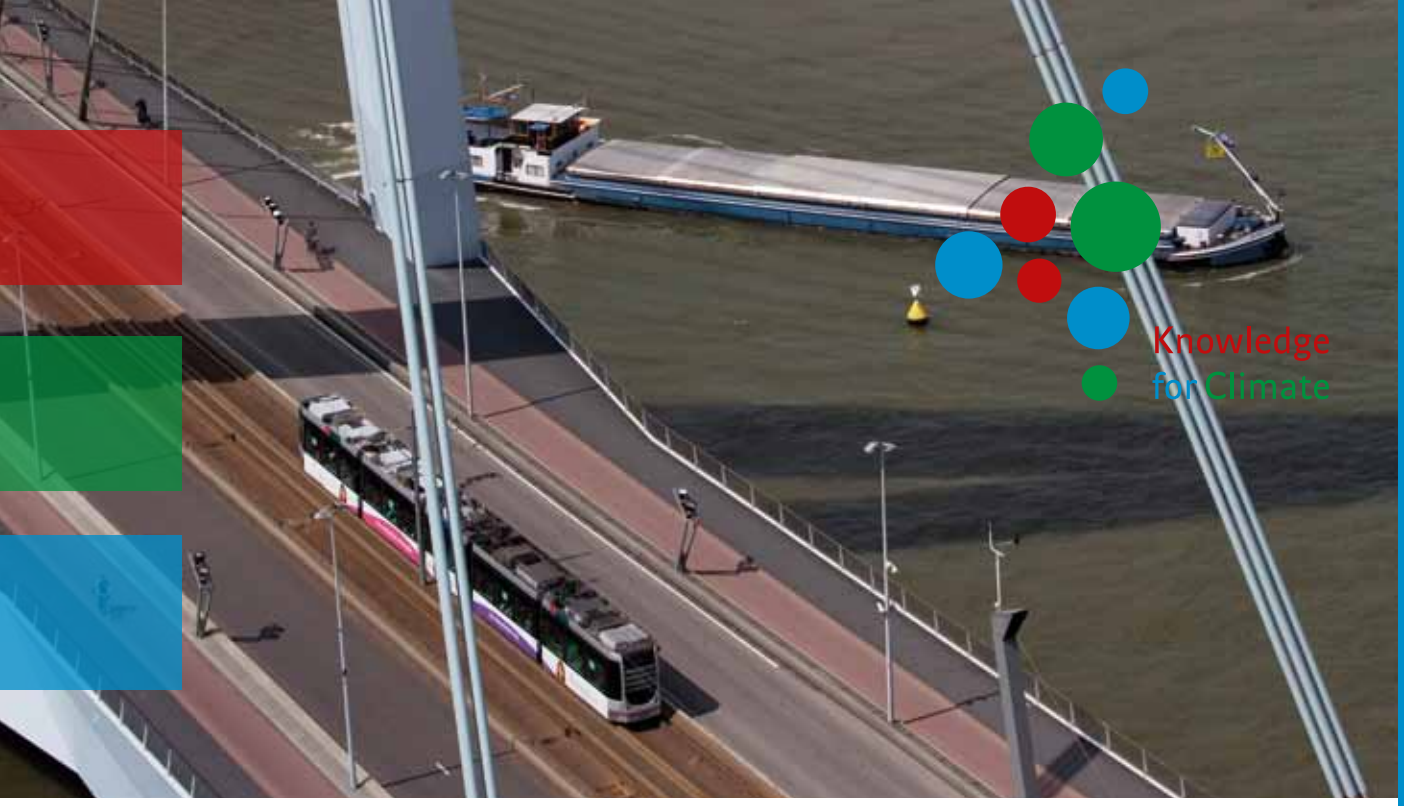


Infrastructure Networks Climate Adaptation and Hotspots

Infrastructure as backbone

Infrastructures are the backbones of our society. Climate change can have adverse effects on these important infrastructures. Heavy snow can disrupt transport networks leading to huge traffic jams and causing delays on railway. Droughts can affect the integrity of drinking water distribution. Thunderstorms and lightning strikes, e.g. on transformer stations, can cause blackouts and other grid reliability issues. The worst case scenario is a system break down in which coherent infrastructures fall like dominoes. Since transport and utility infrastructure is vital to society, climate change calls for timely adaptation and transformation of our on-surface and sub-surface networks.

Aims

The objective of the research programme 'Infrastructure Networks Climate Adaptation and Hotspots' (INCAH) is to gain insight into the effects of climate change on the Dutch transport, energy and drinking water infrastructures. These risks can be reduced by improving functional and technical design of the networks, and by intensifying asset management. In addition, the aim is to develop robust strategies to allow these networks to maintain their function, adapting to the effects of climate change.

