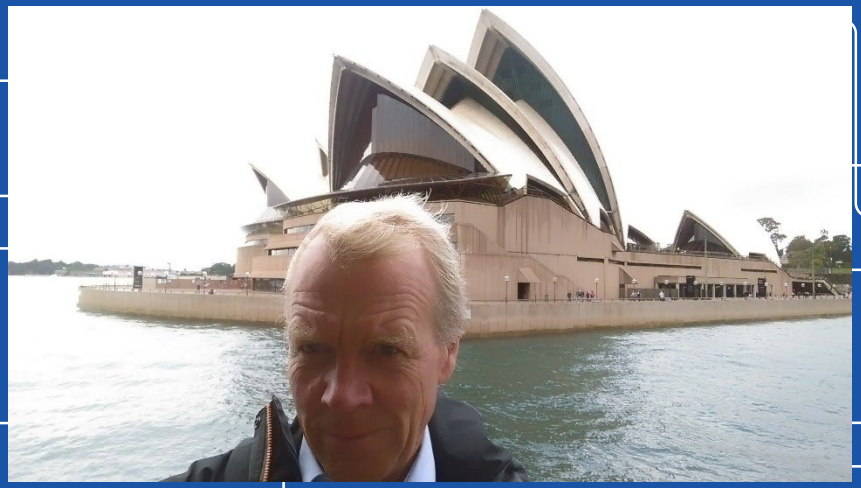
Adaptation of the Infrastructure to Climate Change

Johan Silfwerbrand

KTH Royal Institute of Technology (SE)

KTH Climate Action Centre, Oc. 16, 2024



Outline

- Background
- Climate change: Mitigation
- Climate change: Adaptation
- *Trafikverket* (Swedish Transport Administration) & Adaptation to Climate Change
- Lund University
- Blue-grey-green surfaces
- *SKR* (Swedish Association of Local Authorities and Regions)
- Research needs
- Concluding remarks

