



## Resilient Infrastructure Networks Capability Statement

**Resilient Infrastructure Networks: A Deltares multi-disciplinary group working towards increasing infrastructure resilience.**

### Our vision

Understanding risk is at the core of making informed decisions. Our activities in infrastructure resilience are anchored in research and consultancy for risk assessments. We align ourselves with the conceptual risk framework of the United Nations, performing the identification and characterization of the hazards, of the infrastructure exposed to the hazards and its vulnerabilities.

The disruption of essential services delivered by critical infrastructures is a major component of the impacts of natural hazards. We advise the prioritization of actions based on risk assessments and network criticality analyses, integrating opportunities and underpinning sustainable societies.

Our work supports informed decision making and the customization of action perspectives and implementation. Our activities on designing action perspectives acknowledge all phases of the disaster risk management cycle. We address challenges for infrastructure development and maintenance, and the need for long-term adaptation planning and preparedness as well as the response and recovery in the aftermath of disasters.

We pursue the development and application of enabling technologies that support the adoption of approaches adjusted to both data-rich and data-scarce environments. We ensure that the methods and -tools relate to the institutional development level of the infrastructure stakeholders.





**Our focus**

- Transportation
  - Roads
  - Railways
  - Ports
  - Inland Water Systems
- Utilities
  - Electricity
  - Communications
  - Water
- Flood defences
- Both existing and planned infrastructure

**Challenges for infrastructure development**

- **Aging infrastructure**
- **Climate change** results in increasing stress for the infrastructure
- **Rapid urbanization** results in fast infrastructure development
- **Multi sectoral involvement** is crucial
- **Access to information** is often difficult
- Critical infrastructure projects are often **long term developments**
- **New technologies** will become available
- **Communities want to be more prepared for the future**, without scarifying the present

**Why plan for the long-term?**

- **Prevention:** a good understanding of extreme events can save lives and avoid economic losses
- **Build trust and form partnerships** agreements: sharing of knowledge and information among critical infrastructure operators within one region builds trust and often leads to partnership agreements that are beneficial for multiple parties
- **Efficiently retrofit existing infrastructure** to be better prepared for future extremes
- **Multi hazard awareness:** take into consideration all possible threats when constructing a new infrastructure
- **Cope with changing conditions**
- **Improve capacity to respond to disasters**
- **Disaster resilience inspires people**, they feel empowered to make a change

**Our activities**

**Natural Hazard Risk Assessments**

We rely on in-house expertise in all risk components, based on the conceptual framework **Risk = Hazard x Exposure x Vulnerability.**

- Hazards
  - Flood (fluvial, pluvial and coastal)
  - Landslides
  - Subsidence
  - Earthquakes
  - Wild fires
  - Extreme Weather
  - Climate change
- Exposure and Vulnerability
  - Engineering
  - Geotechnics
  - Damage estimates
  - Reliability Analysis

Our activities provide an integral perspective

- Multi-hazard assessments
- Infrastructure systems approach and cascading effects
- Losses for infrastructure users and society in general
  - Economics
  - Traffic analysis
  - Criticality
  - Spatial planning
  - Societal and technological developments

Technological and methodological excellence enable our activities.

- Remote sensing
- Big data analytics
- Monitoring and instrumentation
- Stakeholder elicitation
- Collaborative assessments

**Decision Support: Risk Evaluation and Prioritization of Actions**



We provide action perspectives towards future-ready infrastructure. Decision support prioritizes actions reflecting uncertainty in future developments and an understanding of the societal impacts of disruptions.

