Agenda

Welcome and introduction

14.15 – 15.45 hybrid presentation session

afterwards in person training sessions

Programme Day 1 *(in-person and online)*

13:00	Registration & lunch
14:00	**Welcome and introduction**
14:15	**Hybrid session - presentation of ICARUS project results with Q&A session:** **ICARUS** - Improve the uptake of Climate change Adaptation in the decision making processes of Road aUthoritieS
15:45	Break
16:00	Demonstration and training on the ICARUS climate change adaptation implementation process *(in-person only)*
18:00	**End of Day 1**
19:00	Dinner *(Restaurant La Tasca, Voldersgracht 13 & 14, Delft)*

CEDR
Conférence Européenne des Directeurs des Routes
Conference of European Directors of Roads

Programme Day 2 *(in-person only)*

09:00	Demonstration and training on the use of impact chains to understand climate resilience
10:15	Break
10:30	Demonstration and training on the use of the adaptation options database and evaluation approaches of adaptation options
12:30	Lunch
13:30	Demonstration and training on specific recommendations to include Nature Based Solutions in climate change adaptation solutions
14:30	Break
14:45	Demonstration and training on overcoming implementation barriers
16:00	Summary of obtained feedback, open questions, implementation issues and Closing remarks
17:00	**End of Conference**

Practicalities

To connect to the WiFi
- Go to eduroam.deltares.nl
- Register
- Receive an sms
- Use received log-in information to connect to the eduroam WiFi

In case of questions
- For people online: use the chat
- For people in Delft: raise your hand

When joining the teams session from Delft, please make sure
- Mute yourself 
- Sound off 

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Improving the uptake of Climate Change Adaptation in the Decision-Making processes of Road Authorities; output of the ICARUS project

Thomas Bles, Deltares

Enhancing resilience via adaptation

Plenty of research on resilience

- Risk and resilience frameworks
- Resilience assessment tools
- Adaptation frameworks

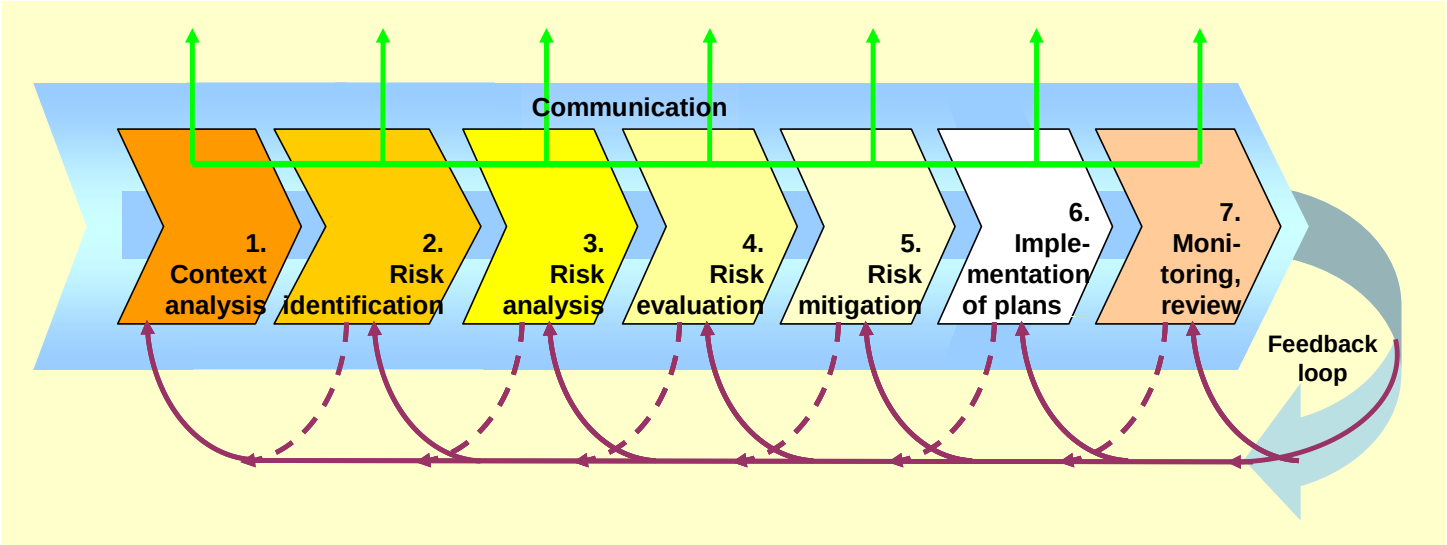
Implementation is lacking

- Existence of tactical gap; no line of sight
- Unclear level of acceptable risk
- Insufficient connection to decision making
- Economic appraisal of adaptation options is uncommon
- Insufficient inclusion of relevant NRA stakeholders

ICARUS

Resilience and climate change adaptation frameworks exist

CEDR: RIMAROCC and ROADAPT



Source: CEDR 2011 and 2015

ROADAPT
Roads for today, adapted for tomorrow

Guideline on the use of data for the current and future **climate**

Cause

Guideline on performing a GIS-aided **vulnerability assessment**

Effect

Guideline on performing a **socio economic impact analysis**

Consequence

Risk Evaluation

Guideline on performing a **quickscan** (preliminary climate change risk assessment)

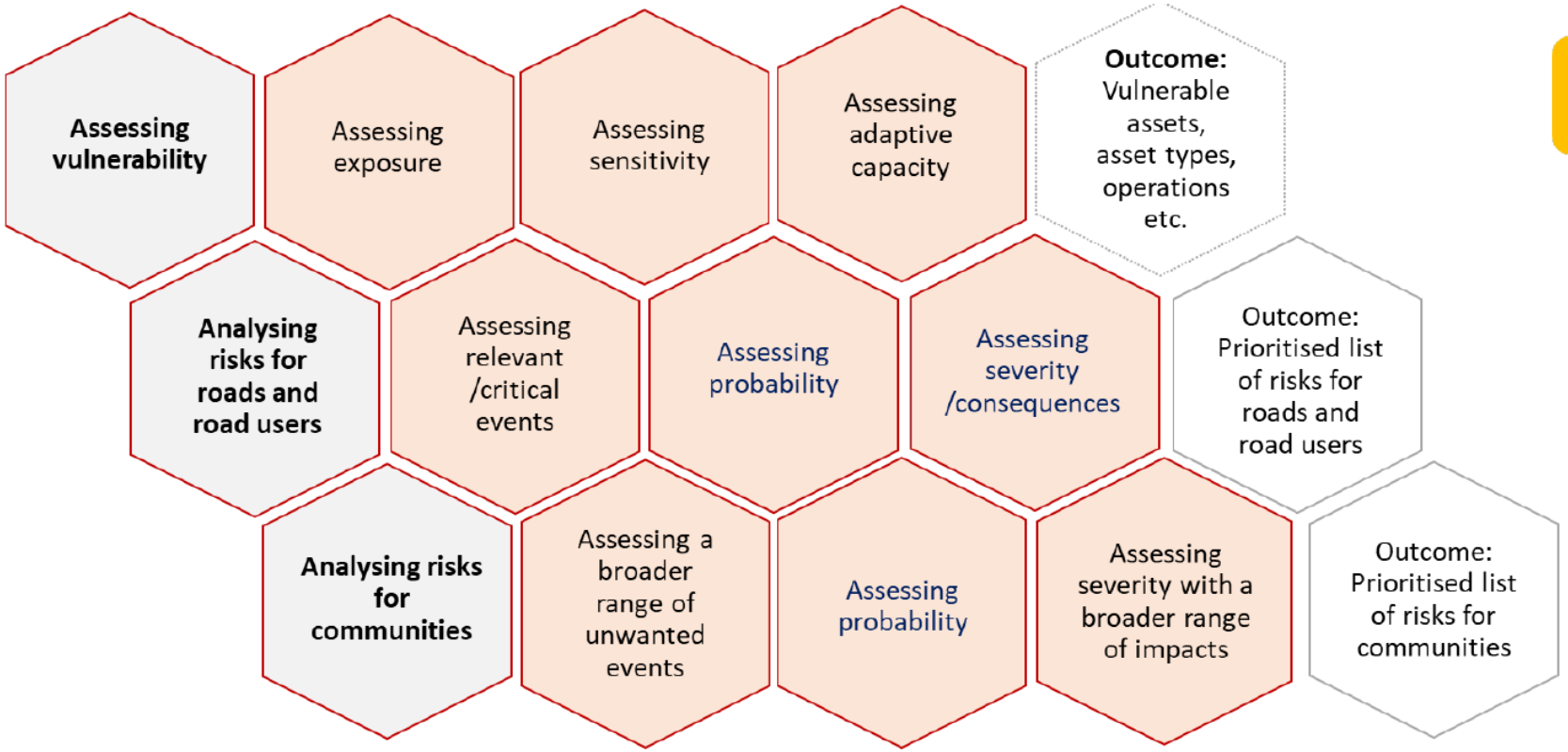
Overview of **adaptation measures** and guideline on choosing a **strategy**

Risk mitigation

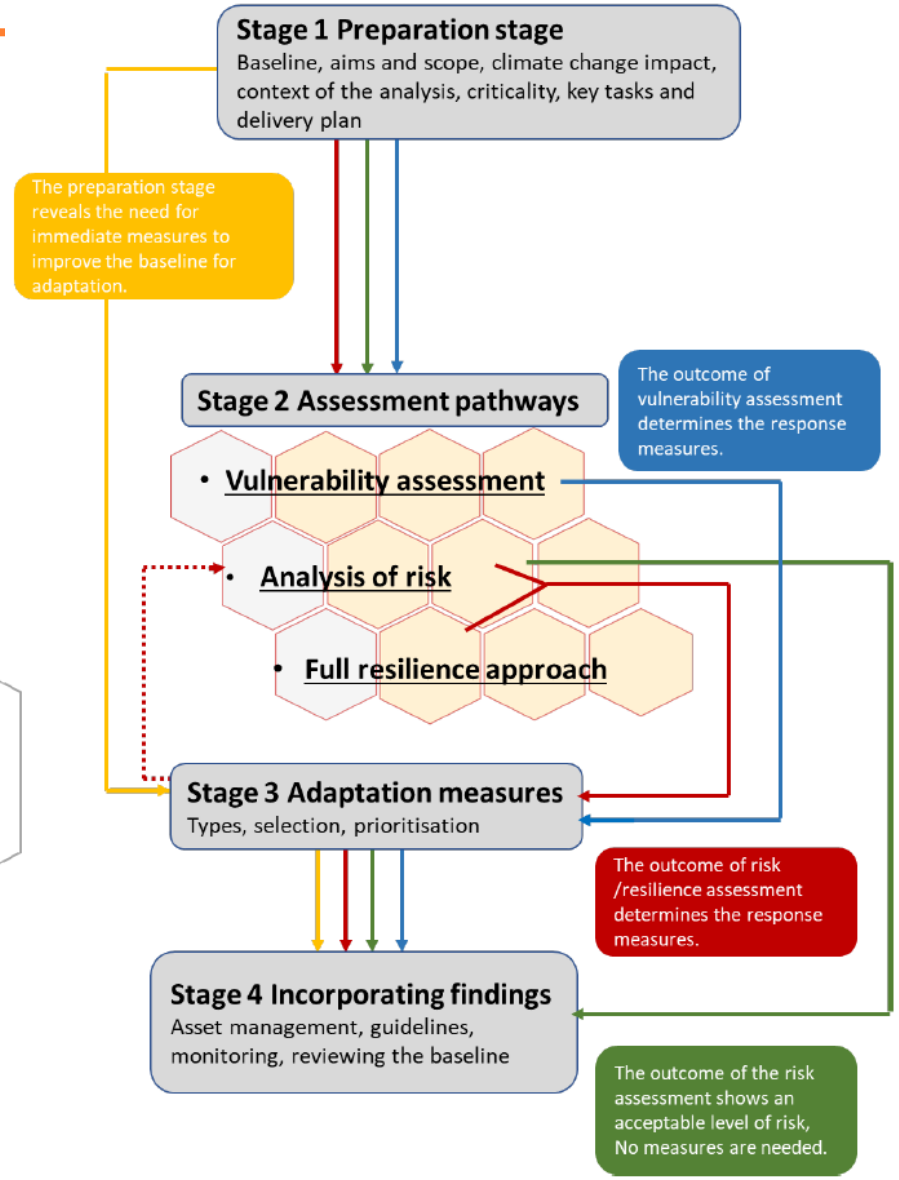
Integrated with **RIMAROCC** framework

ICARUS

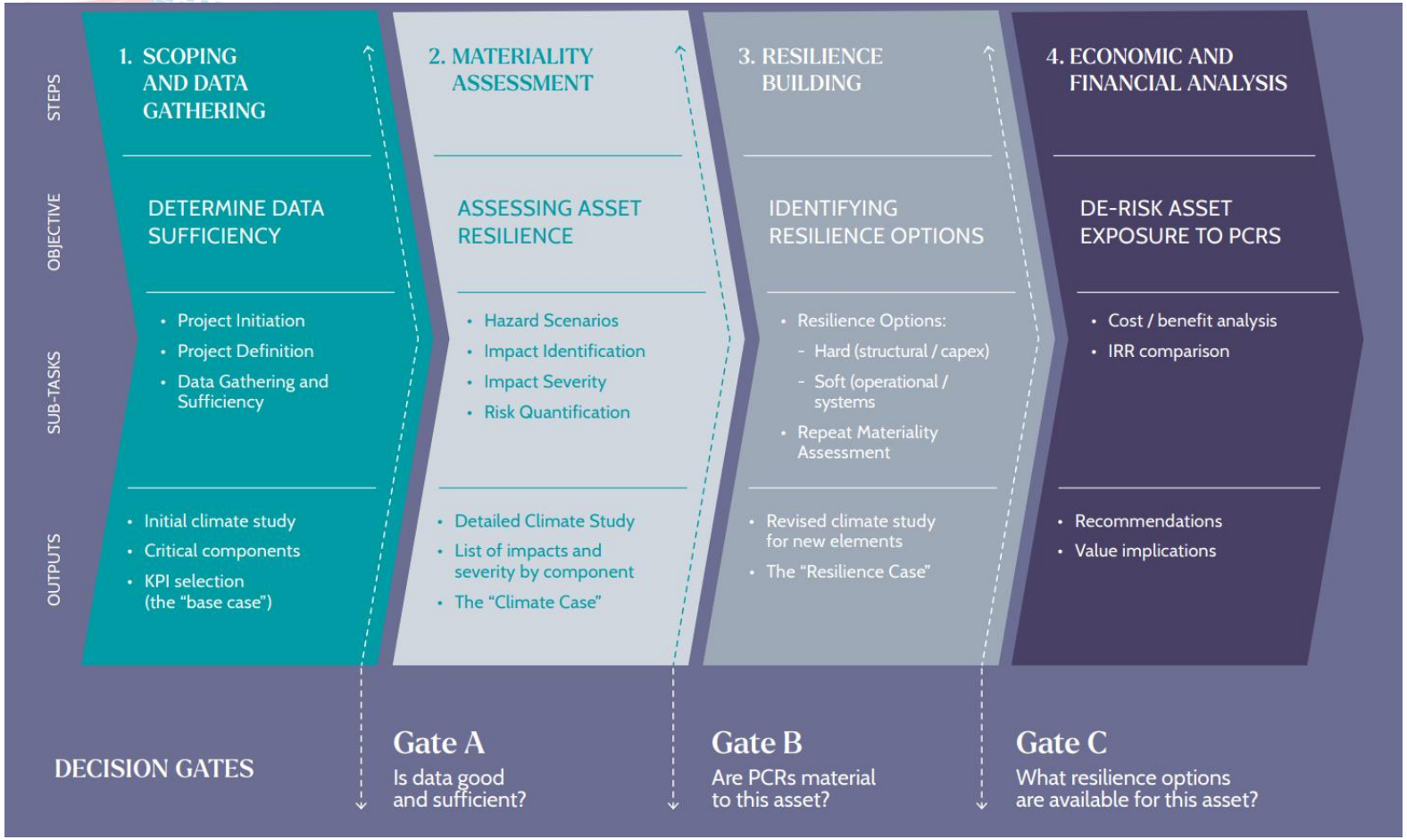
Resilience and climate change adaptation frameworks exist