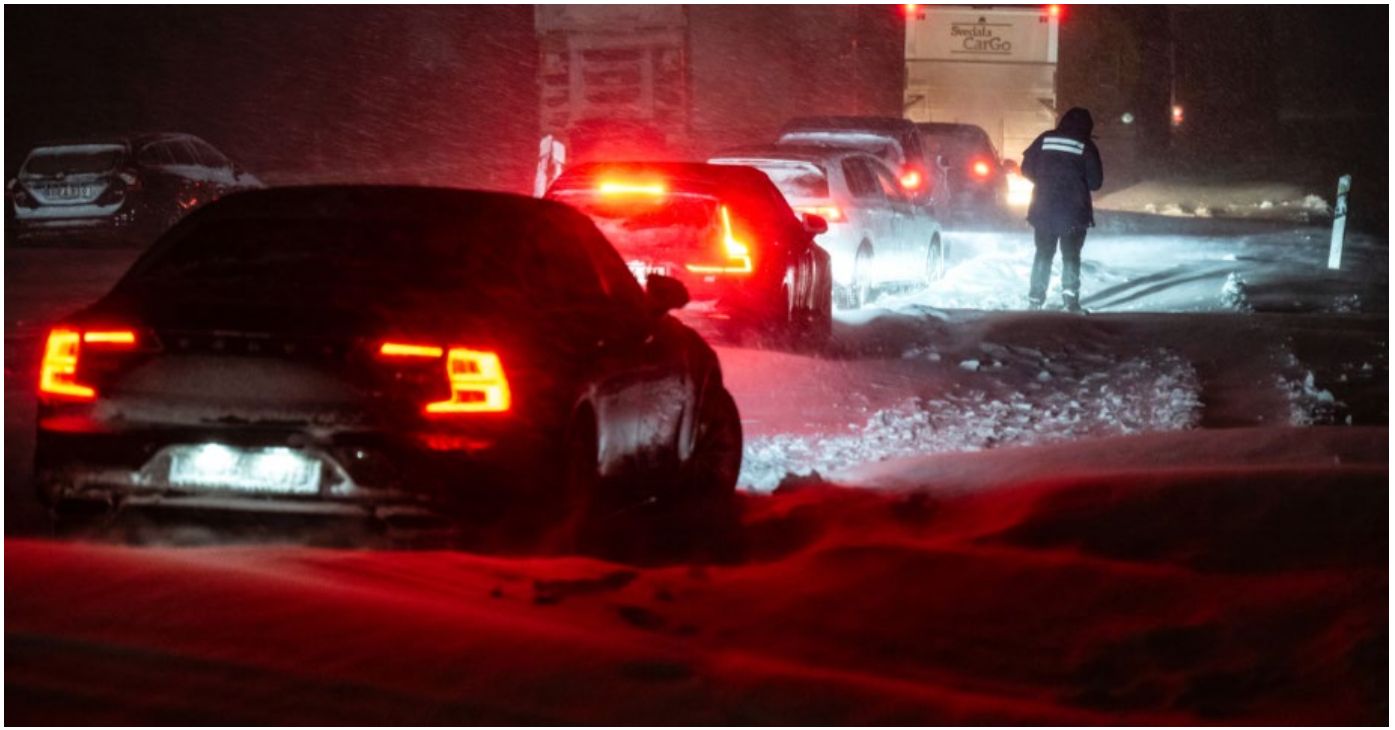
Climate changes

Nässjö, Jan. 16, 2023

Floods in Göteborg, Västerås, Åre & Örebro (SE), late summer in 2023

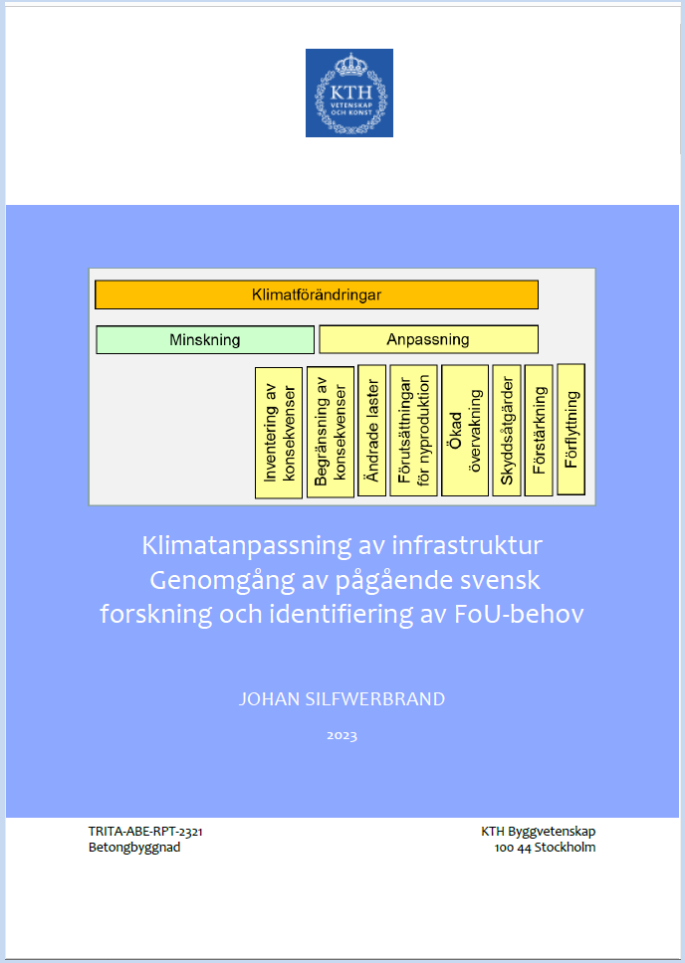
Landslide, E6, Stenungsund, Sept. 23, 2023

Snow chaos on E22, Jan. 3-4, 2024



1000 vehicles trapped during 38 hours

Literature & pilot study



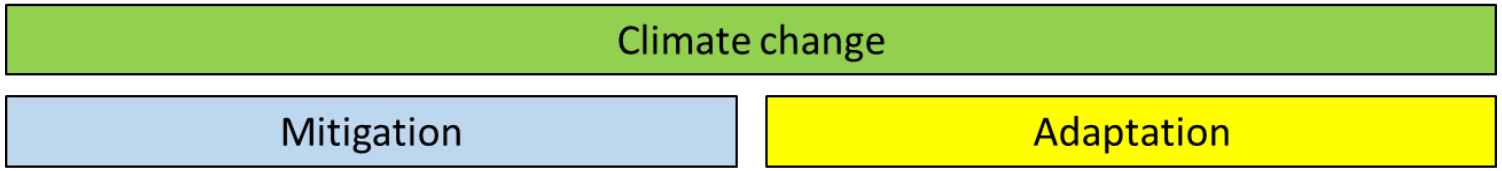
Sponsors: Vinnova (through InfraSweden) & KTH Climate Action Center

2022-23

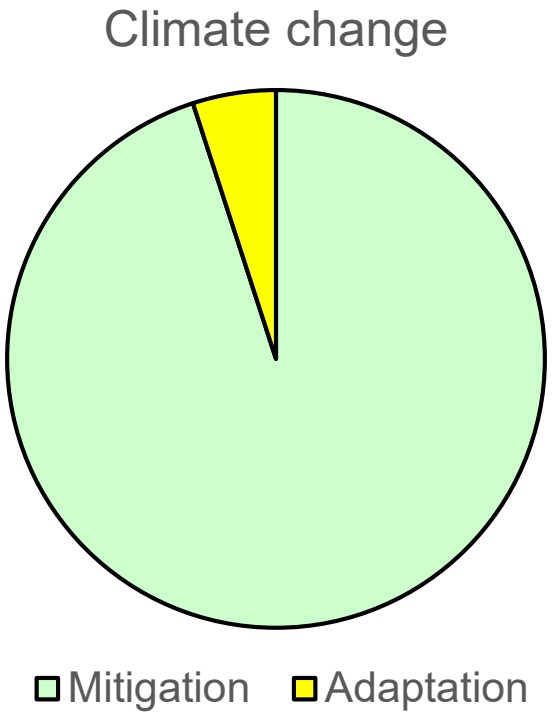
Aim & limitations

- **Aim**: To identify knowledge gaps & research needs within the area of adapting the infrastructure to climate change.
- **Limitations**: Focus on Swedish conditions and somewhat more weight on the most frequently used material, concrete.