- All phases of the disaster management cycle (Preparedness, Prevention and Mitigation, Response, Recovery)
  - Climate Change adaptation
  - Business Continuity Planning
  - Forecast-based emergency management
  - Early-warning systems
- Decision making under deep uncertainty
  - Adaptation tipping points
  - Robust decision-making
  - Dynamic Adaptive Policy Pathways
- Socio Economic Analyses
  - Life-Cycle Cost
  - Cost-Effectiveness analyses
  - Cost-Benefit Assessments
  - Multi-Criteria Analyses
- Institutional and stakeholder analyses



Stakeholder Engagement, Implementation and Capacity Building

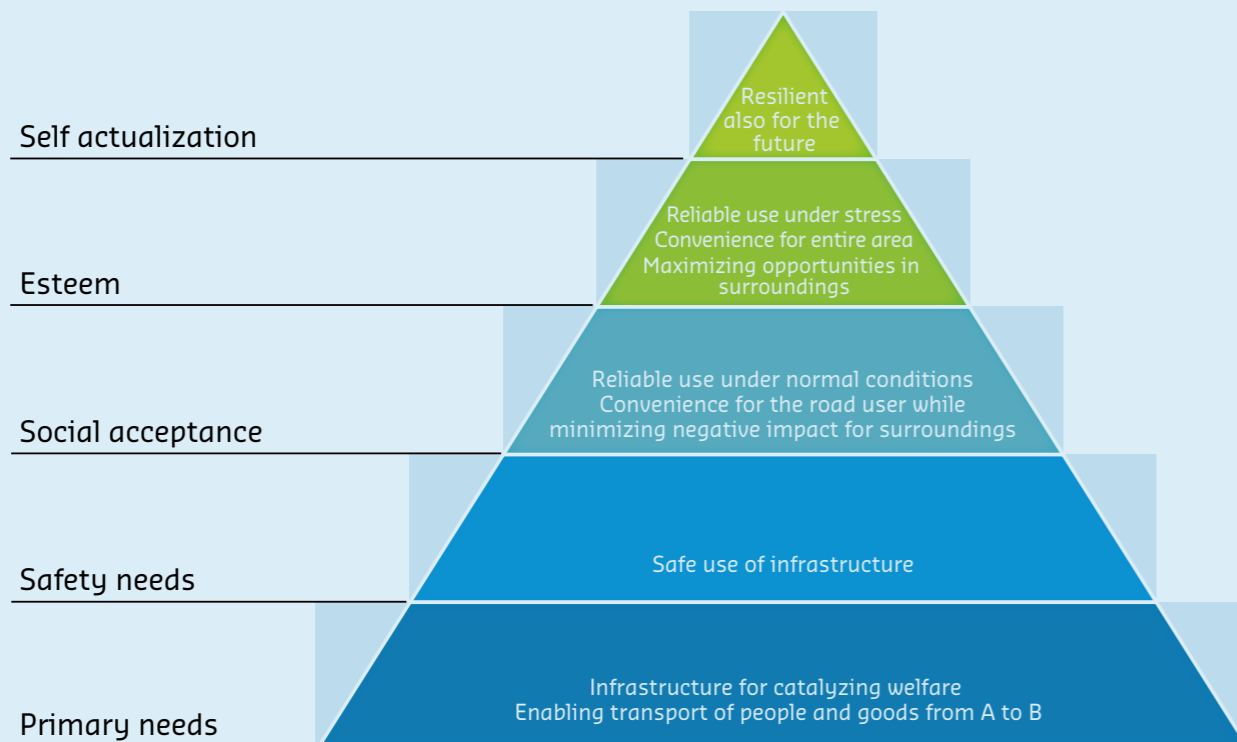


We acknowledge the value of collaborative approaches combined with the application of engineering knowledge. We incorporate stakeholders' experiences, adjust to local priorities and preferences and gain access to data that is otherwise formally unavailable. This allows us to contribute to sustainable decisions and implementations through knowledge-sharing and the stimulation of local cooperation. Capabilities include:

- Stakeholder elicitation process
- Courses and workshops
- Integration with asset management
- Financing
- Procurement

We customize the methodology to the objectives of the assessment and its implementation.

For this purpose, we have introduced a framework, the "Critical Infrastructure Development Pyramid". Our activities support the development of resilience through a stepwise approach, built on strong foundations.