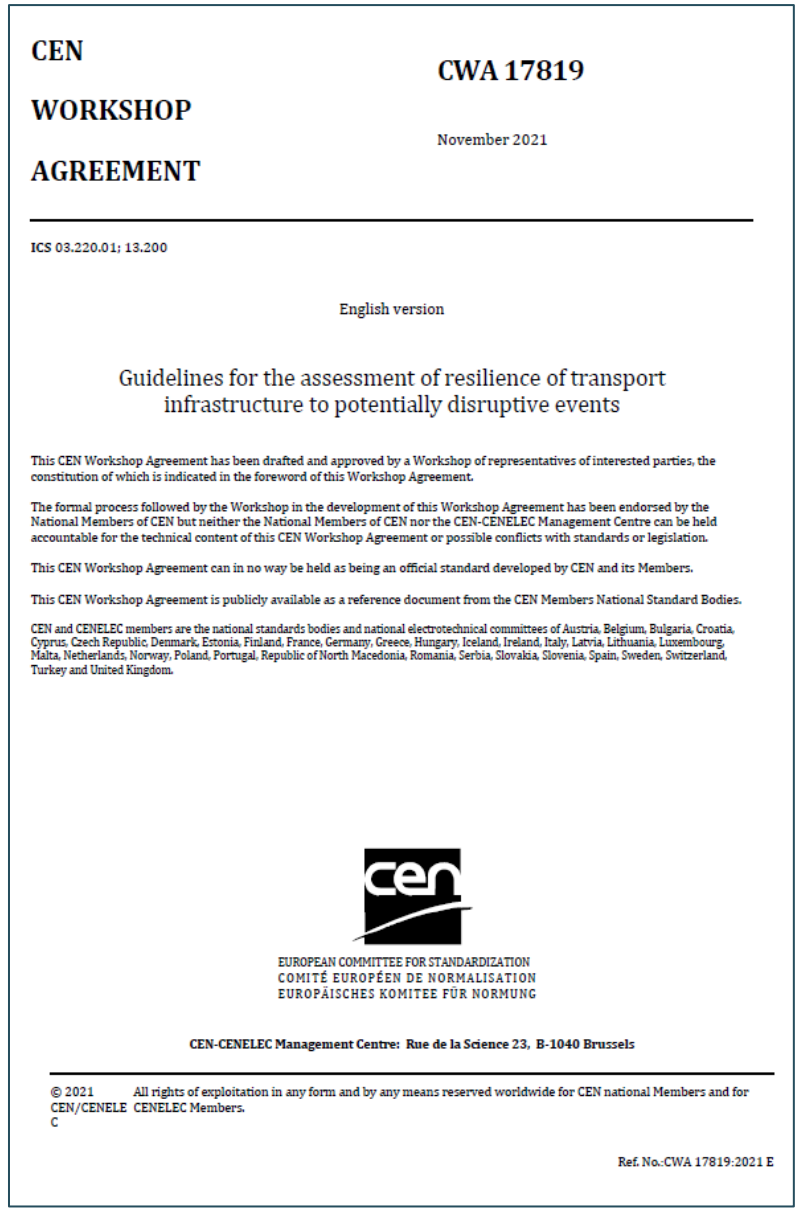
Source: PIARC 2023



Resilience and climate change adaptation frameworks exist



Source: CCRI 2022



CEN WORKSHOP AGREEMENT

CWA 17819

November 2021

ICS 03.220.01; 13.200

English version

Guidelines for the assessment of resilience of transport infrastructure to potentially disruptive events

This CEN Workshop Agreement has been drafted and approved by a Workshop of representatives of interested parties, the constitution of which is indicated in the foreword of this Workshop Agreement.

The formal process followed by the Workshop in the development of this Workshop Agreement has been endorsed by the National Members of CEN but neither the National Members of CEN nor the CEN-CENELEC Management Centre can be held accountable for the technical content of this CEN Workshop Agreement or possible conflicts with standards or legislation.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No.:CWA 17819:2021 E

Source: CEN 2021

The ICARUS project

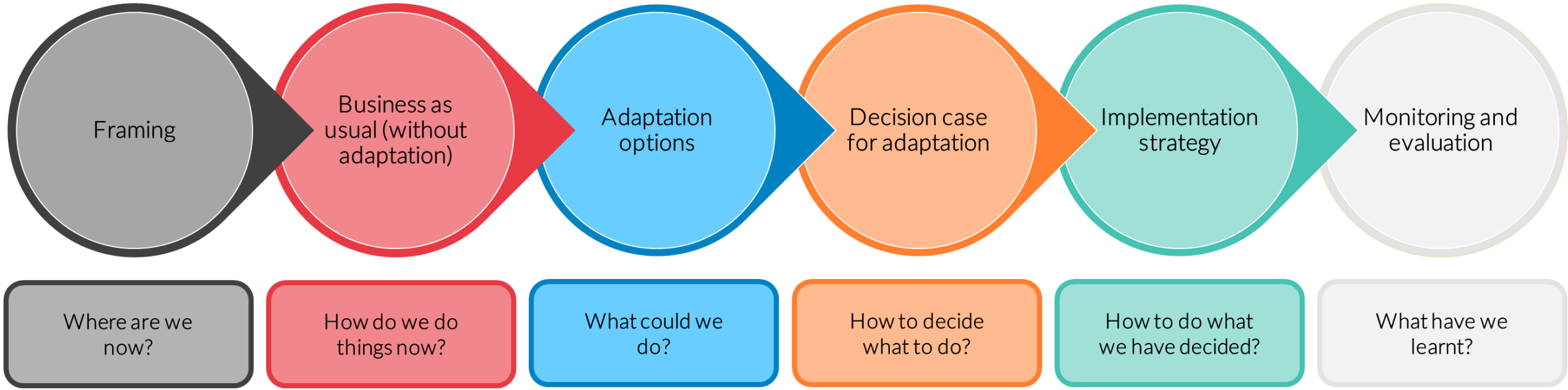
- CEDR call 2021: Climate Change Resilience
- June 2022 – May 2024
- Partners
  - Deltares (coordinator, The Netherlands)
  - Tecnalia (Spain)
  - Ramboll (Finland, Denmark)
  - Research Driven Solutions (Ireland)
  - Maple Consulting (UK)

Main ICARUS objectives

To provide **guidance and guidelines** on how to build and implement the **business case for resilience** via adaptation, by **balancing the service levels** that the road network needs to achieve with the **costs and benefits** for enhancing resilience

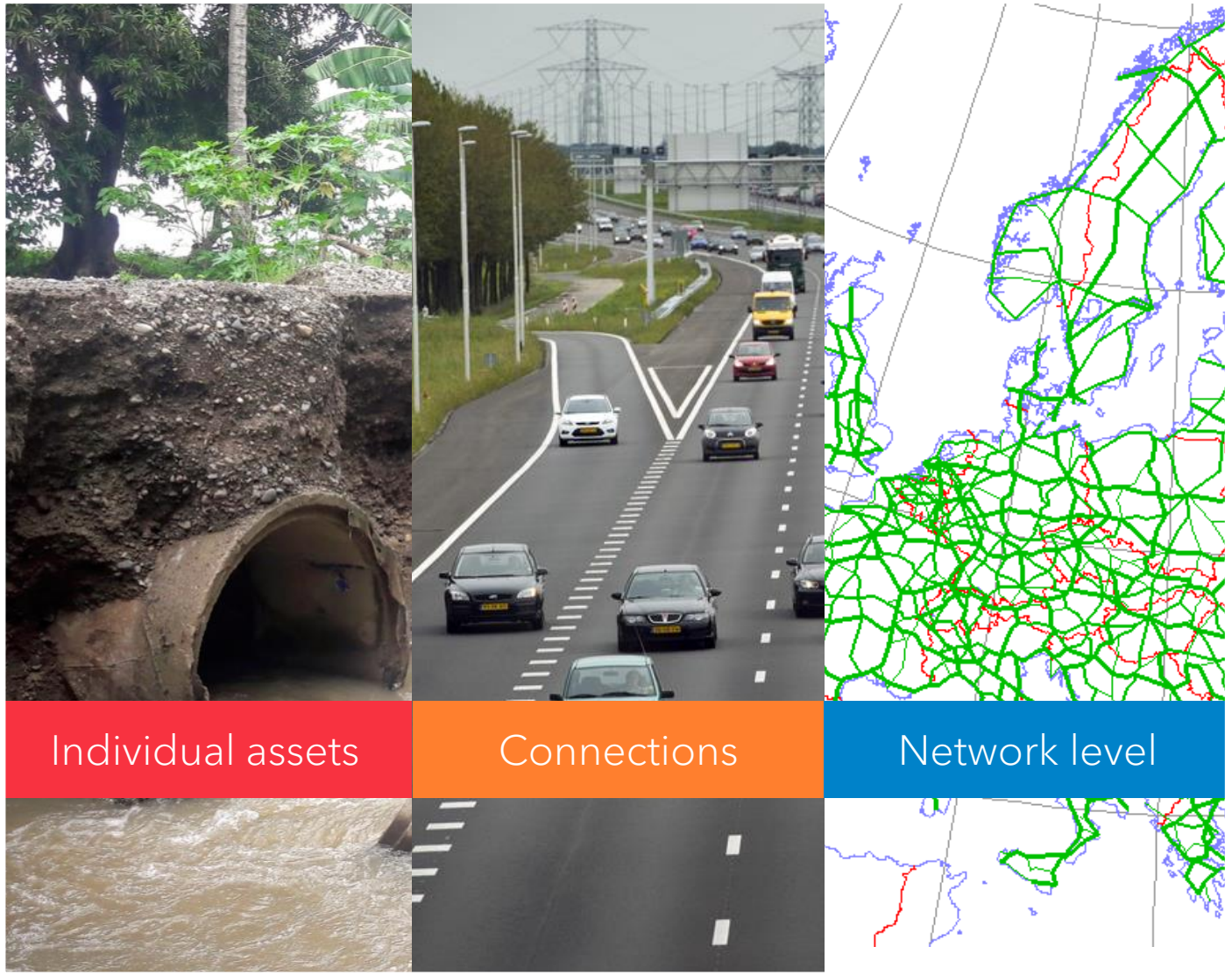
To ensure that existing research and new ICARUS research can be implemented in practice by NRAs as well as by their supply chain stakeholders

One ICARUS framework

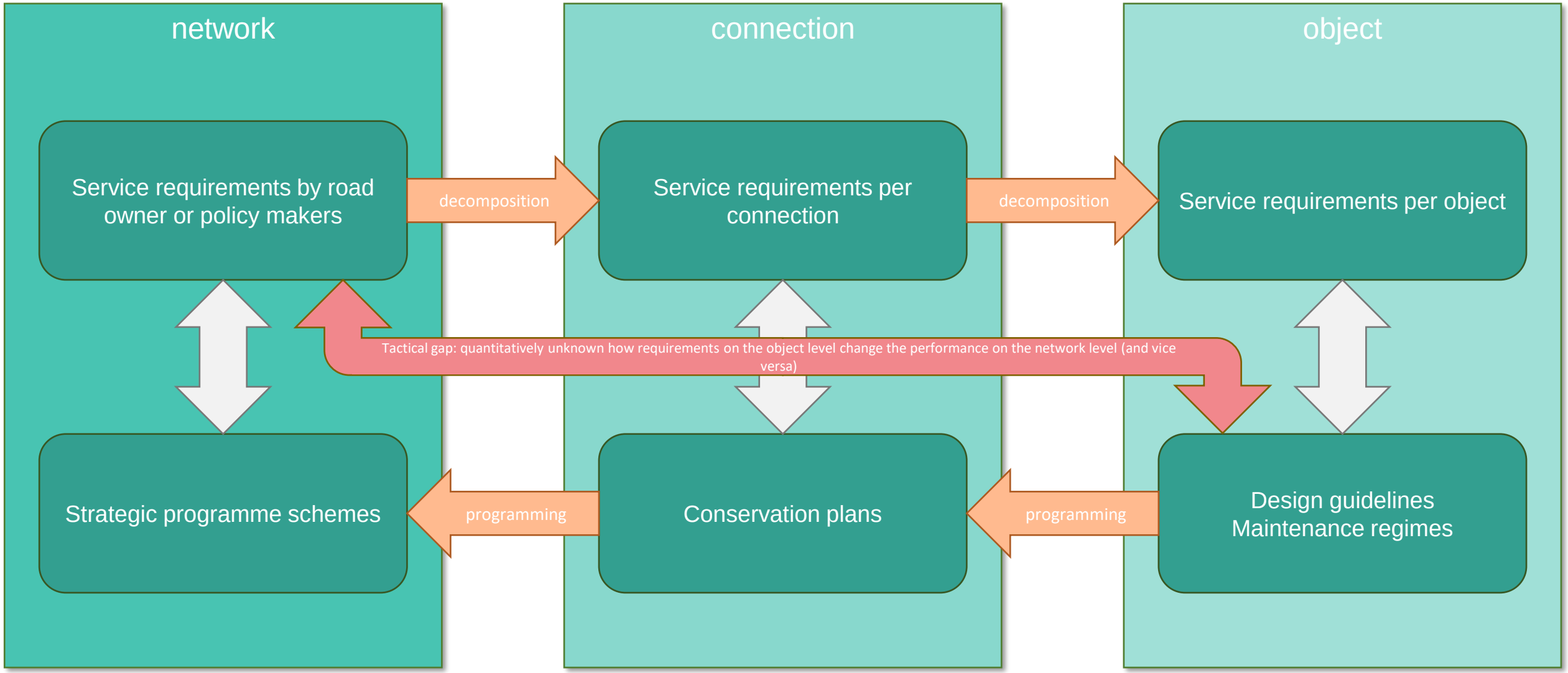


- ICARUS provides targeted research to enhance the use of the framework
- In this presentation: the core research results