Measures against climate change



Estimated shares of available R&D



Background

- Most climate-related research is directed towards mitigation.
- Concrete research is, e.g., focusing on making it greener by using industrial by-products such as fly ash, slag, and silica fume.
- Severe tipping points for the climate change may already be here.

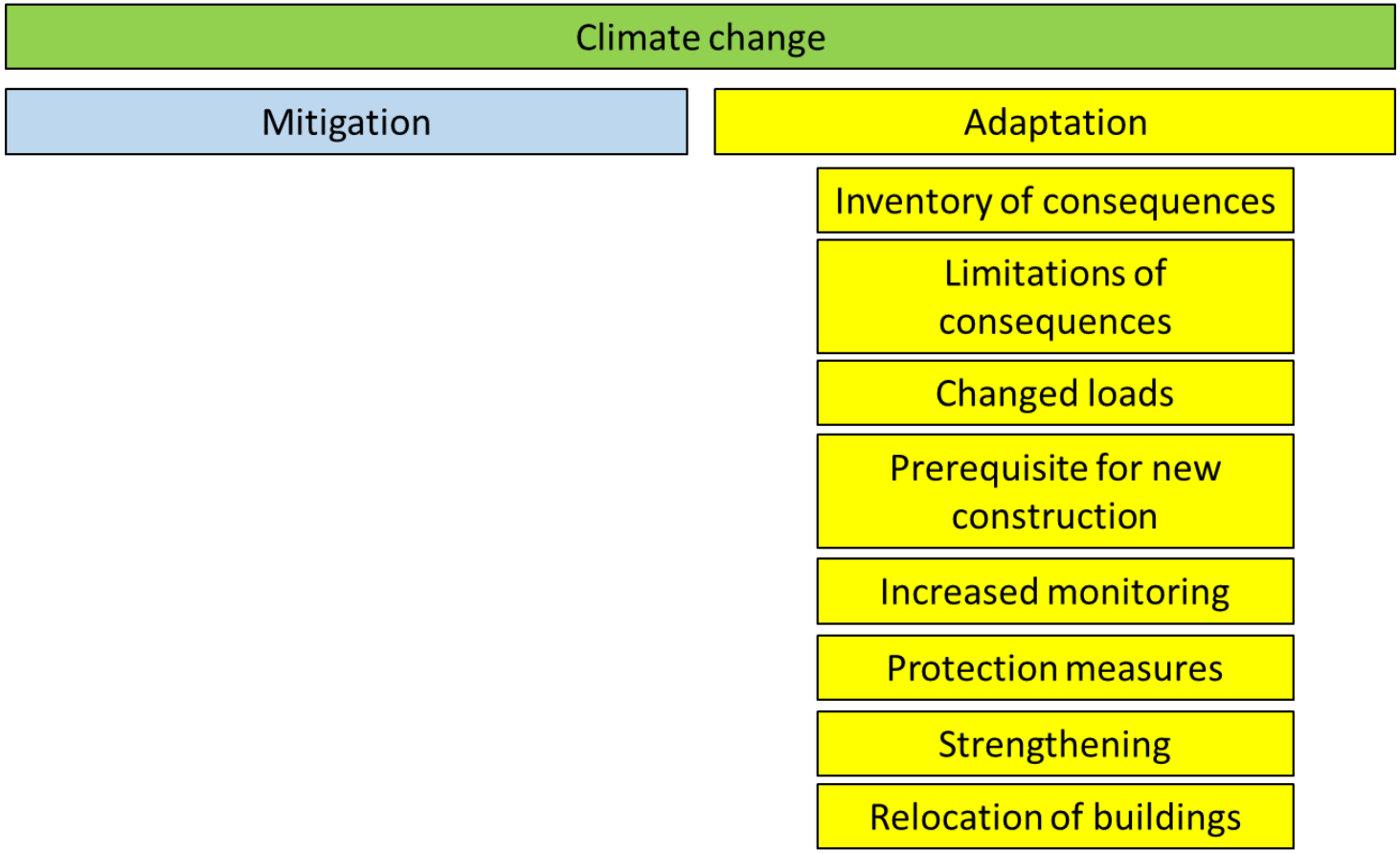
Concrete & Mitigation

Climate change

Mitigation | Adaptation

- Supplementary Cementitious Materials
- Optimized mix design
- Optimized cross section
- Thermal mass
- Prolonging service life
- CO_2 uptake
- Repair
- Reuse & recycling
- CCS & CCU