The central research questions addressed within INCAH

- What are relevant effects of climate change on infrastructures?
- To what extent do these effects threaten the safe, sound and reliable operation of infrastructures, their availability and socio-economic productivity?
- How can we avoid congestion, service interruption, system breakdown or even systemic crisis through reinforcing effects rippling through interconnected infrastructures?
- Through what policies, strategies and governance can we adapt infrastructure networks and make our economic hotspots robust and resilient to climate change?

Research findings per infrastructure system

For the assessment of the physical infrastructure we developed a methodology that offers a structured process to consider the effects of climate change on infrastructure. The methodology is based on the resilience of the considered infrastructure system. Combining information about resilience with climate scenarios leads to valuable insights for policy making. What are the main insights so far?

Drinking water infrastructure

The effect of climate change on the functionality of the drinking water distribution network has been examined. The most commonly observed effect of climate change on the water pipelines is an increased pipe failure during winter and late summer. These effects can be attributed to (1) large temperature differences between pipe and soil causing thermal stresses, and (2) periods of drought causing differential settlements.

Embankments and peat dikes

To assess the consequences of droughts and periods of heavy precipitation for embankments a new analysis procedure has been developed. This method results in a model for peat dikes, that gives robust results and is computationally efficient. Climate change will alter the current stability conditions: the model shows that the dike, used in the validation, fails if the evapotranspiration increases by a factor two.

Railway system

For the railway system an in-depth analysis has been carried out on a long term database of infrastructure related disturbances. We find that the contribution of extreme weather to infrastructure disturbances is underestimated in the expert judgments. We also analyse the broader consequences of extreme weather on delays and cancelations of trains as experienced by travellers. Results show that it is mainly the rails and infrastructure that is affected and to a lesser extent the trains.

Inland water transport

For inland water transport the impact of climate change on inland water transport in the Rhine and Danube river basins is addressed. The meteorological and hydrological models used lead to the conclusion that the year-to-year variation in water levels will dominate. Structural changes increasing the probability of long periods with low water levels are not yet clearly visible during the period up to 2050, but in the period after 2070 low water problems may become problematic.

Adaptation strategies

Costs and benefits of adaptation strategies are explored by means of real options analysis. This methodology is based on the principle that if the expected net benefits of investment are currently insufficient, adaptation can be postponed. Since investments are irreversible and the degree of climate change and its impacts are highly uncertain, waiting to adapt can be optimal.

Case studies in Hotspot Rotterdam

Robustness of the road network

The focal hotspot for testing and application of the INCAH knowledge is the Rotterdam Rijnmond-region. One of the interesting case studies is the assessment of the robustness of the Rotterdam road network during extreme weather. We have taken a close look at the following scenarios: (1) Heavy snow, (2) Extreme slipperiness caused by snow, ice or freezing/ extreme wind, (3) Heavy rain for a long period and (4) Very dense fog. The table below gives a summary of the events and their effects, based on experienced vulnerable spots in the local and regional network. These effects are translated into measures in a transport model.

The next step is to incorporate the empirical effects from the Rotterdam-Rijnmond case in the transport model, and to evaluate adaptation measures and strategies. Examples of measures are improving design of a tunnel or the sewer system, introducing weather related mobility management measures, or improving the level of cooperation and communication between traffic managers and emergency services.

Robustness of the road network: four scenarios and their effects on the road network of Rotterdam

	Scenario	Events	Effect on road network
1	Heavy snow	• All roads are poorly accessible • Roads with slope are not accessible	• Greatly reduced traffic flow and speed • Decreased traffic demand
2	Extreme slipperiness/ Wind	• Van Brienenoordbrug closed • Willemsbrug en Erasmusbrug are poorly accessible	• Roadblock at Van Brienenoordbrug in both directions • Slow-moving traffic on other bridges
3	Heavy rain for a long period	• Sewage reaches drainage capacity, leading to flooding of roads • A lot of surface water on all roads	• Closing of several tunnels (not the Maastunnel) • Reduction in road capacity and traffic speed
4	Very dense fog	• Distance of visibility of less than 50 meters (definition of ANWB)	• Very slow driving

Other cases

- Road embankments: testing of embankment model for road embankment: determining the effects on stability and bearing capacity during and after high water levels on both sides of the embankments
- Tunnel: new design parameters for a tunnel, based on probability of failure and severity of consequences
- Corridor A15: identification of asset management strategies for the transport corridor for several different transportation types (multimodal corridor)
- Electricity production plant: economic effects of fresh water shortage due to low river levels on production of electricity in power plants
- Bicycle traffic in Rotterdam: effects of extreme weather on demand for trips by bicycle

Contact

Consortium leader
Prof. Lori Tavasszy, MSc
T +31 88 866 8532
lori.tavasszy@tno.nl