Scales



Existence of a tactical gap



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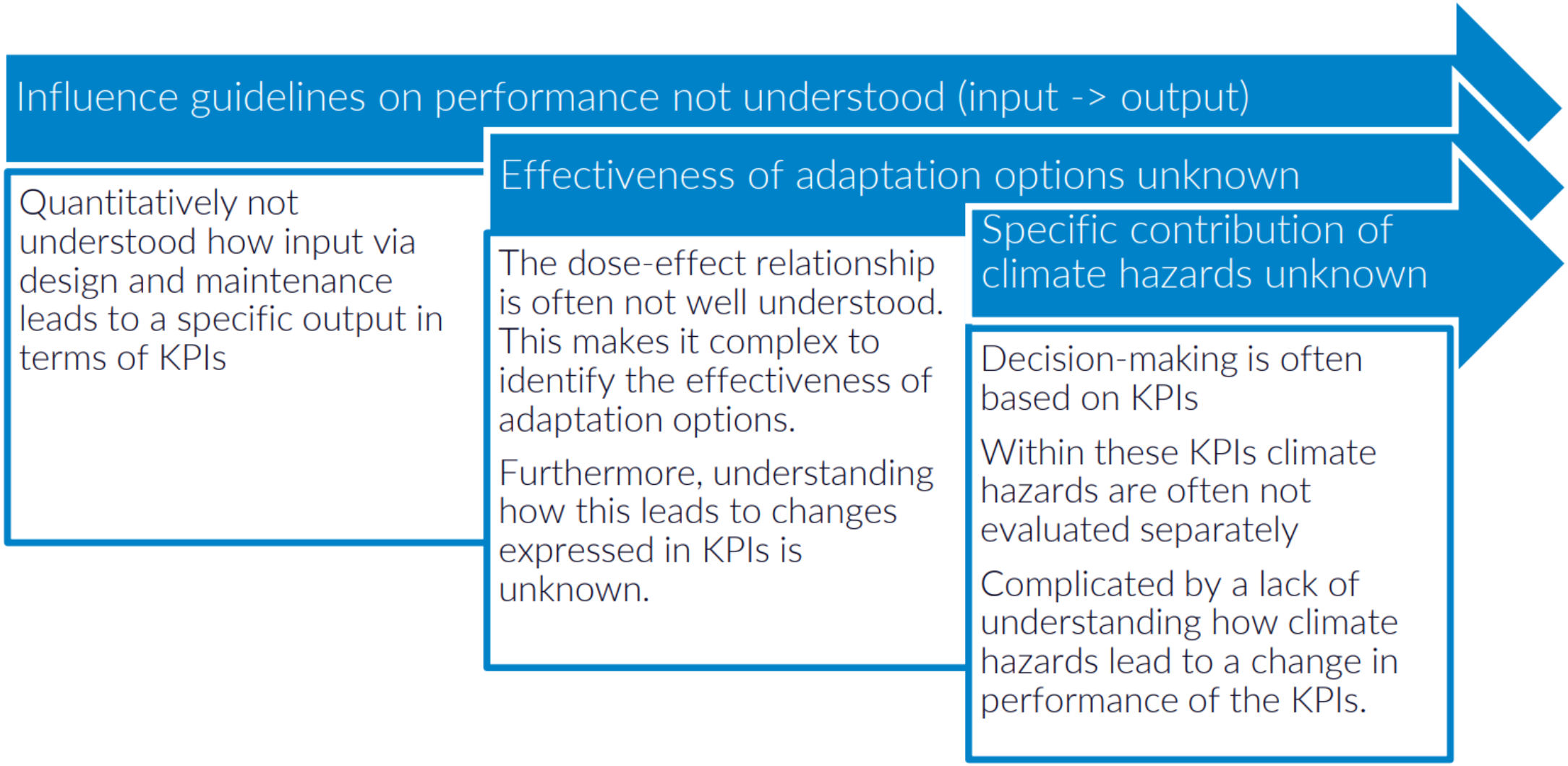

Existence of a tactical gap

Individual assets level

e.g. dimensions to withstand a 1/50 years flood

Connections level

Network level

e.g. 96% availability

How do design or maintenance guidelines on asset level …

…translate to achieving KPIs on network availability?

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NRA decision criteria

Service driven	Ensuring a minimum service level
Budget driven	Maximum service with given budget
Optimum service	Strive for service levels where costs and benefits are balanced
Policy driven	Biodiversity Carbon Climate change adaptation Environmental partnerships Equity and inclusion

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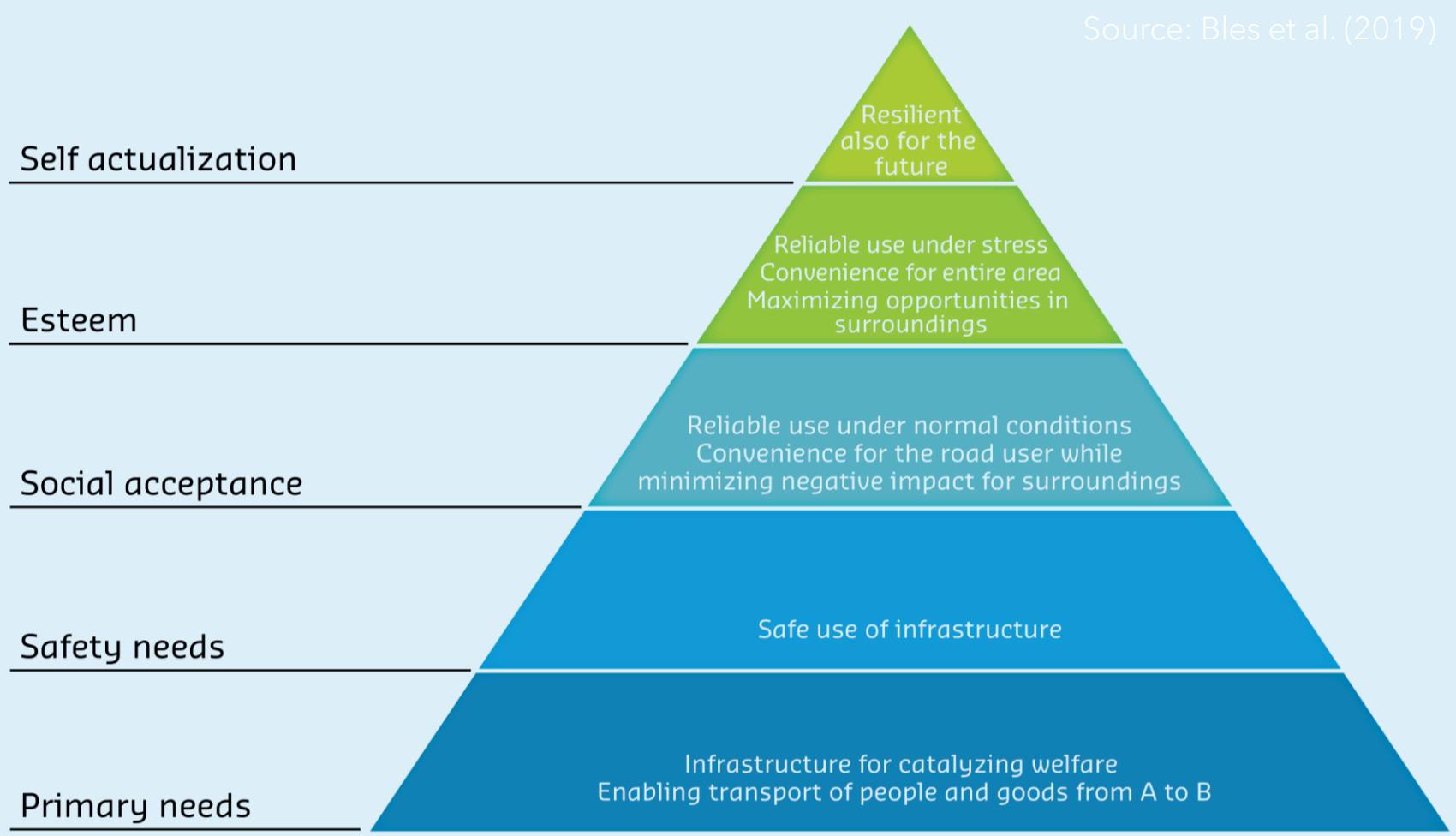
Output and input based steering mechanisms

KPI's (output)

Availability
Safety
Environmental effects
Road user needs
Resilience

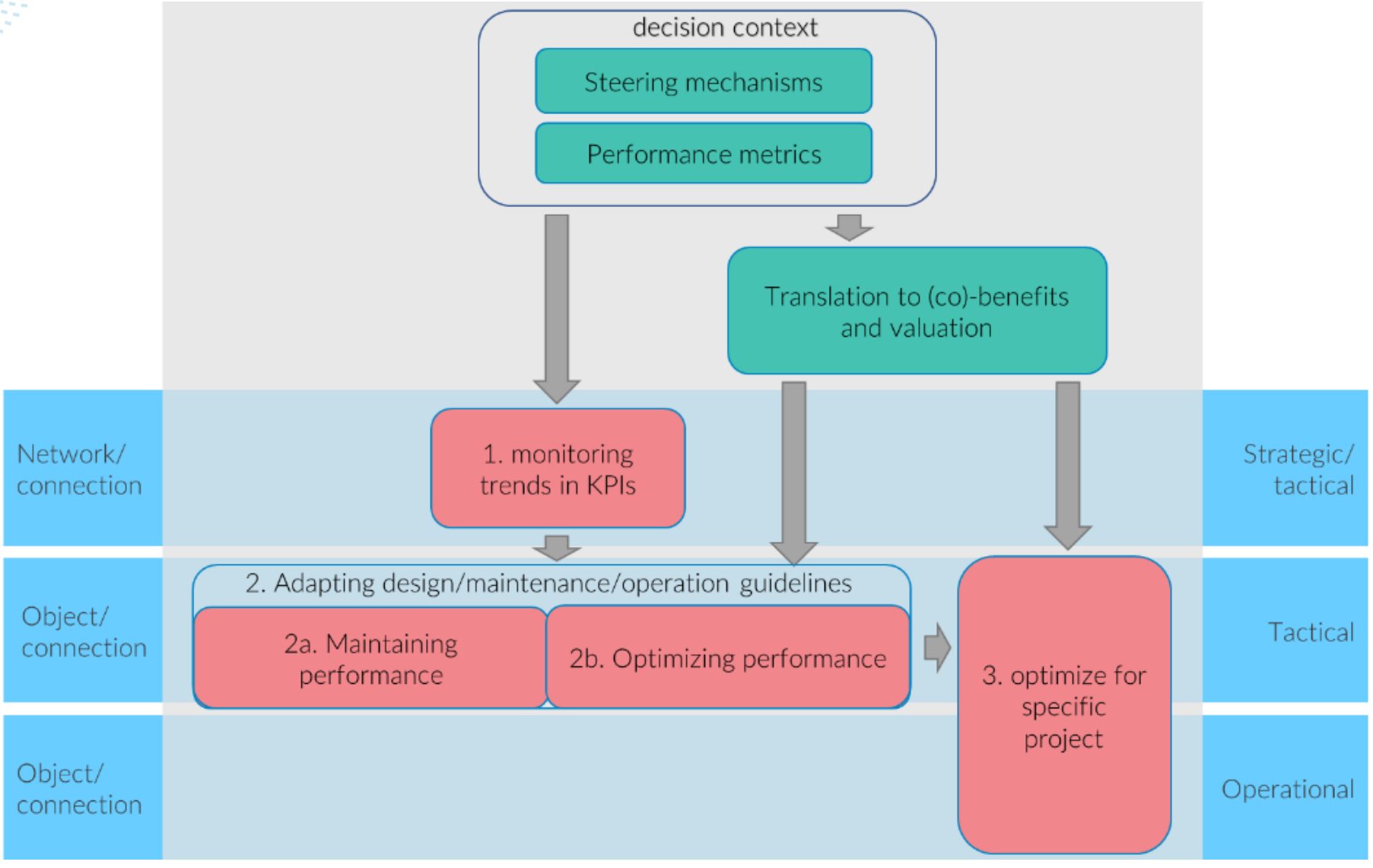
Other policies
Biodiversity
Carbon
Climate change adaptation
Environment
Inclusion



Key Performance Indicator	Metric	Possible unit
Availability, **Or sometimes referred to as fast and reliable journeys**	Delay	Vehicle Loss hours; sometimes categorised by unplanned and planned closures An average delay per vehicle distance
	Network availability	% of time and length in a year that a road or part of a road is closed; sometimes categorized by unplanned and planned closures Average speed
	Travel time	Average travel time to relevant points of interest Journey time reliability
	Social inclusion	Average travel time to basic everyday activities
	Incident clearance	Average time needed to re-open a (part of) the road after an incident happened
Safety	Killed or seriously injured	Number of casualties Number of injuries
	Incidents	Number of collisions
	infrastructure safety,	% distance driven over roads with a safety rating above an agreed threshold % road network length of roads with a safety rating above an agreed threshold
	emergency response	Average time needed for first responders to be at the location of an incident
	in time preparedness for extreme weather	percentage of time and length for which the road was prepared in time for the extreme weather

Benefit	Description	Quantification	Valuation	Indicator for magnitude of impact
Availability				
Travel time, leisure	Value of travel time for persons in their leisure time	Minutes of increase/decrease in travel time	Travel loss hours / value of travel time	Number of users of network and level of change
Travel time business	Value of travel time for businesses	Minutes of increase/decrease in travel time	Travel loss hours / value of travel time	Number of users of network and level of change
Reliability of travel time	The value of reliability of predicted travel time for users	Reliability of predicted travel time measured as e.g., percentage of average travel time of a road network	Value of reliability	Number of users of network and level of change
Availability of network	The value of being able to always access public services and critical infrastructure	-		
Availability: Connectivity and social inclusion	Connectivity and travel time to basic everyday activities	-	-	-
Durability		-	-	-
Replacement	Costs associated with wages, materials etc.	Hours worked, units of material, fuel machine hours etc	Wages, costs of materials, fuels, machinery, etc.	-
Upgrading	Costs associated with wages, materials etc.	Hours worked, units of material, fuel machine hours etc	Wages, costs of materials, fuels, machinery, etc.	-
Safety	Value of injuries/fatalities	Increase/decrease in the risk of injuries/fatalities	Value of statistical life	Number of users of the network and level of change
Health effects		-	-	-
Air pollution	Improved air quality from increased coverage of plants	Increase/decrease in the level of particle matter	Value of statistical life, quality adjusted life year	Number of affected individuals and level of change
Noise	Lowered noise levels from noise barriers of coverage from plants	Increase/decrease in the level of decibel	Value of statistical life, quality adjusted life year	Number of affected individuals and level of change
Job creation	Job creation from investment in climate adaptation/resilience	-	-	-
Ecosystem services	Value assigned to areas due to their aesthetics, opportunities for walking, socializing etc.	Increase/decrease in level of greening or ha of green areas	Stated/revealed preference methods	Number of users of the area, and level of change in provision of environmental good
Water quality	Value assigned to good quality of water, e.g., stemming from conta-minants from run-off	Increase/decrease in quality status, e.g., ecological status based on threshold values		Number of affected individuals and level of change.
Climate				
Embodied carbon	Emissions arising from construction materials, transport, and installation	Increase/decrease in the number of embodied carbon emissions	Social cost of carbon	Level of change in the number of embodied carbon emissions