Measures to adapt built environment to climate change



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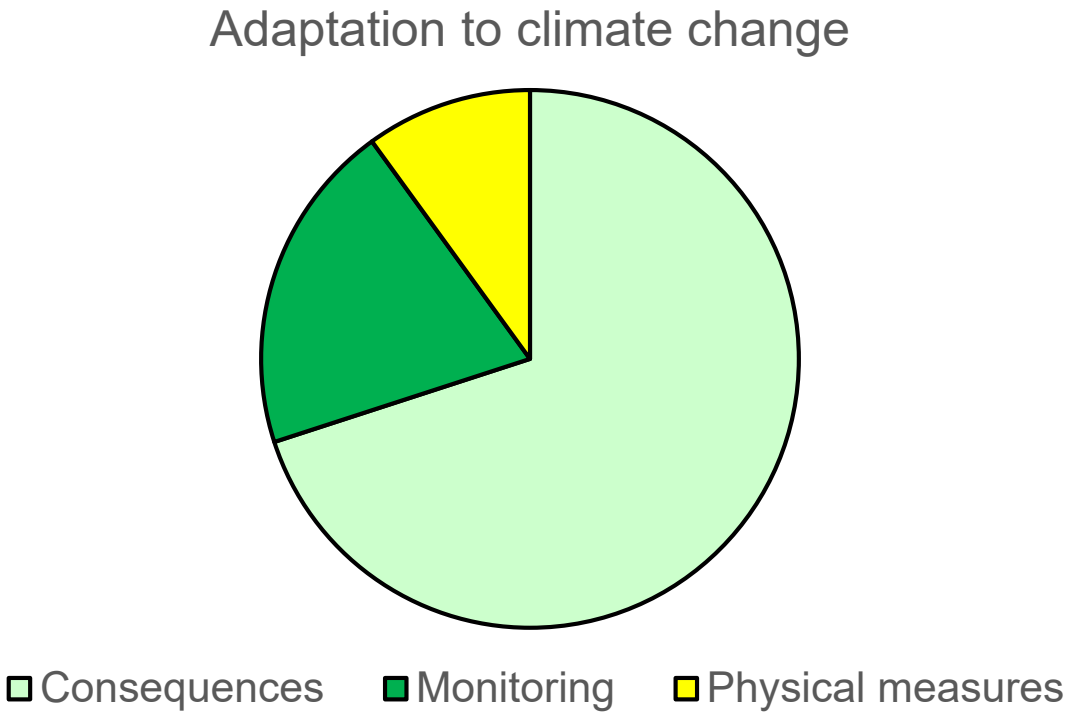


Trafikverket

Trafikverket

- 2012-: *Trafikverket* participate in a network with 21 authorities (led by SMHI) for adaptation to climate change.
- 2014: *Trafikverket* developed a strategy for adaptation to climate change.
- 2016: *Trafikverket* adopted an action plan containing 20 activities.
- 2017: The action plan was updated to Version 2.

Trafikverkets strategy for adaptation to climate change

1. Create beneficial conditions for an efficient work with adaptation.
2. Prevent negative consequences of climate change through creating robust civil engineering structures.
3. Handle the effects of climate change.

Impact on the transport infrastructure

Climate change	Impact on the transport infrastructure
Sea level rise	• Sea water flows into tunnels. • Islands are disconnected from the mainland. • Road & railway sections are flooded.
Ground water table change	• The soil stability can be weakened & damage the foundation.
Heavy precipitation & large flows	• The risk of scour, material removal, flood, earth fall & landslide increases. • Mud streams may block culverts that in turn may lead to flushing road & railway sections away.
Increased average temperature	• The evaporation increases causing more precipitation. • More zero temperature passages that may give pavement damages & increased risk of slippery. • Increased use of de-icing salt in northern parts of Sweden.
Heat waves & drought	• The rutting on asphalt roads increases. • Risk of moisture, mould and corrosion increases.
Forest fire	• Traffic on roads close to forest fires may be stopped.

Swedish Transport Administration (2018)

Trafikverkets action plan (2017) – concrete measures to adaptation (6 of 20)

- Develop methods for determining when and where various measures are cost efficient for adaptation to climate change. (No 8).
- Adapt new and reconstructed structures for present and future climate. (No 10).
- Increase the resistance of existing road and railroad infrastructure against climate change. (No 12).
- Remedy systematic shortcomings, e.g., under-designed road culverts. (No 13).
- Adapt maintenance measures to climate change. (No 14).
- Reinforcing units, e.g., replacement bridges. (No 20).