Software and Methodological Development

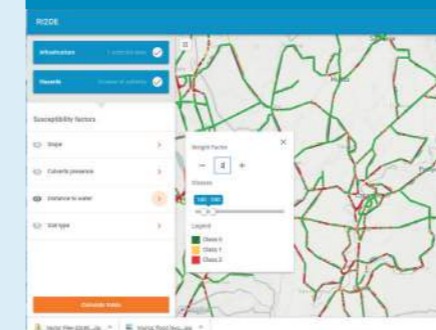
We invest in enabling technologies contributing to work efficiency and facilitating the use of open-source data. We pursue solutions to complex challenges through the development of systematic methodologies anchored in leading research. Our ability to incorporate stakeholder input maximizes the flexibility of our approaches.

RA2CE tool - Risk Assessment and Adaptation for Critical InfrastructureE



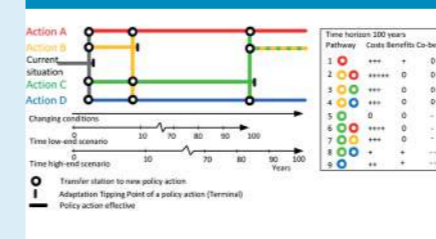
- Tool is developed to support infrastructure owners and operators in risk assessment and adaptation decision-making
- Current capabilities focus on the impact and criticality analysis and risk evaluation in a collaborative setting.
- Ongoing developments towards the prioritization of actions.
- Produces risk maps for the infrastructure networks. This can be expressed in terms of annual expected damage for operator costs (direct) and criticality for societal costs (indirect).
- Incorporates sub-modules for specific capabilities

R12DE - Risk Indicators for Infrastructure in Data-Sparse Environments



- Sub-module integrated in RA2CE tool.
- Suited when the availability of good quality hazard data is limited
- Allows one to gain insight on the degree of susceptibility to different hazards.
- Based on publicly available information and open data.
- Worldwide data coverage and Site-specific knowledge can be incorporated.

Pathways generator for development of Dynamic Adaptive Policy Pathways



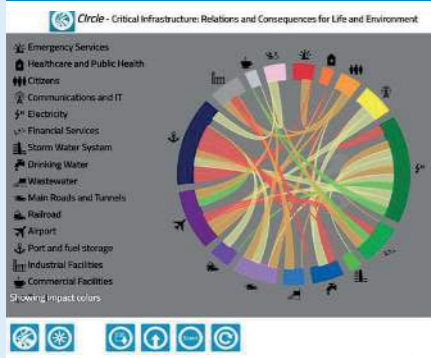
- Links current decision-making to future choices
  - Supports the development of an adaptive plan that is able to deal with uncertain conditions
  - Evaluation of measures under different scenarios
  - Key concept of the tipping point
- <https://www.deltares.nl/en/adaptive-pathways/>

AST - Adaptation Support Tool



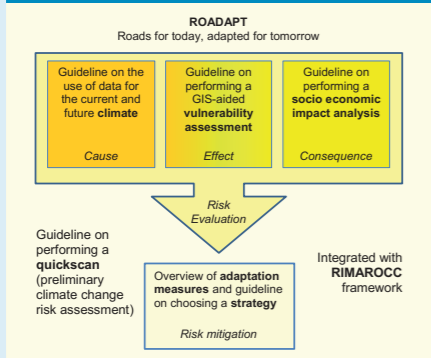
- Touch screen-based application to select adaptation interventions, situate them in the project area and immediately obtain an estimate of their effectiveness and costs.
- Multiple blue, green and grey measures for eco-systembased adaptation such as green roofs, bio-swales, porous pavement and water squares
- <https://www.deltares.nl/en/software/adaptation-support-tool-ast/>

**Circle - Critical Infrastructures: Relations and Consequences for Life and Environment**



- Tool to support the analysis of domino effects of critical infrastructures.
- Facilitates the discussion between the stakeholders which are dependent on each other, builds trust and stimulates future partnerships.
- Users are governmental organizations and agencies, network operators, emergency response organizations as well as large industries who are interested in the dependencies between Critical Infrastructures.
- <https://circle.deltares.org/>