Building the case for adaptation: 3 approaches



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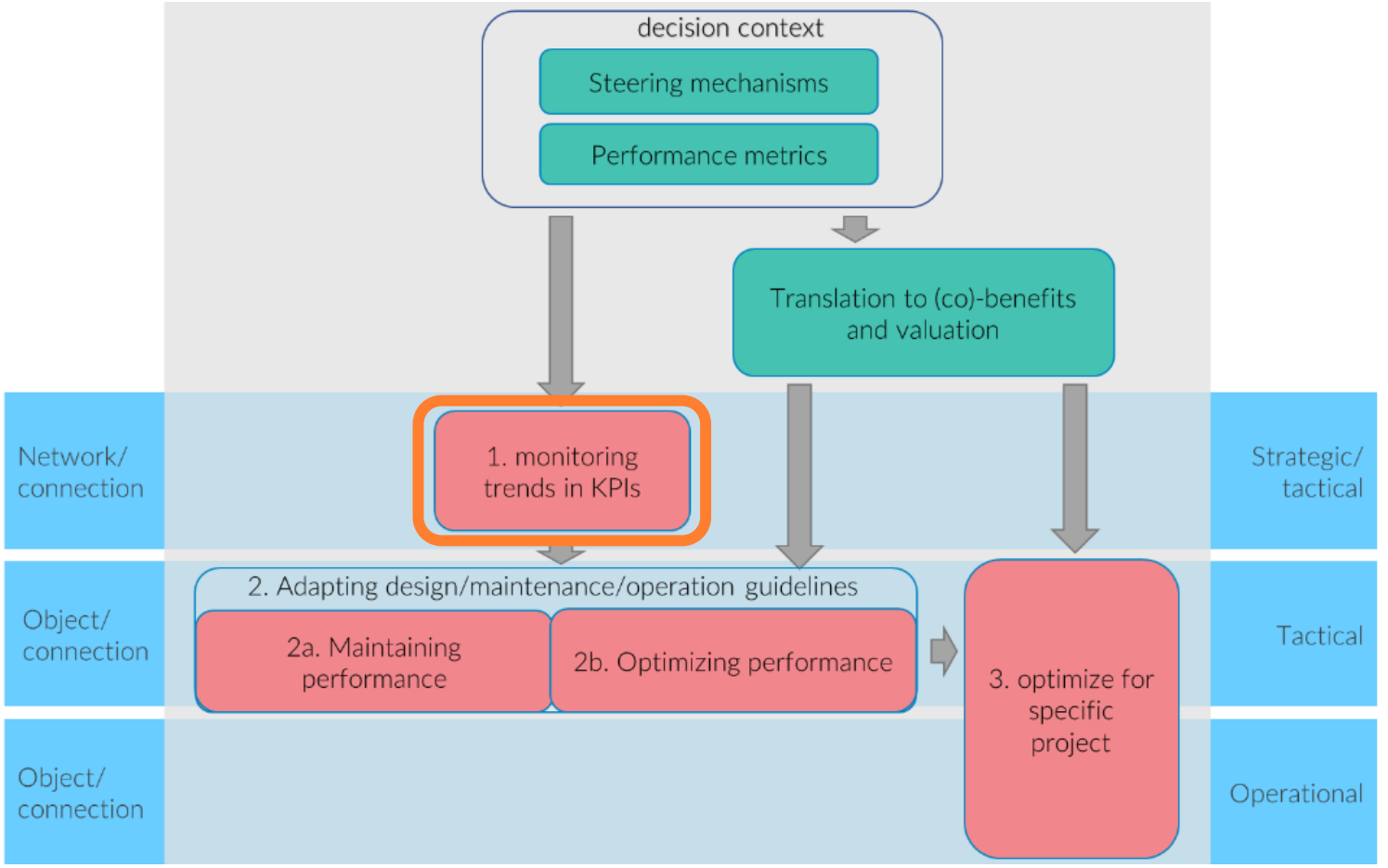
Approach 1

Advantages:

- To underpin need for adaptation
- To understand relation between climate and performance
- To understand dose-effect and effectiveness of measures

Disadvantages

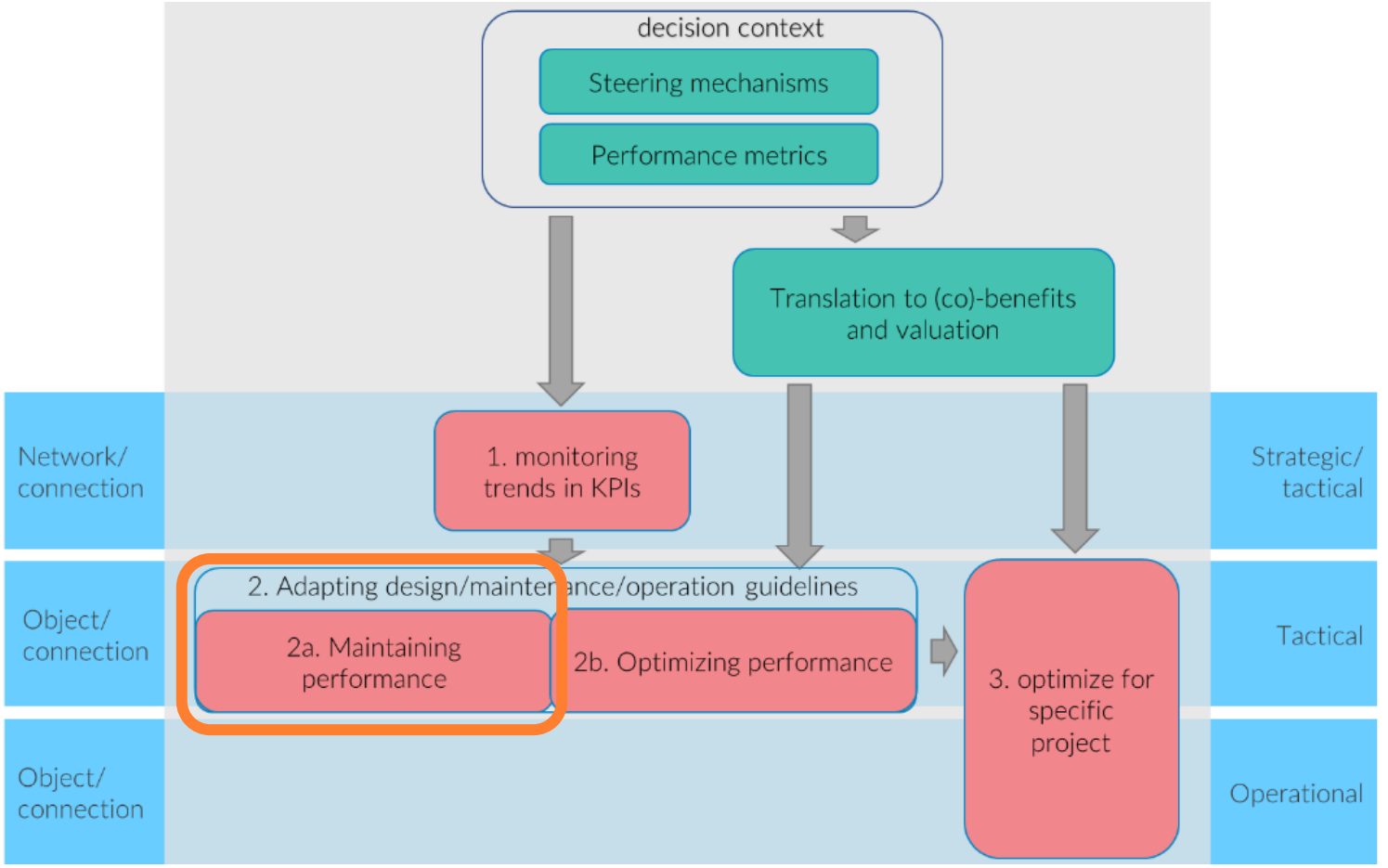
- Only provides arguments
- Only for frequent events
- Necessary to have proper monitoring



Approach 2a

Advantages:
- Straightforward
- No change in performance
- Adaptation of guidelines will lead to ‘automatic’ adaptation in practice

Disadvantages
- No optimized performance
- No insight in additional benefits (no additional budgets)
- No expansion of knowledge base



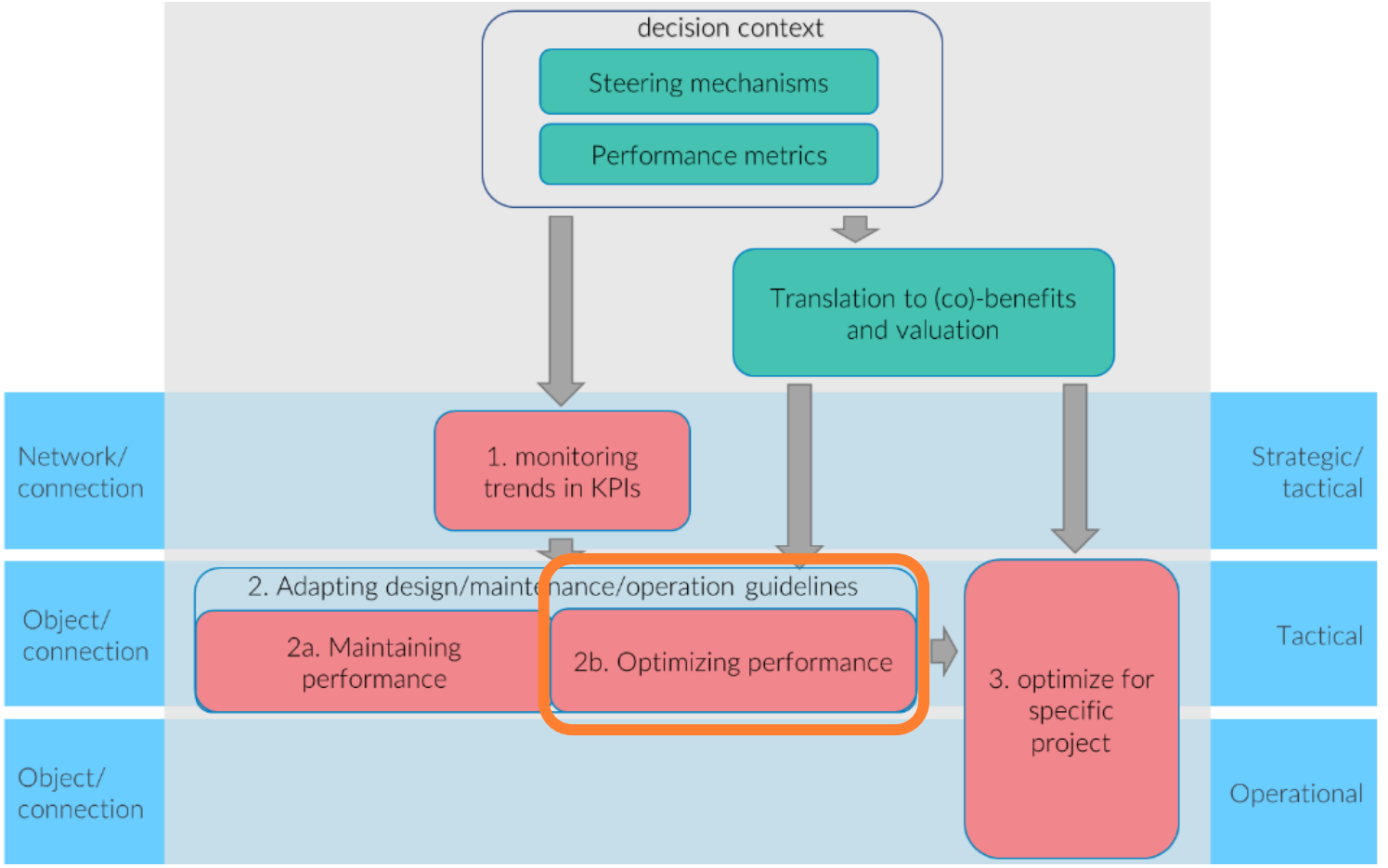
Approach 2b

Advantages:

- Optimum/efficient use of public money
- Adaptation of guidelines will lead to 'automatic' adaptation in practice
- Expansion knowledge base

Disadvantages

- Case based research requests higher need for resources
- Elaborate approach
- Data availability
- Possible extensive discussions to adapt guidelines