Trafikverkets R&D-plan 2022-27

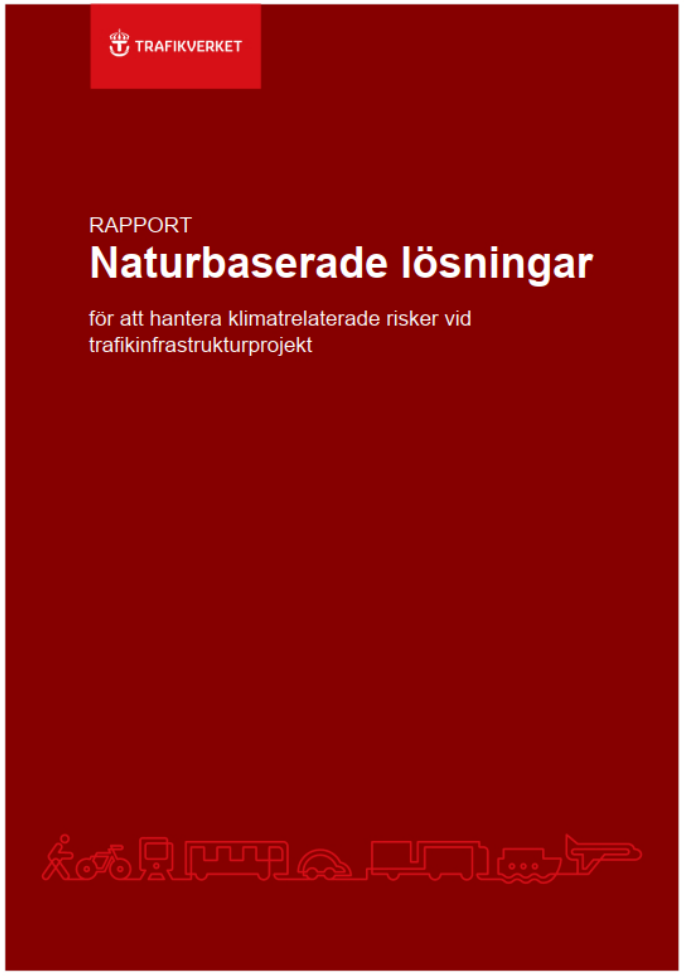
- The plan consists of seven sub-areas (*portföljer*) and a program for the railway area (54 pp):
- Planning, maintaining, enabling, constructing, shipping, aviation, and strategic initiatives.
- 4 first sub-areas: 147 identified ”prioritized research and innovation themes”.
- Within ”strategic initiatives”, 39 research questions are listed.
- Climate change and adaptation to climate change play a very subordinate role.
- The words *klimatförändring* (climate change) (or *klimatförändringar* [climate changes]) and *anpassning* (adaptation) appear only 5 and 4 times, respectively.

The exceptions on climate change and adaptation to climate change

- Knowledge development within the field of adaptation to climate change.
- Increase the understanding of how climate change will impact the transport infrastructure.
- Develop and demonstrate analysis methods for classifying, evaluating and prioritizing measures for adapting the existing transport infrastructure to climate change.
- Climate changes and long-term effects – which structural adaptation may be necessary for living cities and rural areas?

Nature based solutions

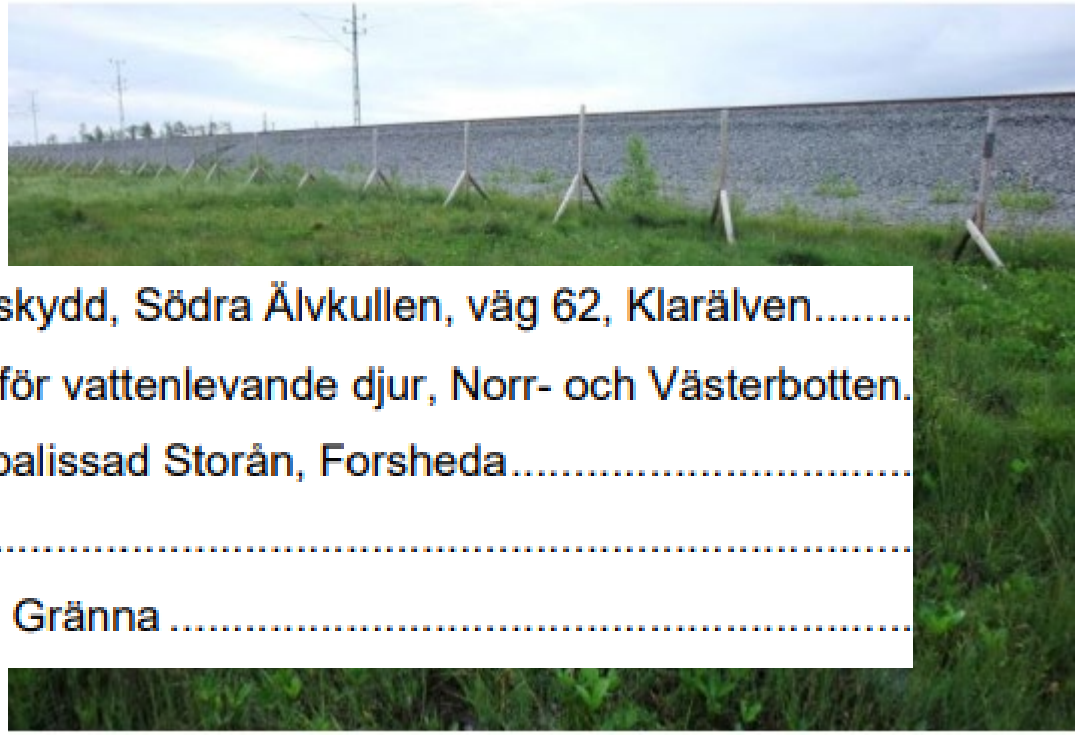
- Trafikverket, 2024
- Author: *Maria Lind*, national coordinator for adaptation to climate change