**ROADAPT - Roads for today, adapted for tomorrow**



- risk assessment framework for roads, developed for CEDR
- guidelines for operators, owners, contractors and consultants
- includes a Quick Scan method for fast overview of high risk locations
- adaptation measures for natural hazards including floods, landslides and rainfall events
- socio-economic evaluation methods for input to development of adaptation strategy

**Our recent project portfolio**

**Mainstreaming Disaster Risk Management to Sustain Local Infrastructure, The Philippines, 2018-201**

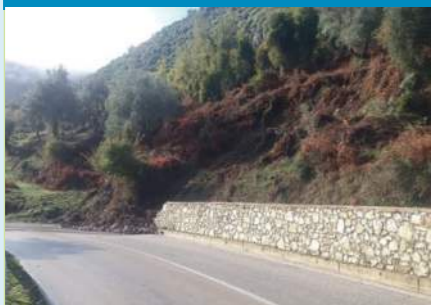
Client: World Bank



- Increasing the capacity and knowledge of local government units
- Multi-hazard risk assessment of the road network
- Prioritization of corrective investments, primarily those for flood management and roads improvement
- Re-evaluation of planning, design standards and asset management frameworks.
- Consultation of stakeholders and collaborative approaches.
- Decision Making under Uncertainty.

**Climate resilient road assets in Albania, 2018-2019**

Client: World Bank



- Assisting stakeholders in the prioritization of future climate and seismic resilient investments in road assets
- Multi-hazard risk assessment of the road network
- Prioritization of mitigation measures
- Re-evaluation of planning, design standards and asset management frameworks.
- Consultation of stakeholders and collaborative approaches.

**Lifeline Utilities Business Continuity Planning, Turkey, 2017-2018**

Client: World Bank



- Impact of natural hazards on lifeline utilities of Tuzla Organized Industrial Zone, Istanbul
- Energy (electricity and natural gas), transport, water, waste water, drain water and communication
- Development of the first lifeline utility BCP for industrial zones
- Best practice catalogue that can be used by other industrial zones.

**Building Resiliency to Climate Events in the Road Network, Paraguay, 2017**

Client: World Bank



- Effective strategy to manage climate risk at Paraguay's road network
- Vulnerability assessment of the country's roads to climate change
- Review of the current road asset management system within the Ministry of Public Works
- Recommendations to internalize risk reduction measures within the road project cycle.

**Multi-hazard risk assessment, cost-benefit analysis, and resilient design recommendations, Afghanistan, 2015-2017**

Client: World Bank



- Multi-hazard risk assessment at national level
- Development of probabilistic models for flooding and seismic risks
- Cost-benefit analysis of mitigation measures
- Stakeholder consultation
- Elaboration of guidance documents on on disaster resilient reconstruction efforts in Afghanistan

**INTACT - impact of extreme weather on critical infrastructure; effects of extreme weather on the hinterland connections of the Port of Rotterdam, 2016-2017**

Client: European Union



- Multi-hazard risk assessment on hinterland connections of the port
- Cascading effects between various infrastructure networks
- Preliminary and detailed risk assessment
- Stakeholder consultation; collaborative risk assessment
- Effects of climate change on the risk profile

**Climate for InnovA58, The Netherlands, 2016-2017**

Client: Rijkswaterstaat (Dutch Ministry of Infrastructure and Environment)



- Climate vulnerability assessment and adaptation
- Improving resilience of the A58 highway in the future
- Recommendations on how to improve network resilience based on best practices in Europe and the US

Deltares is a leading applied research institute and specialist consultant delivering innovative solutions and applications in the fields of water, infrastructure and subsurface.

## Deltares expertise

- Delta Infrastructures
- Flood Risk
- Adaptive Delta Planning
- Ecosystems and Environmental Quality
- Water and Subsoil Resources
- Software Innovation
- Expertise in policy, science and engineering disciplines.
- Combination of specialised consultancy and applied research to address sustainability concerns.
- We focus on the United Nations' Sustainable Development Goals by thinking globally and acting locally.