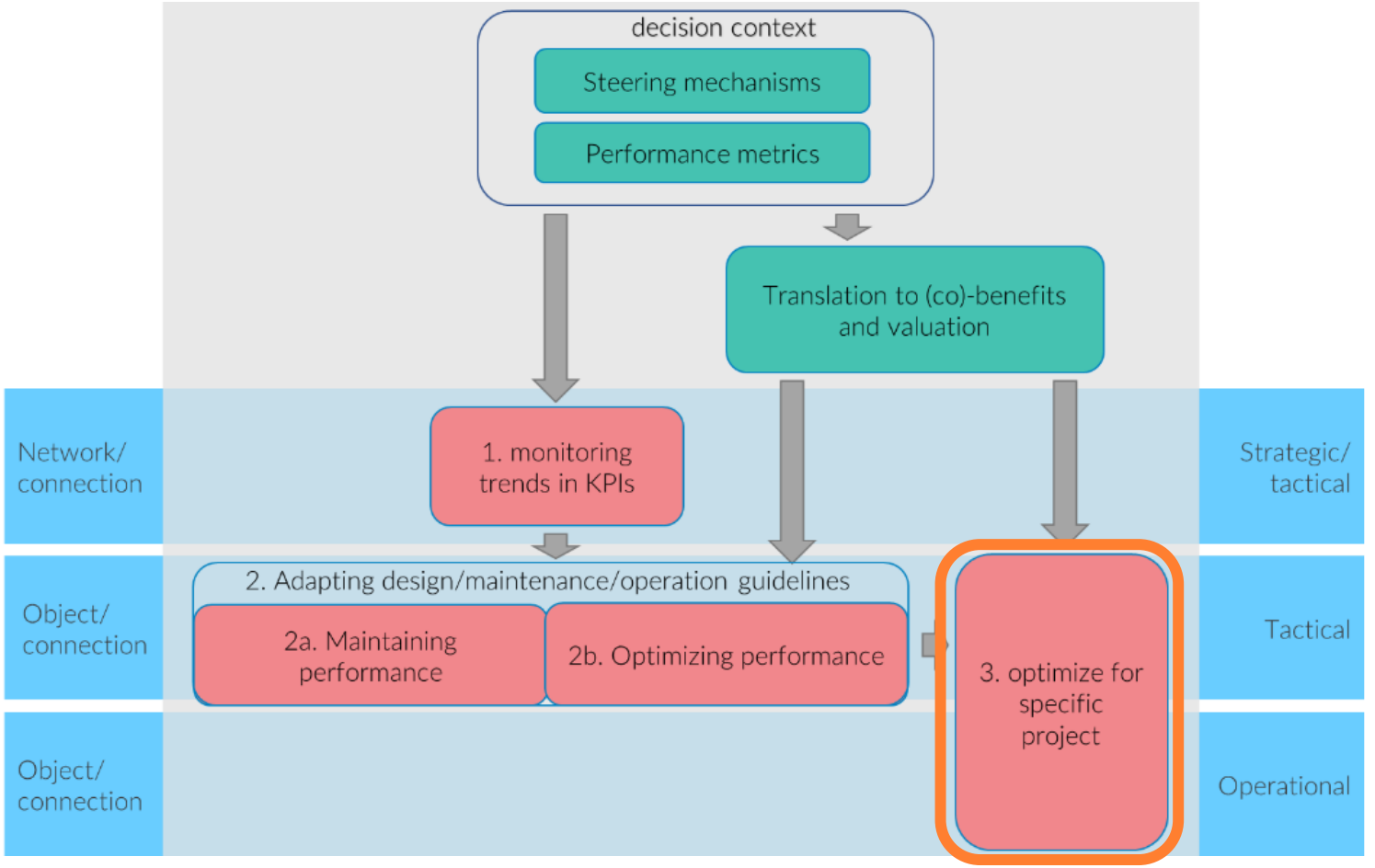
Approach 3

Advantages:

- Optimum/efficient use of public money
- Especially worth considering for bigger projects
- Gradual increase of knowledge base and ability to later link approach 2b

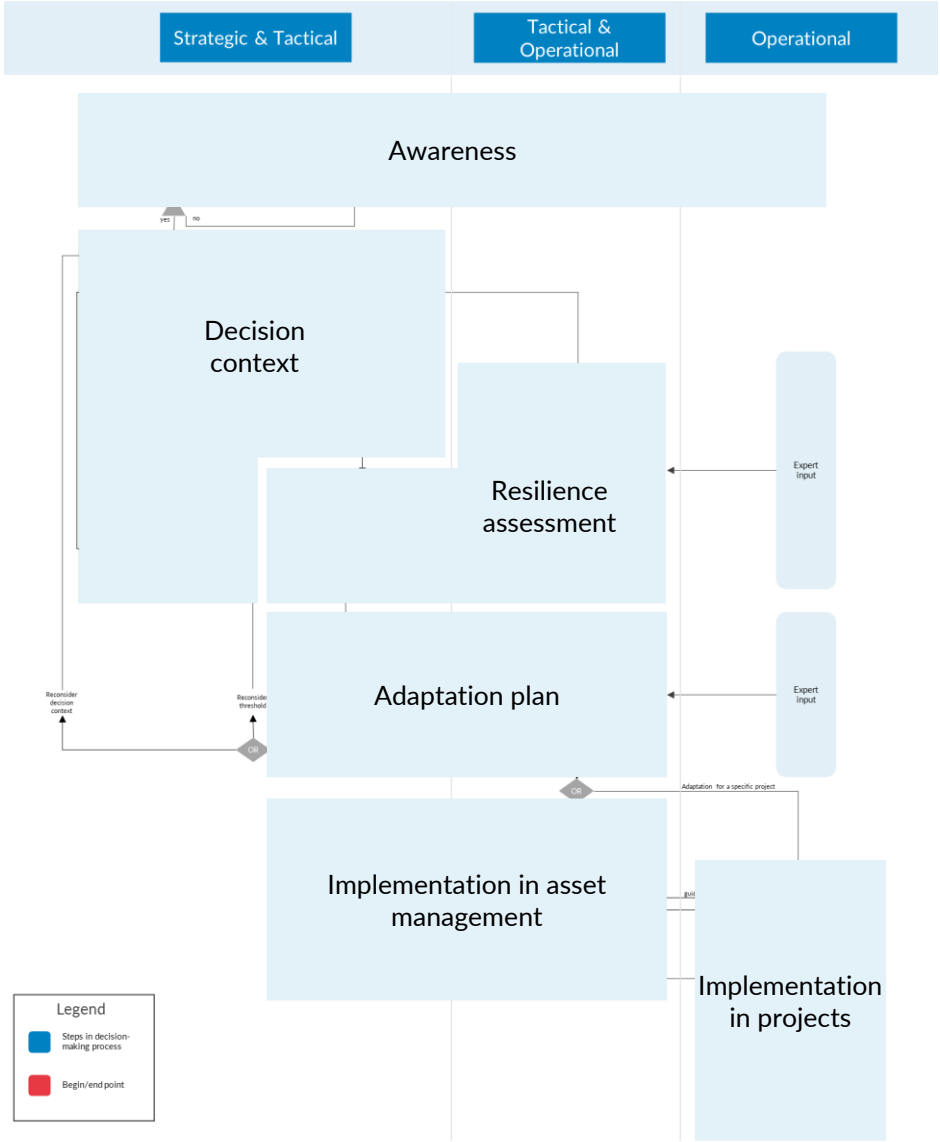
Disadvantages

- Not efficient to do such analyses for all projects
- Resources not sufficiently available at operational level



Adaptation Implementation Process

- All management levels should be engaged
  - Continuous shifts
  - One person in charge recommended
- Link with the decision context is key
  - Resilience and adaptation assessments should be tailored
- Understand how climate change affects performance
- Implementation via two routes
  - Adapting asset management
  - Individual project level



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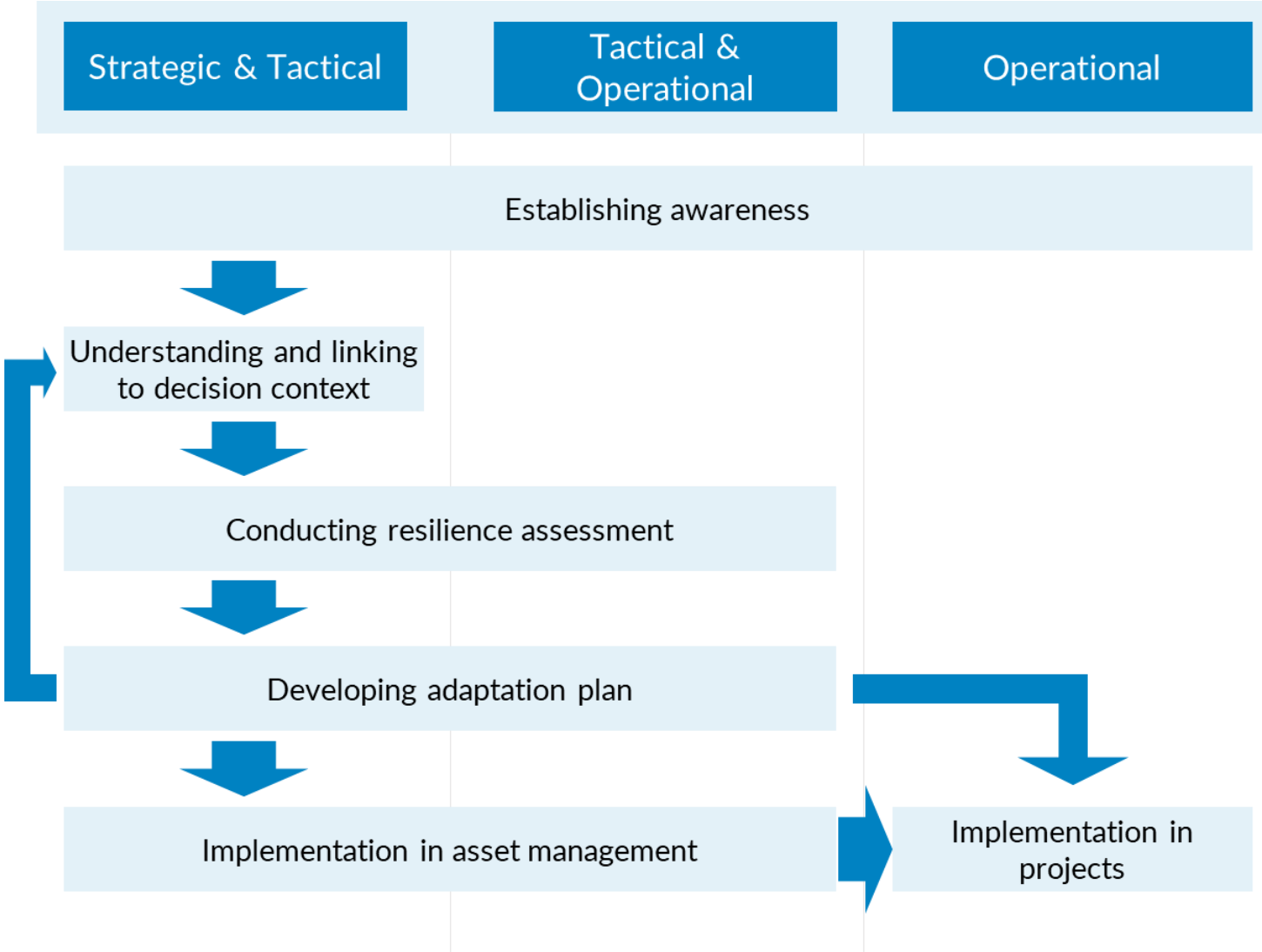
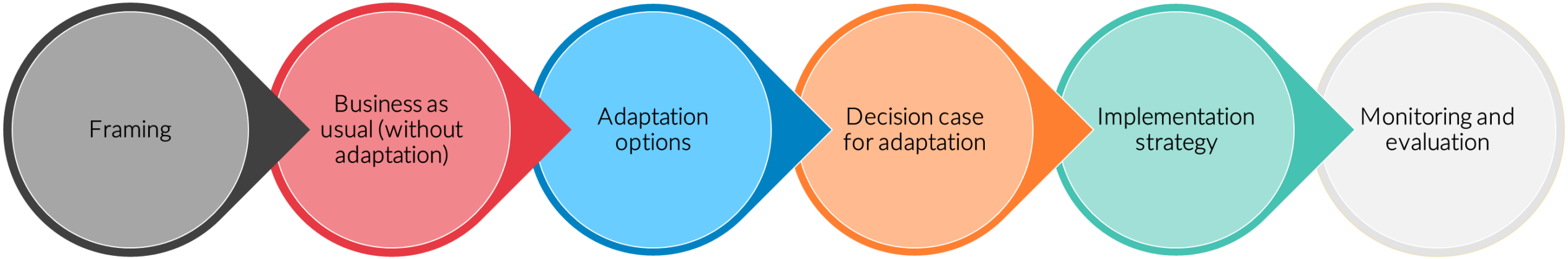
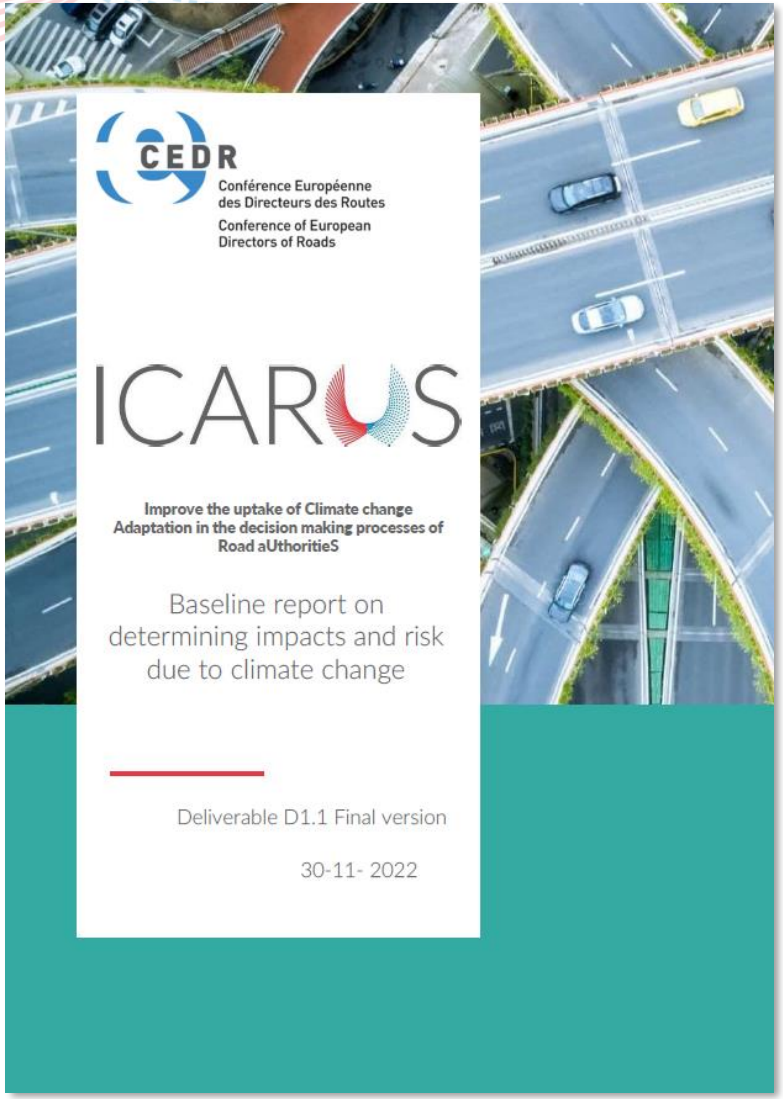