Nature based solutions

1. Save and restore existing eco systems
2. Appropriate maintenance and sustainable use of eco systems
3. Recreation of lost eco systems or creation of new ones

Examples of nature based solutions



Stabilitetsåtgärder och erosionsskydd, Södra Älvkullen, väg 62, Klarälven.....

RemiBar – Fria vandringsvägar för vattenlevande djur, Norr- och Västerbotten.

Erosionsskydd – Väg G619 Träpalissad Storån, Forsheda.....

Haparandabanan – Banvallen .....

Vretaholm eklandskap Väg 993, Gränna .....

Semi permeable railway embankment through swamps

Changes for the infrastructure: Examples

Increased heat island effect: Use more green & grey areas instead of black ones

Higher sea levels: Protect cities close to the shore

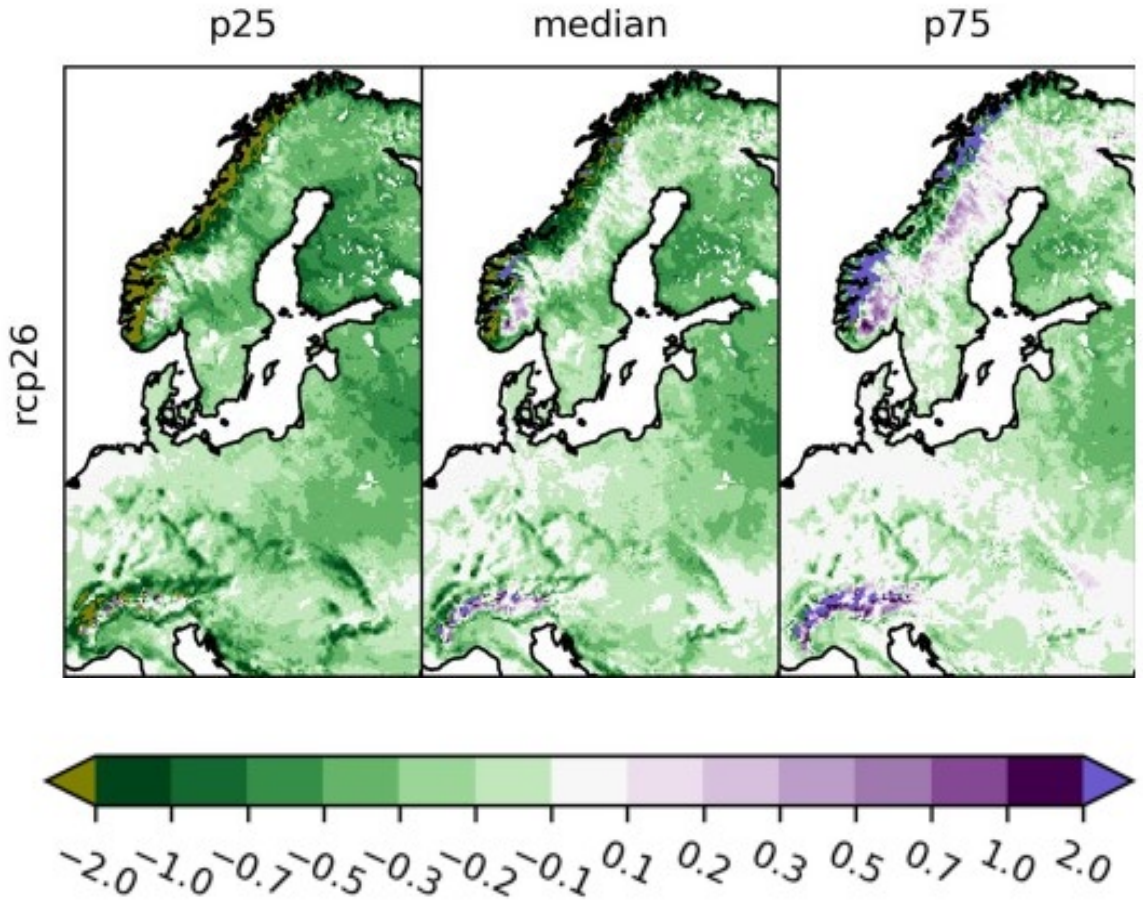
More intense fires: Increase fire resistance