Nienke Maas, MSc
T +31 88 866 3137
nienke.maas@tno.nl

Communication
Nadine Croes
T +31 88 866 0927
nadine.croes@tno.nl

TNO
www.tno.nl

www.knowledgeforclimate.org/infrastructurenetworks

Subscribe to newsletter
nadine.croes@tno.nl

Photo credits
page 1 Marc Heeman
page 2 Noor van Mierlo

Working with Hotspots / Stakeholders

- Hotspot Rotterdam region
- Ministry of Infrastructure and the Environment
- Public Works and Water Management (Rijkswaterstaat)
- City of The Hague
- Tennet
- Dutch Railways (NS)
- Deltalinqs
- STOWA
- ProRail
- Waternet
- Hotspot Schiphol Mainport
- Port of Rotterdam

Consortium partners

VU University Amsterdam · KWR Watercycle Research Institute · TNO · TU Delft · Deltares Enabling Delta Life

International research partners

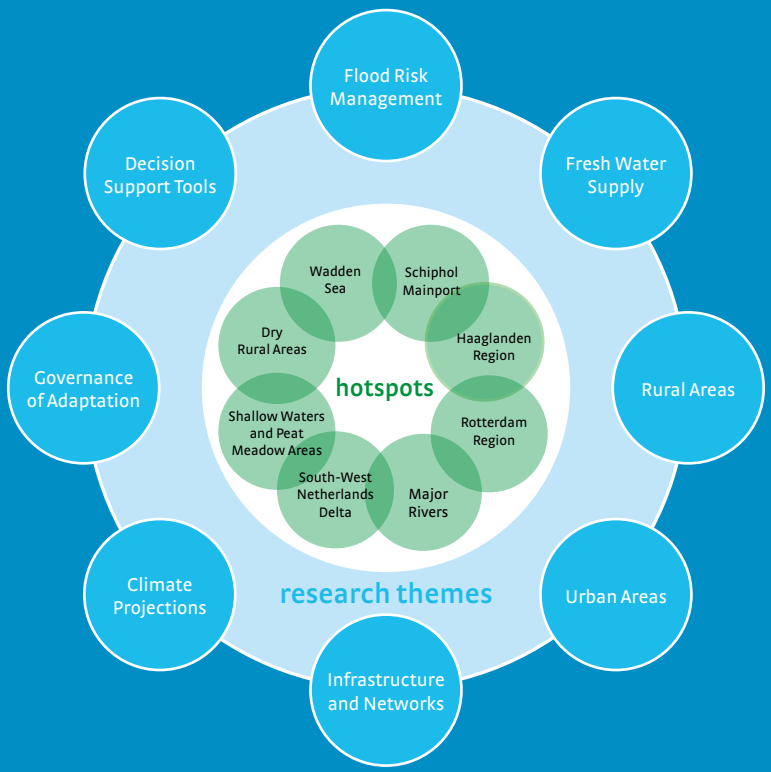
Australian Commonwealth Scientific and Industrial Research Organisation, Australia • Fraunhofer Institute for Systems and Innovation Research ISI, Germany • Louvain School of Management, FUCam (Mons Campus), Belgium • Massachusetts Institute of Technology and US Geological Survey, USA • Purdue University School of Aeronautics & Astronautics, USA • Southern Cross University, Tweed Heads, Australia • Swedish Geotechnical institute, Linköping, Sweden • Tottori University and Arid Land Research Center, Japan • University of Michigan, Center for Sustainable Systems, USA

Knowledge for Climate

To develop the scientific and applied knowledge required for climate proofing the Netherlands and to create a sustainable knowledge infrastructure for managing climate change

Knowledge for Climate is a research programme (2008-2014) that develops knowledge and services needed to make the Netherlands climate proof. Governmental organisations (national government, provinces, municipalities and water boards) and businesses actively participate in the research programme. Knowledge for Climate focuses on eight areas, called hotspots: Mainport Schiphol, Haaglanden Region, Rotterdam Region, Major Rivers, South-West Netherlands Delta, Shallow waters and Peat Meadow Areas, Dry Rural Areas and the Wadden Sea Region. The scientific research is carried out in eight themes by consortia.

- Climate Proof Flood Risk Management
- Climate Proof Fresh Water Supply
- Climate Adaptation for Rural Areas
- Climate Proof Cities
- Infrastructure and Networks
- High-quality Climate Projections
- Governance of Adaptation
- Decision Support Tools



Programme Office Knowledge for Climate

Secretariat
T +31 88 335 7881
office@kennisvoorklimaat.nl

Communication
T +31 317 48 6540
info@kennisvoorklimaat.nl

www.knowledgeforclimate.nl

This research programme is co-financed by the Ministry of Infrastructure and the Environment.