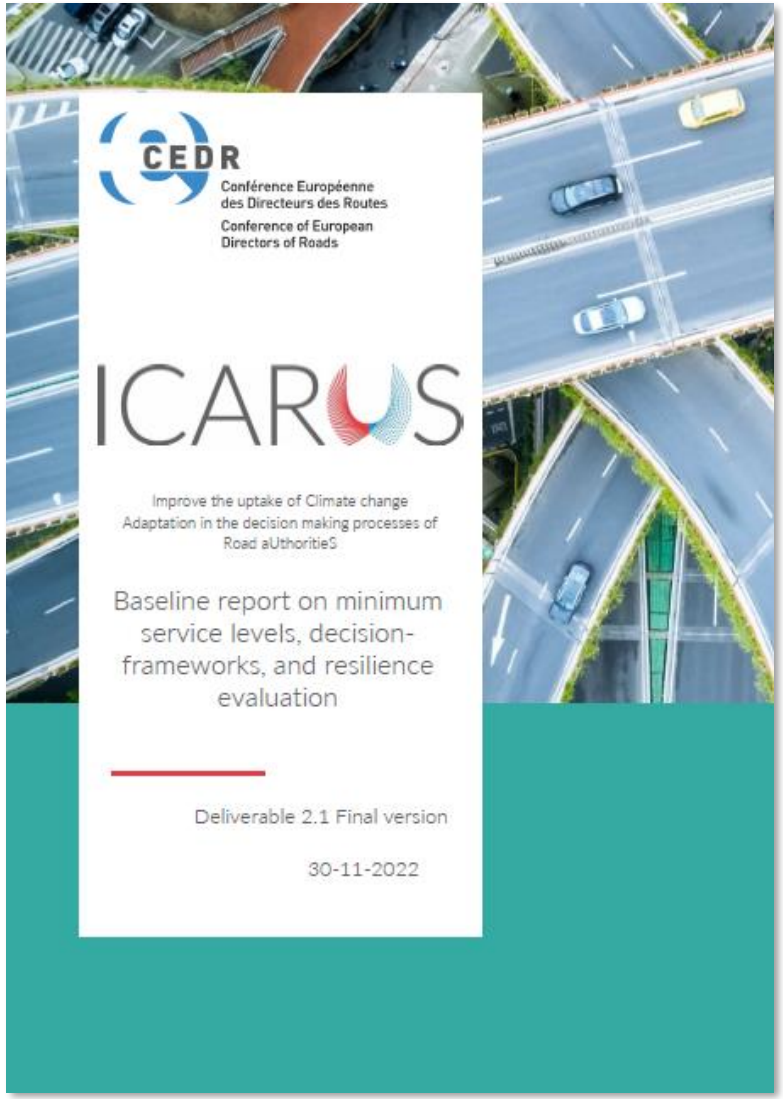
One ICARUS framework

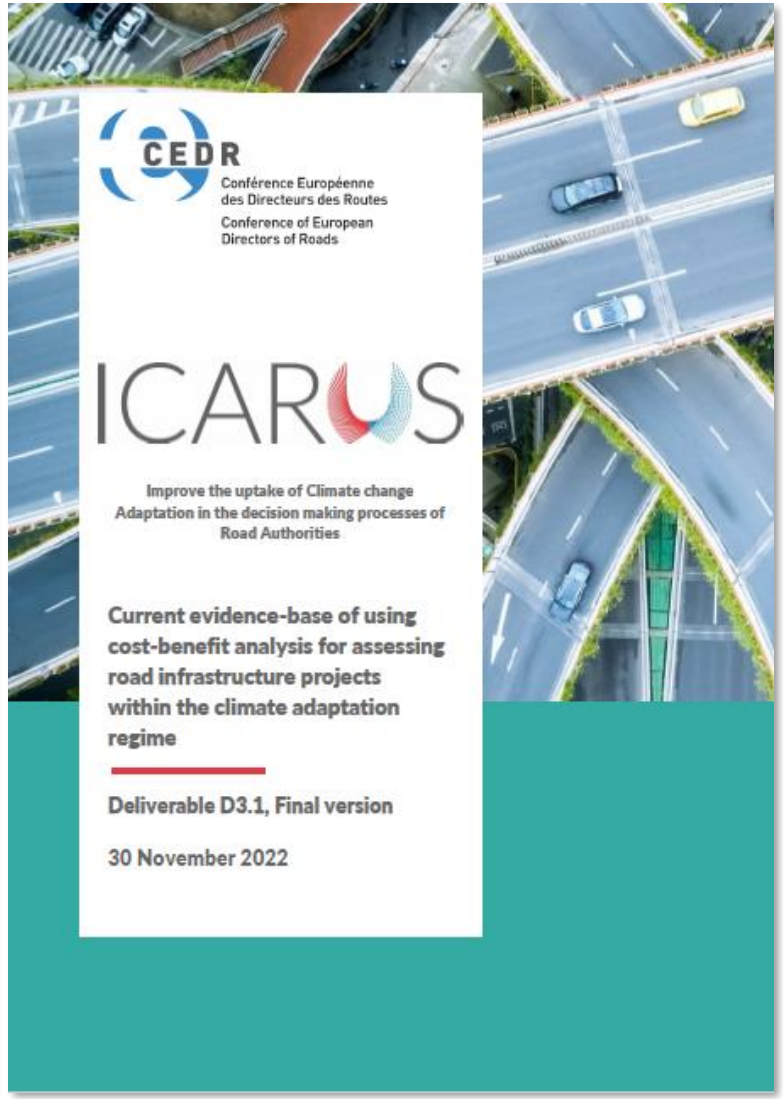


Where are we now?	How do we do things now?	What could we do?	How to decide what to do?	How to do what we have decided?	What have we learnt?
• Asset/ Component/ Subcomponent definition – D1.1 • Decision making at NRAs – D2.2 • KPI identification – D2.2	• How to quantify resilience? – D1.2, D2.1, D3.1 • How to quantify impacts linked to KPIs and (co-) benefits – D2.2	• Identify & classify adaptation options – D2.3 • Nature based solutions – D4.2 • Appraisal of adaptation options – D2.2, D3.2, D3.1	• Decision case for adaptation – D2.2 • Valuation and evaluation adaptation strategies – D3.1 • Nature based solutions – D4.2	• Implementation in NRA processes – D2.3 • Dissemination of findings – D4.3	• Monitoring of KPIs – D2.2

Three baseline reports







ICARUS results

1. Enhancing understanding of resilience and adaptation
2. Enhancing implementation at road authorities
3. Nature Based Solutions
4. Dissemination of results

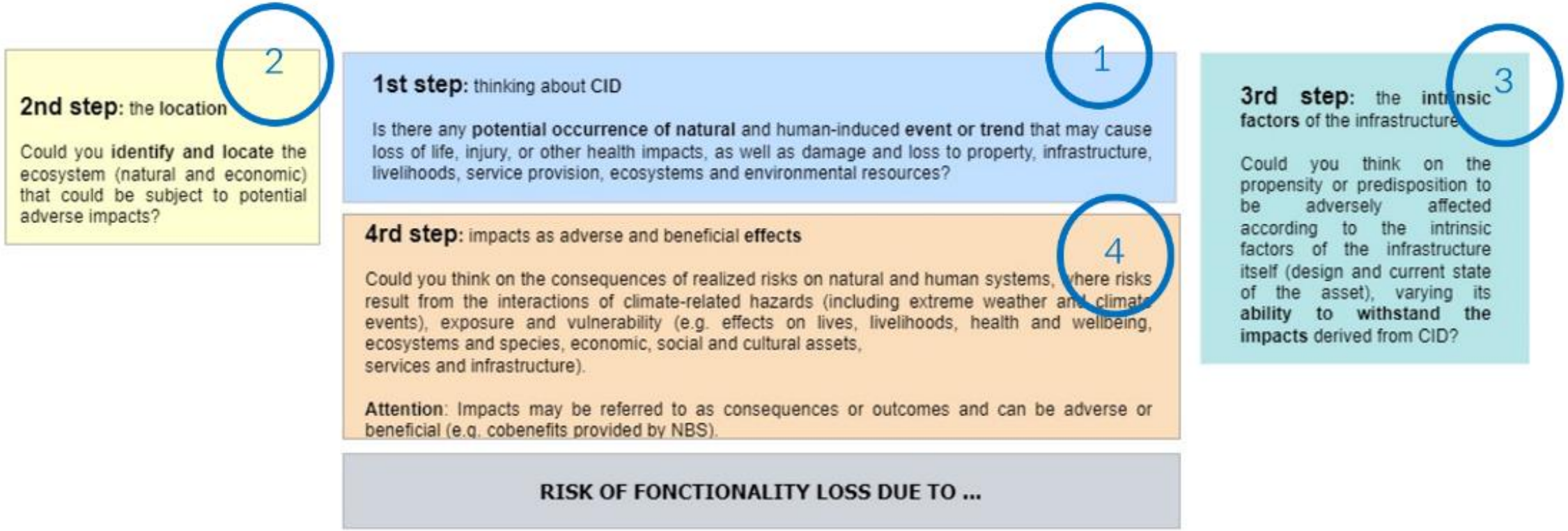
Enhancing understanding of resilience and adaptation

1. Impact chains

- A tool to enhance understanding of the way Climate Impact Drivers will impact the road network
  - Hazard
  - Exposure
  - Vulnerability
  - Impact
- To inform the climate change resilience assessment and Adaptation Strategies

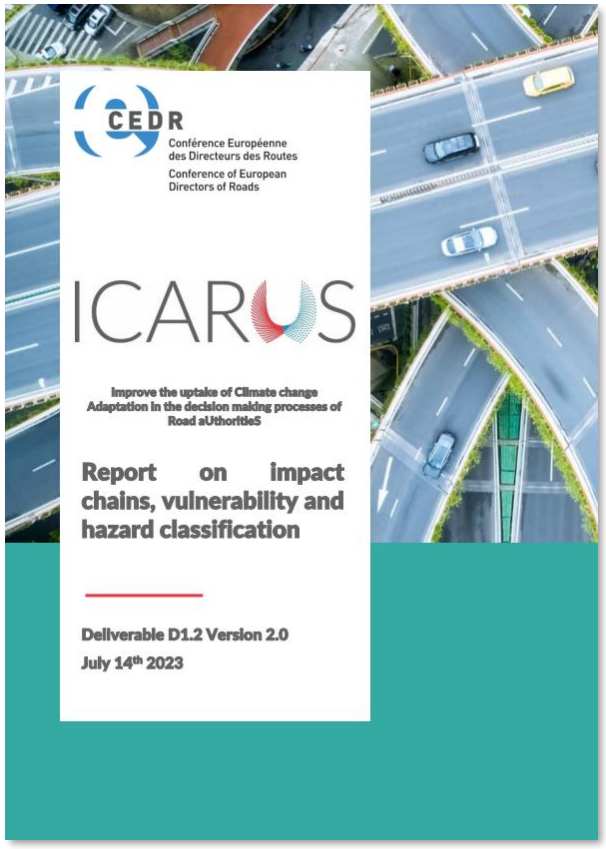
Enhancing understanding of resilience and adaptation