Increased rain: Redesign dams & waste water systems

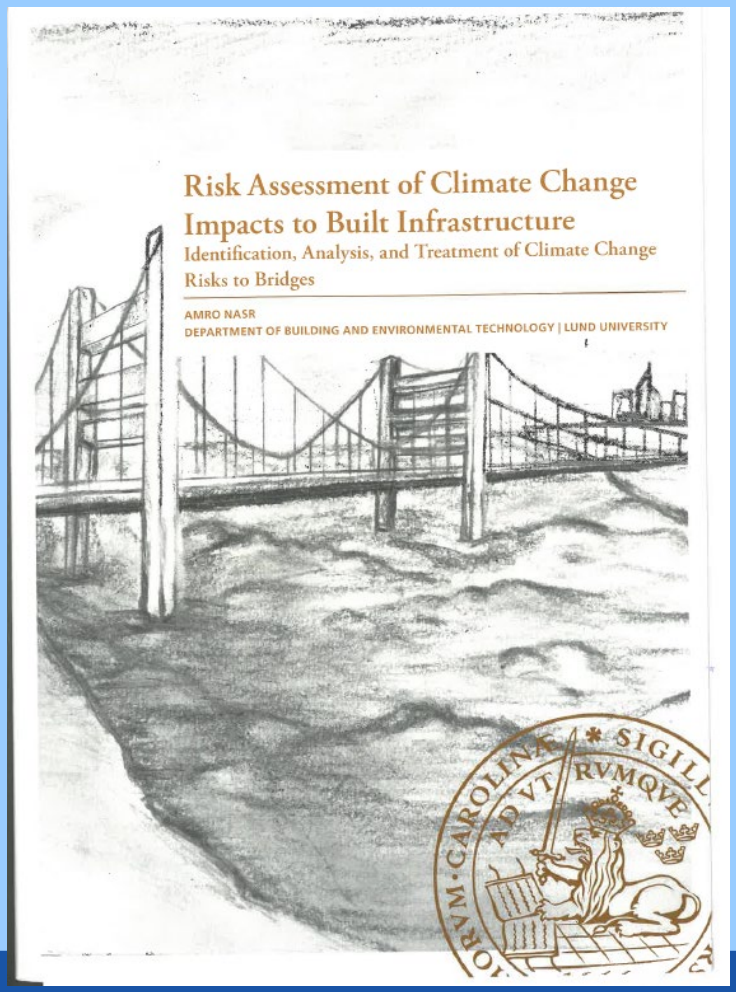
Increased floods: Redesign bridge supports

Increased wind loads: Design loads based on statistics not possible to use

Snow load increases in some areas & decreases in others



Lunds tekniska högskola LTH



Research at LTH

- LTH is leading the Swedish research on adapting the infrastructure to climate change.
- Identifying risks (durability, function, geo-technology, increased loads, accidental loads, extreme weather events, maintenance)
- Amro Nasr's PhD thesis the first Swedish one within adaptation, construction & concrete
- **Besides**: Extensive research within the Division of Water Resources Engineering

Amro Nasr: ”Risk Assessment of Climate Change Impacts to Built Infrastructure”

- Identification of potential risks of bridges
- Decision bases for bridge administrators in four steps: (1) danger, (2) impact, (3) vulnerability & (4) consequences.
- Special studies on four problems (reinforcement corrosion, fungi on wood, concrete creep, erosion under bridges),
- Proposals for future research: mainly new prerequisites for new construction.

