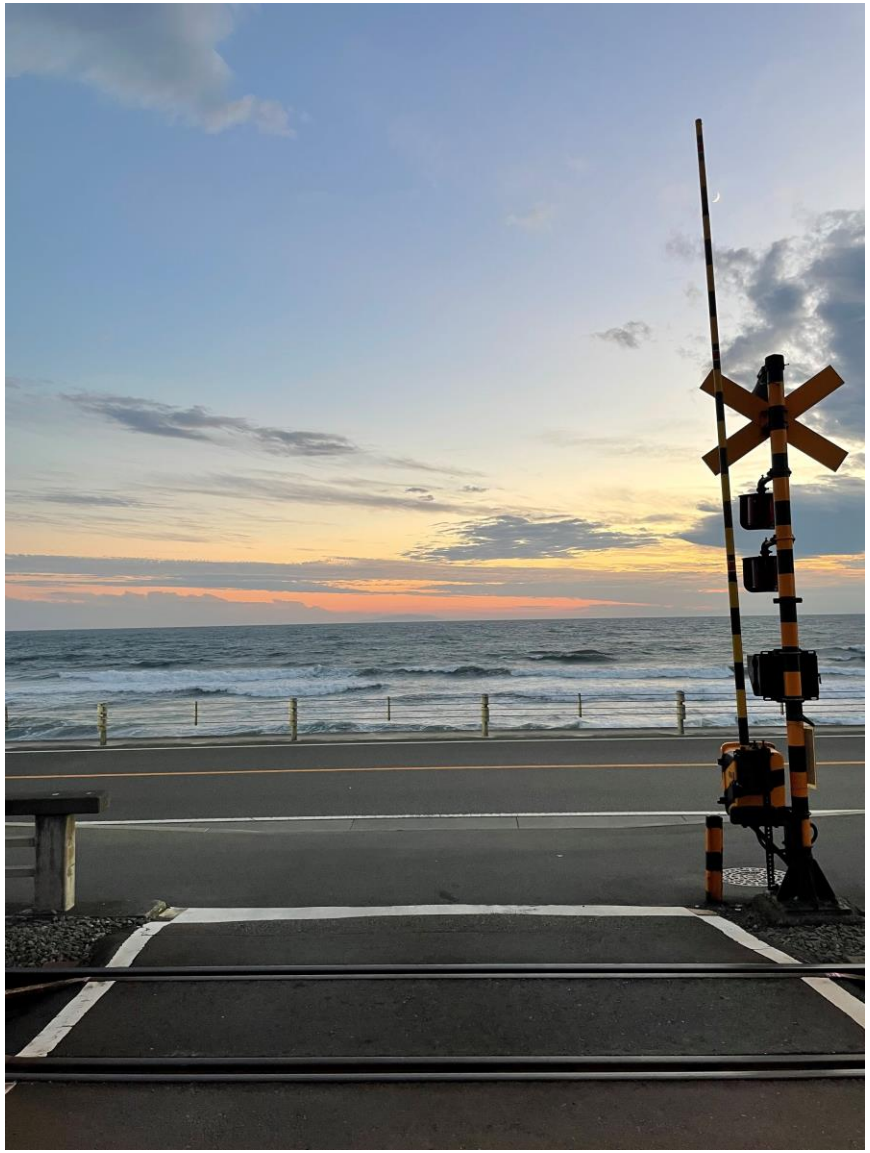

Kamakura, Japan, 2023. Source: Own photo

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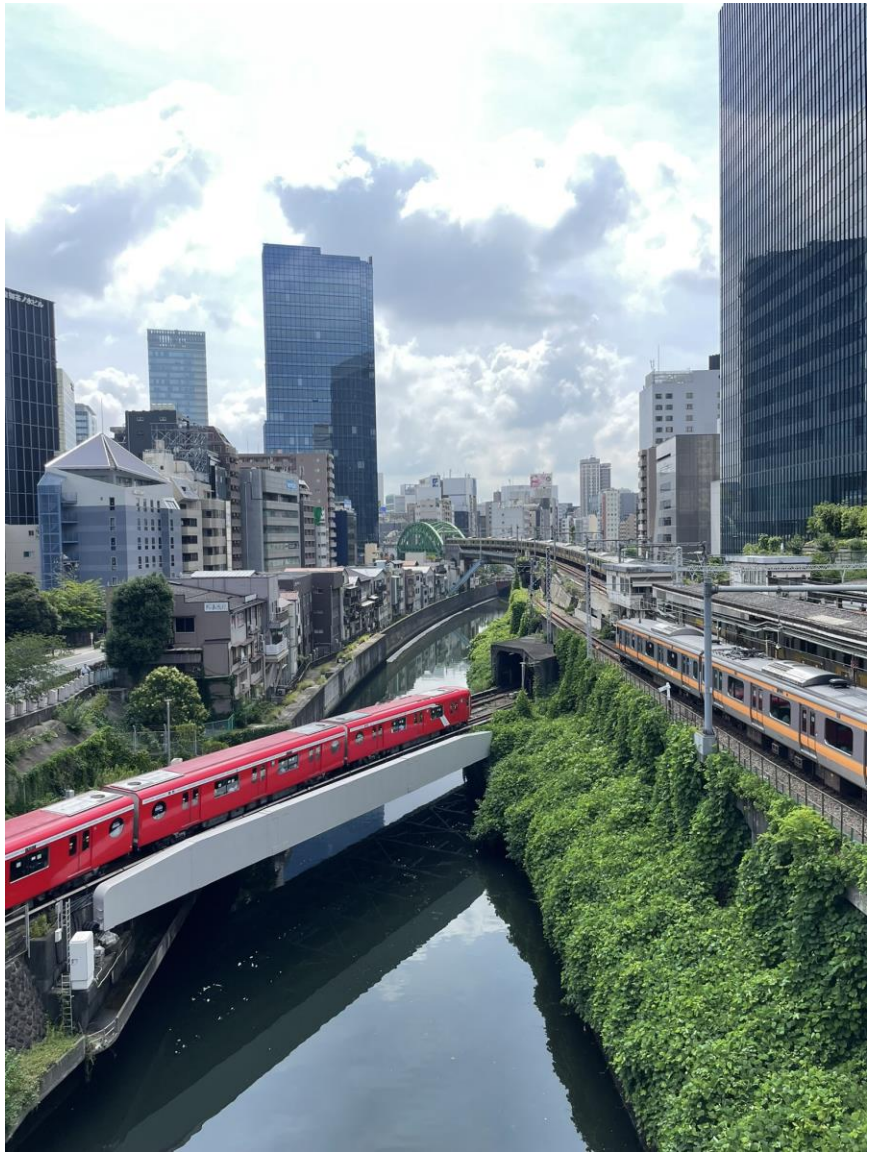

Ochanomizu Bridge, Tokyo, Japan, 2024. Source: Own photo

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