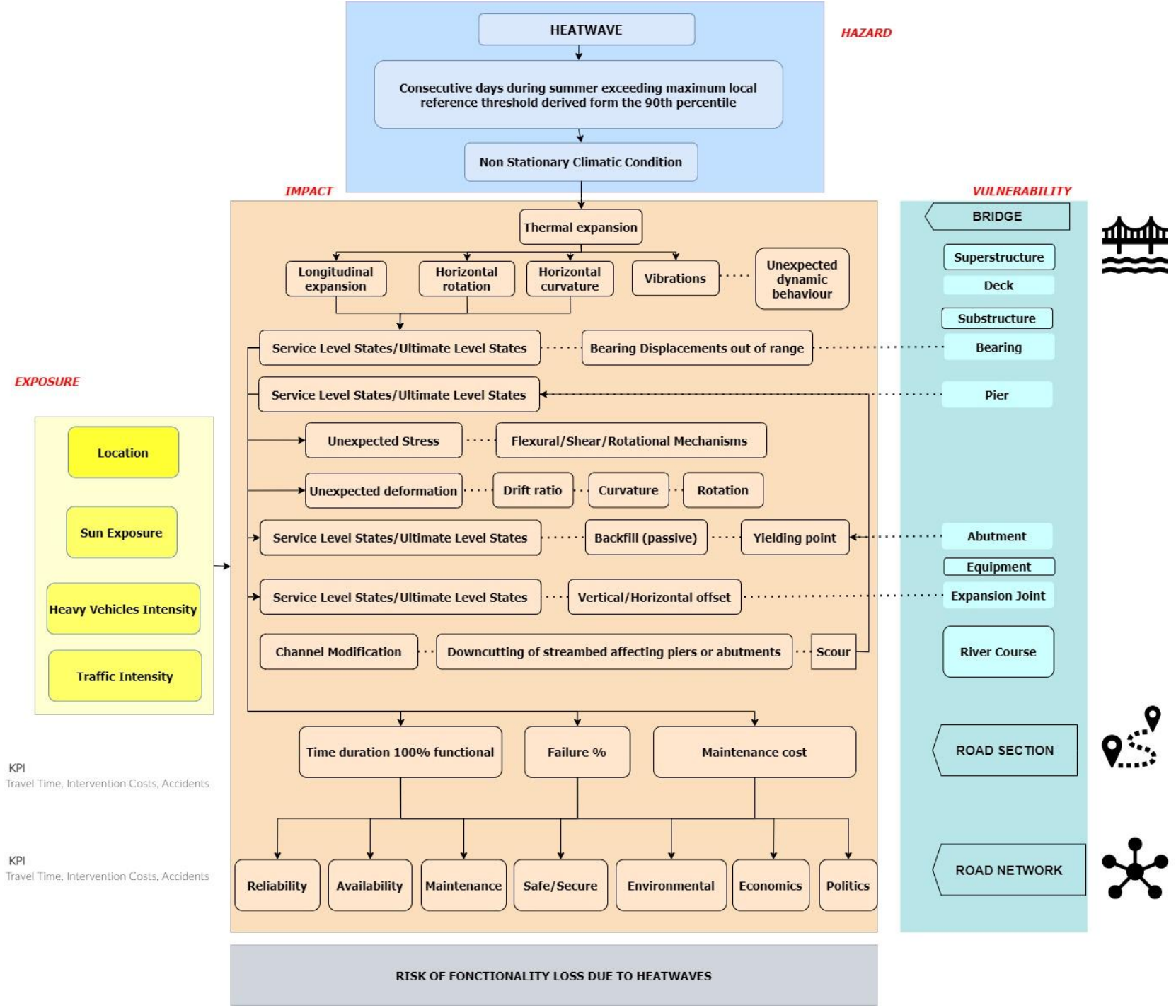
1. Impact chains



Enhancing un

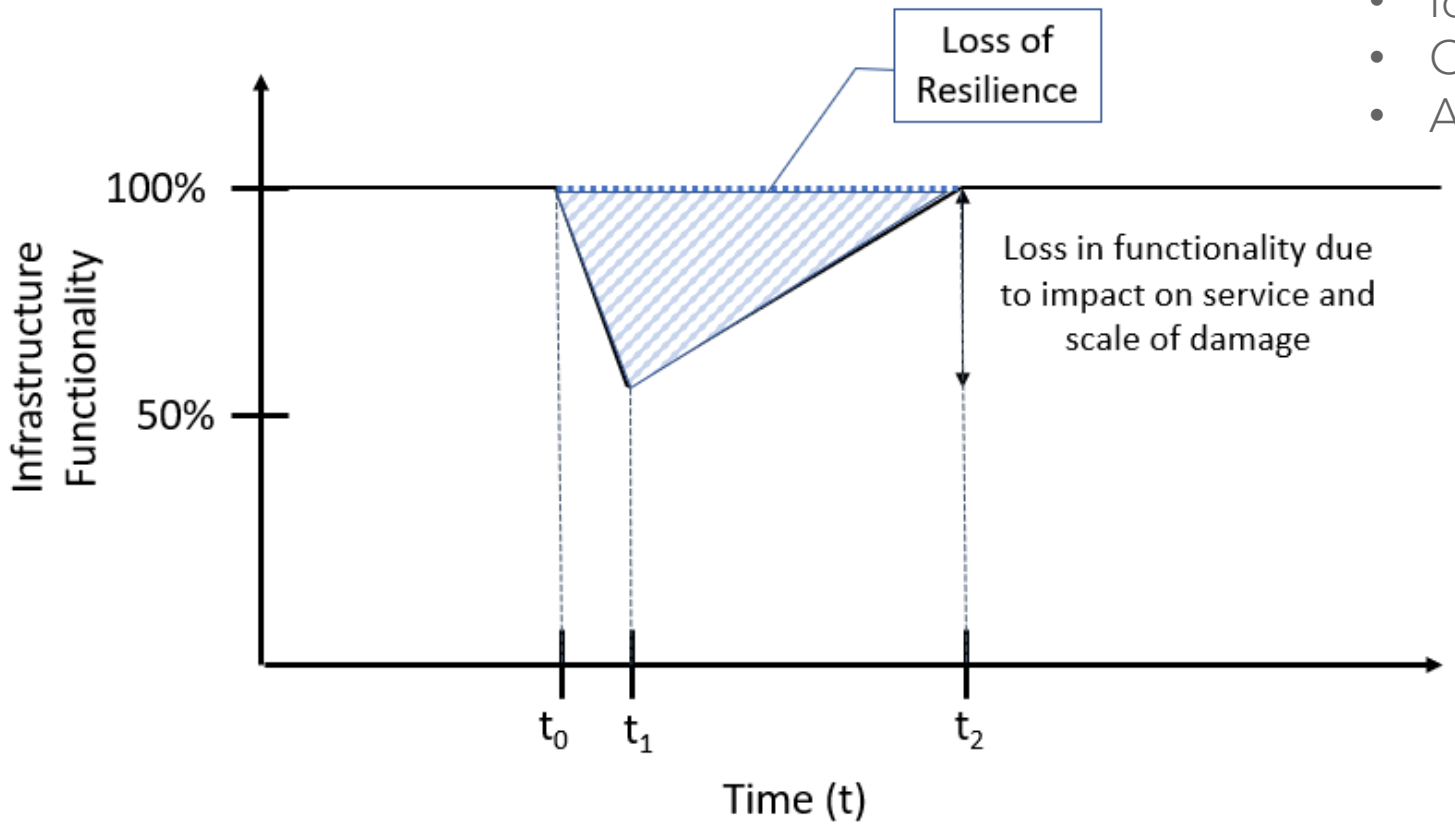
1. Impact chains





Enhancing understanding of resilience and adaptation

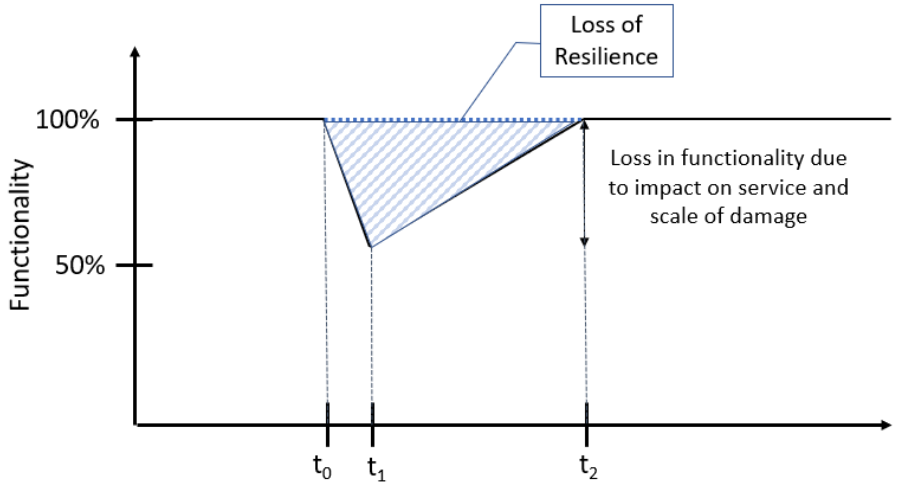
1. Impact chains
2. Resilience impact score

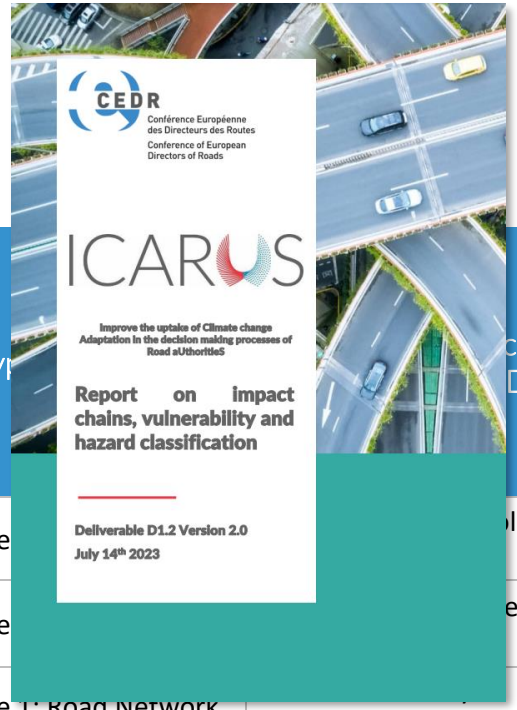


- Classification of hazards based on impact on resilience
  - Identify high impact events
  - Compare different events
  - Aids to further focus of assessment

Enhancing understanding of resilience and adaptation

1. Impact chains
2. Resilience impact score



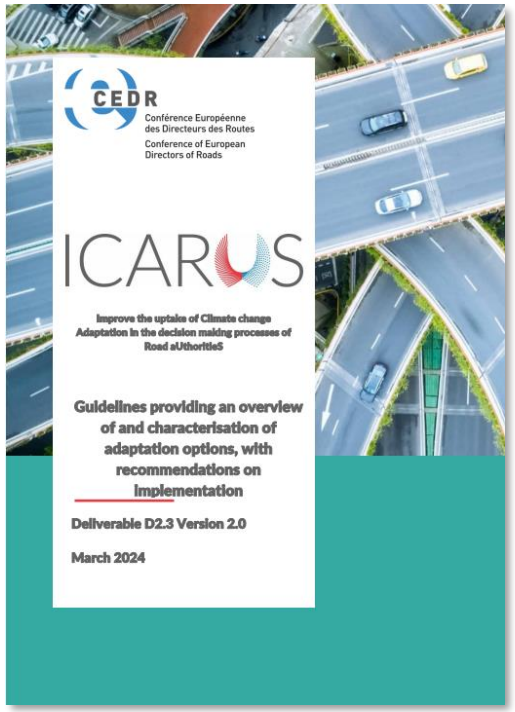


Typ		Event Type	Time		Factors affecting Service		Resilience Impact Score
			Event / CID Duration (t_1-t_0)	Recovery time (t_2-t_1)	Impact on Service due to Damage, Q_d	Scale of Impact, I	
			0: Instant 1: < 6 hours 2: <1 day 3: > 1 day	0: No disruption 1: <1 day disruption 2: < 1 week disruption 3: < 1 month 4: > 1 month	0: No Impact 1: Small Impact 2: Medium Impact 3: Large Impact	1: Object 2: Connection 3: Network	
Example		Extreme Event	3	2	1	3	7.5
Example		Extreme Event	1	3	3	2	12
Example 1: Road Network	Landslide	Extreme Event	1	4	3	3	22.5

Enhancing understanding of resilience and adaptation

1. Impact chains
2. Resilience impact score
3. Adaptation options database

- > 500 adaptation options

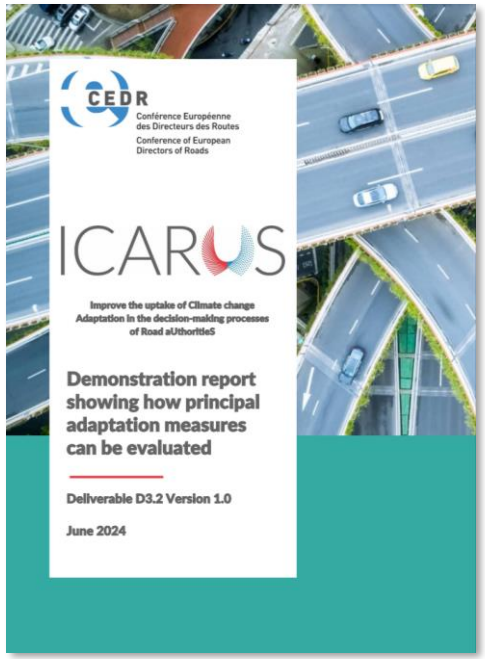


Climate Impact Driver			Impact on Infrastructure	Adaptation Option	Adaptation Option Characteristics										
Climate Impact Driver	Sub-driver	Type of event (Extreme event or slow-onset process or trend)			Applicable Asset Type	Asset Scale (Object / Connection / Network)	Road Project Life Cycle Stage	Impact Chain Stage 1. Hazard 2. Exposure 3. Vulnerability 4. Impact	Disaster Risk Management Cycle Stage Prevention Preparedness Response Recovery	Short/ Long Term Solution	Is the climate impact driver addressed?	Is this a Nature-Based Solution?	NbS Comment	NBS Evidence Base	Can Emerging Technologies be applied?
	Extreme Heat	Extreme event	07-3 Impact on road works: decreased time window for paving due to heat waves (maximum and minimum diurnal temperature and number of	Modify the concrete mixture to ensure adequate workability and curing time	Concrete pavements	Connection	Construction	3. Vulnerability	Prevention	Short term (operational and tactical)	Yes	no			Yes
	Extreme Heat	Extreme event	07-3 Impact on road works: decreased time window for paving due to heat waves (maximum and minimum diurnal temperature and number of	Restrict working in high temperatures	Concrete pavements	Connection	Construction	3. Vulnerability	Prevention	Short term (operational and tactical)	No	no			No
	Extreme Heat	Extreme event	07-3 Impact on road works: decreased time window for paving due to heat waves (maximum and minimum diurnal temperature and number of	Restrict concrete paving during periods of heavy rain	Concrete pavements	Connection	Construction	3. Vulnerability	Prevention	Short term (operational and tactical)	Yes	no			No
	Extreme Heat	Extreme event	07-3 Impact on road works: decreased time window for paving due to heat waves (maximum and minimum diurnal temperature and number of	Working during the night	Bituminous pavements	Connection	Construction	2. Exposure	Prevention	Short term (operational and tactical)	No	no			No
	Extreme Heat	Extreme event	07-3 Impact on road works: decreased time window for paving due to heat waves (maximum and minimum diurnal temperature and number of	Working during the night	Concrete pavements	Connection	Construction	2. Exposure	Prevention	Short term (operational and tactical)	No	no			No
	Extreme Heat	Extreme event	08-01 Melting asphalt, asphalt rutting increase due to material constraints, thermal expansion on bridge expansion joints and paved	Modification in road pavement design and maintenance, changing, for instance, asphalt properties.	Pavements: bituminous, concrete, semi-	Object - Connection	Construction	3. Vulnerability	Preparedness	Short term (operational and tactical)	Yes	no			Yes
	Extreme Heat	Extreme event	08-01 Melting asphalt, asphalt rutting increase due to material constraints, thermal expansion on bridge expansion joints and paved	Modification in road pavement design and maintenance, updating construction and maintenance standards.	Pavements: bituminous, concrete, semi-	Network	Initial Proposal Stage	3. Vulnerability	Preparedness	Long term (tactical and strategic)	Yes	no			Yes
	Extreme Heat	Extreme event	06-6 Decrease in skid resistance on pavements from migration of liquid bitumen due to maximum and minimum diurnal temperature and number of	Anti-oxidation additives	Pavements: bituminous, concrete, semi-	Network	Initial Proposal Stage	3. Vulnerability	Preparedness	Short term (operational and tactical)	Yes	no			Yes
	Extreme Heat	Extreme event	06-6 Decrease in skid resistance on pavements from migration of liquid bitumen due to maximum and minimum diurnal temperature and number of	Cold mill and overlay, thin surface patches	Pavements: bituminous, concrete, semi-	Connection	Operation and Maintenance	3. Vulnerability	Recovery	Short term (operational and tactical)	Yes	no			Yes
	Extreme Heat	Extreme event	06-6 Decrease in skid resistance on pavements from migration of liquid bitumen due to maximum and minimum diurnal temperature and number of	Harvesting of heat energy from the pavement	Pavements: bituminous, concrete, semi-	Object - Connection	Initial Proposal Stage	3. Vulnerability	Prevention	Short term (operational and tactical)	Yes	no			Yes
	Extreme Heat	Extreme event	06-6 Decrease in skid resistance on pavements from migration of liquid bitumen due to maximum and minimum diurnal temperature and number of	High albedo pavements, heat shield pavements, water retention pavements	Pavements: bituminous, concrete, semi-	Connection - Network	Initial Proposal Stage	3. Vulnerability	Prevention	Short term (operational and tactical)	Yes	no			Yes
	Extreme Heat	Extreme event	06-6 Decrease in skid resistance on pavements from migration of liquid bitumen due to maximum and	Placing warning signs	Pavements: bituminous	Connection -	Operation and	2. Exposure	Preparedness	Short term (operational	No	no			No

... | Database of Adaptation Options | Dropdowns | Reference list EmT | Reference list NbS

Enhancing understanding of resilience and adaptation

1. Impact chains
2. Resilience impact score
3. Adaptation options database
4. Assessment opportunities of adaptation options



- Proposed assessment structure
  - Climate Impact Driver
  - Critical contextual information
  - Effectiveness of adaptation option
  - Involved NRA process and typical NRA guidelines
  - Best practices
  - Lifetime of adaptation option
  - Dependencies with other developments
  - Valuation (cost, benefits, co-benefits)
  - Relevant data and sources

ICARUS

Enhancing implementation at road authorities

1. Connect to the context for decision making
2. Three approaches to facilitate decision making
3. ICARUS adaptation implementation process
4. Defining optimum service levels
5. Solutions to overcome implementation barriers
6. Dedicated communication of results
7. Training package