Blue-grey-green system solutions

- Water
- Hard-made surfaces
- Vegetation

Background

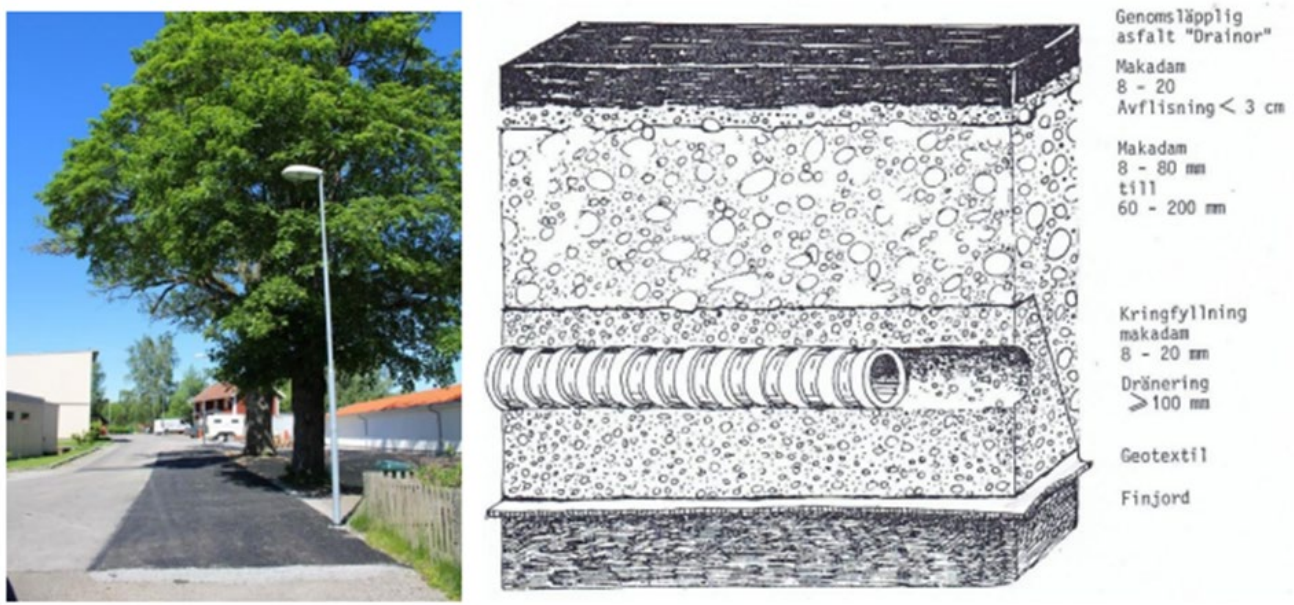
- Increased precipitation and floods may be the most severe consequence of climate change in Sweden.
- Sewage & storm water systems are in many cases old & damaged.
- They are designed for the maximum rainfall in a 2-10 year perspective (dams are design for the 1000 year rainfall).
- Much higher environmental demands today – flooding of storm water not sustainable method.

Copenhagen's cloudburst plan

- Parts of Copenhagen's waste water system is 150 years.
- Designed for the 10 year rain.
- New storm cloudburst plan in 2012 (flood in 2011).
- Combined measures regarding developed storm water system above & under ground level and solutions that slow down the water transport.
- Aim: Copenhagen cloudburst safe in 2030-2040.

Troell & Thidell, SLU (2018)

”Climate secured system solutions for urban areas” (RISE et al.)



System solution for storm water handling in *Lilla Vallen, Växjö*. The road system consists of drainage asphalt. (Sörelius et al., 2017).

Sveriges Kommuner och Regioner

SKR

Swedish Association of Local Authorities and Regions

SKR & Adaptation to climate change

- It is possible to download a number of publications form the web.
- They give examples describing how ,municipalities have handled, are handling and may handle climate change.
- Focus on heat waves & drought, rising seal levels and shorter winter periods.

Sveriges Kommuner och Regioner

Protection wall on *Falsterbonäset*

- 21 km long protection wall for 200 MSEK.
- Consists of walls with vegetation that together with existing sand dunes will develop protection against future high tide.
- Intended to project homes with at total value = 80 000 MSEK.
- Prototype with L = 50 m, b = 13 m & h = 1,7 m exists.

Protection wall on *Falsterbonäset*

- *Vellinge* municipality's flood protection consists of an exterior and an interior protection.
- The project was started in 2024.
- It consists of four stages.
- The most vulnerable areas are treated first.
- Stages 1 & 2 are started in 2024 and anticipated to be completed in 2027.
- Stages 3 & 4 are still waiting for detail planning.
- All stages are anticipated to be completed in 2031.

Vellinge.se

Klimatanpassning.se

- *Myndighetsnätverket för klimatanpassning* (MNKA)* is responsible for this web page.
- *MNKA* consists of 30+ Swedish authoroties & SKR.
- The Network's working fields:
  - ❖ Development of new knowledge & data
  - ❖ Increase the commitment & disseminate knowledge in the society
  - ❖ Work for improving frameworks & steering documents
  - ❖ Sharing information
  - ❖ Competence enhancement

*Authorities networks for adaptation to climate change

Future research

Research needs 1 (2)

Development of new design loads for wind and snow (not based on irrelevant statistics).

Development of efficient methods to strengthen existing structures.

Efficient concrete barriers protecting built environment close to the shore from rising sea levels.

Continuing of the promising research on “blue-grey-green” systems for protecting urban areas for floods.

Research needs 2 (2)

Development of refined concrete pipes for waste water & storm water systems.

Investing the effects of climate change on concrete's competitiveness in comparison with other construction materials such as timber & asphalt.

Adapting the production of concrete structures to climate changes considering both advantage of (shorter winters) and disadvantages (increased risk of thermal cracks).

Concluding remarks

Climate change is impossible to stop but all measures to make it as small as possible are necessary.

Recent concrete research has been devoted to mitigation by using SCMs etc. for making greener concrete.

We need to intensify our research towards adaptation to climate change.

Concrete has an important role in the energy transition & to protect our society.

The report (in Swedish) may be downloaded from Diva

https://kth.diva-portal.org/smash/get/diva2:1801499/FULLTEXT01.pdf