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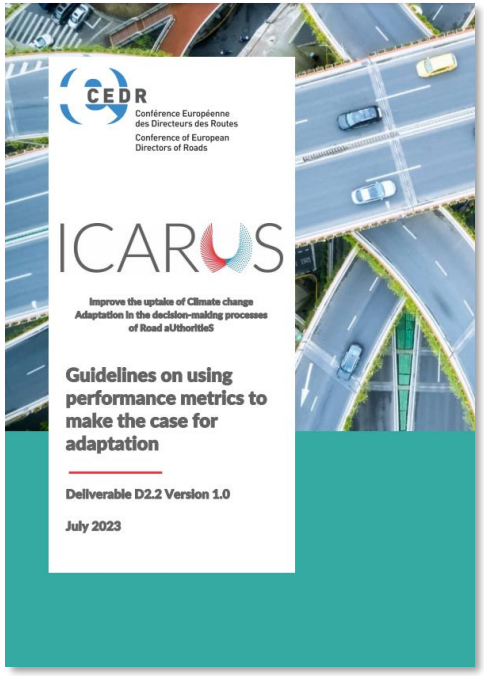

- KPI requirements
  - Include extreme events
  - Have appropriate spatial scale
  - Consider seasonal KPIs
- Influencing decision making
  - Understand NRA steering mechanisms
  - Understand the line of sight
  - Understand dose-effect relation for adaptation options
  - Communicate with all relevant managerial levels
- Identify (co-)benefits based on decision context

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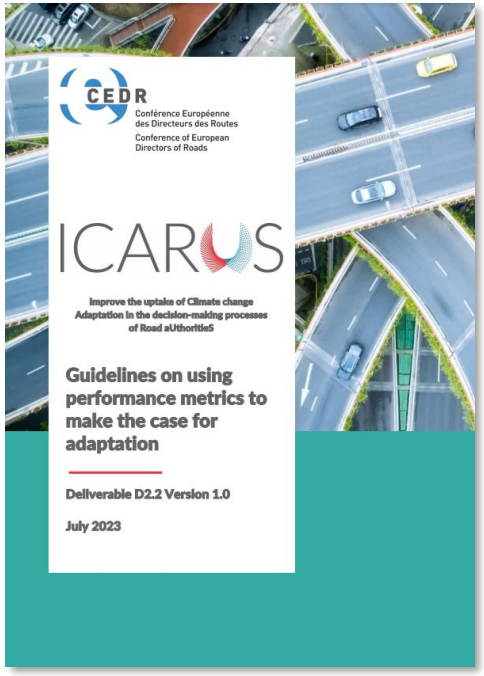

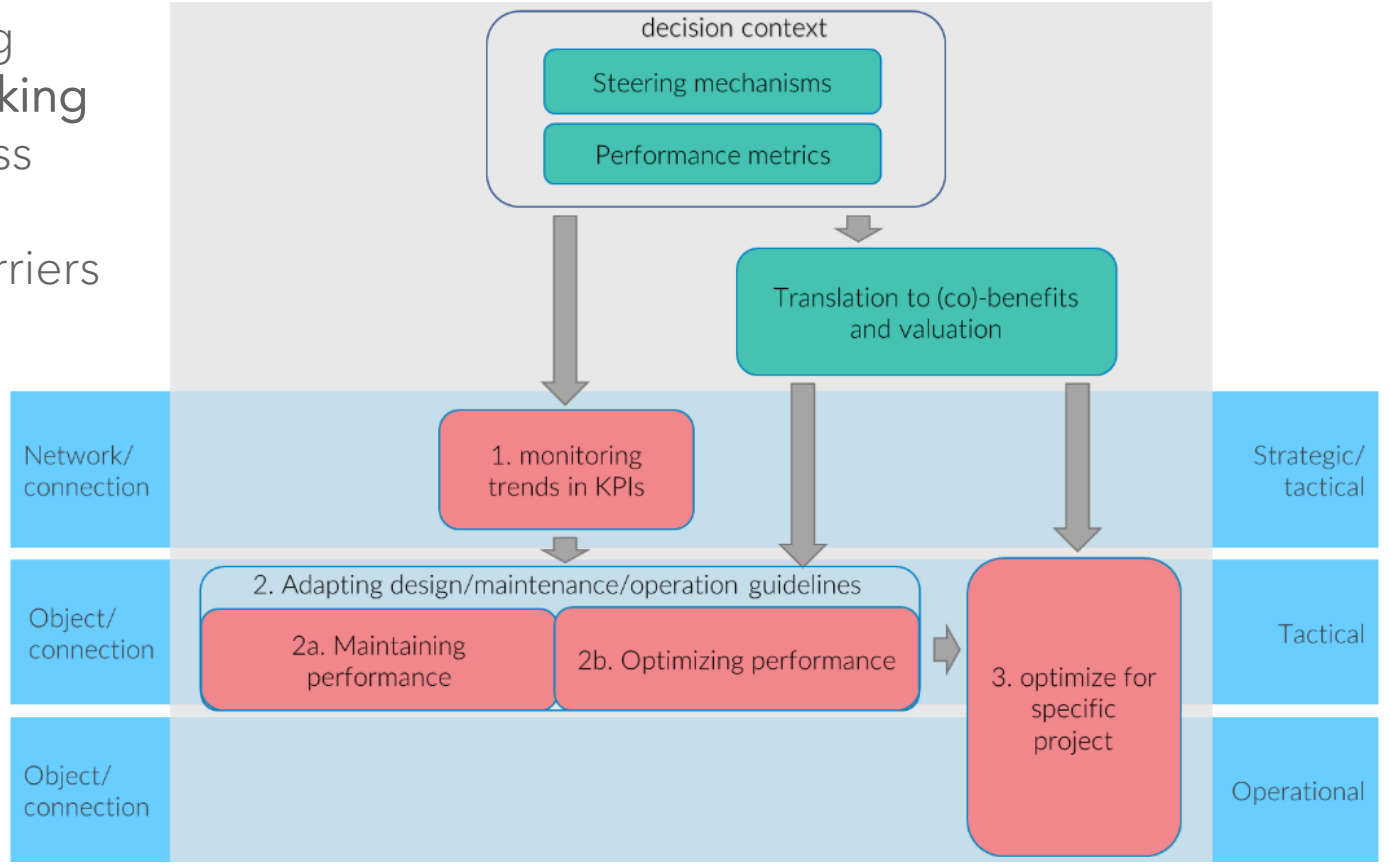

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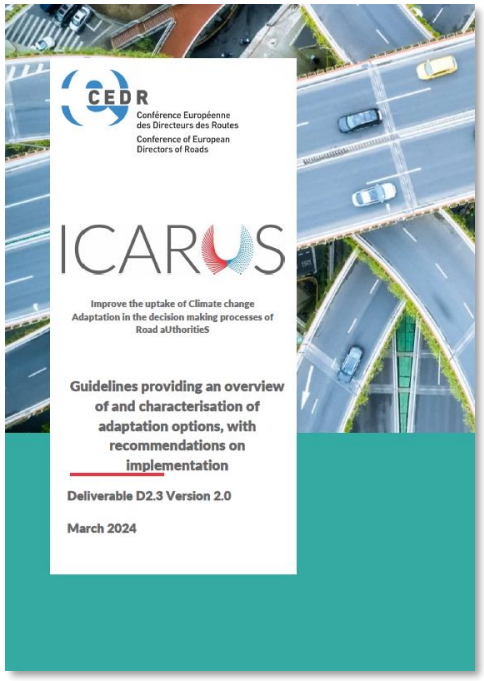

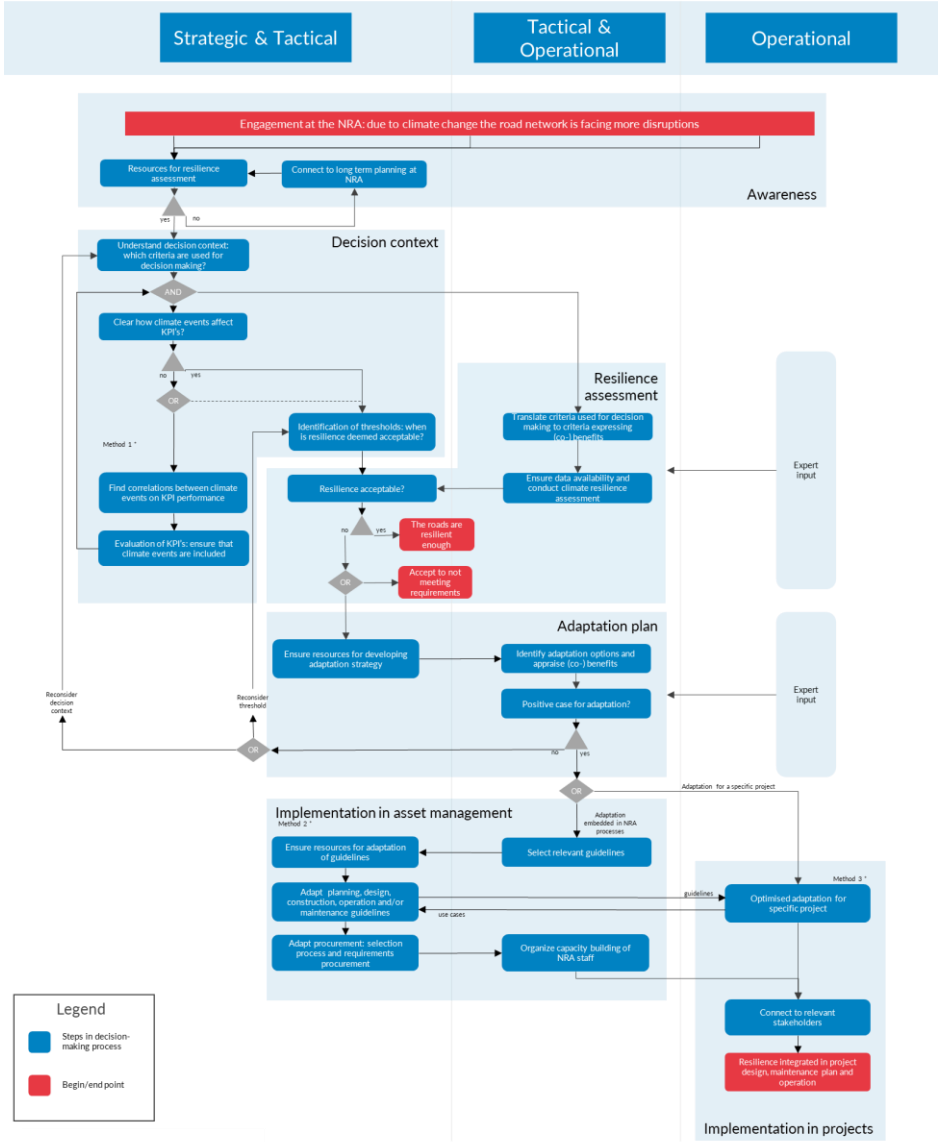

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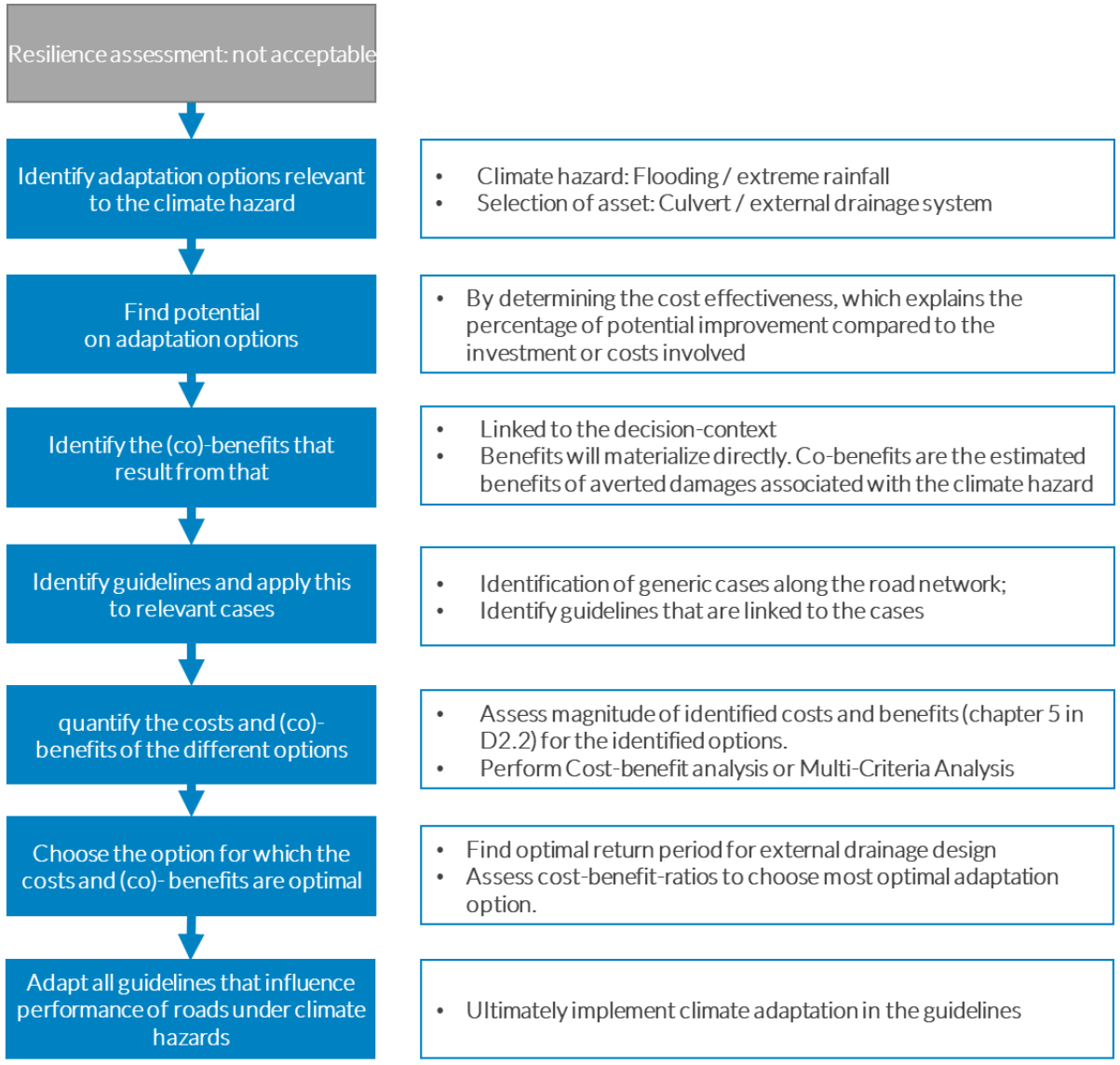
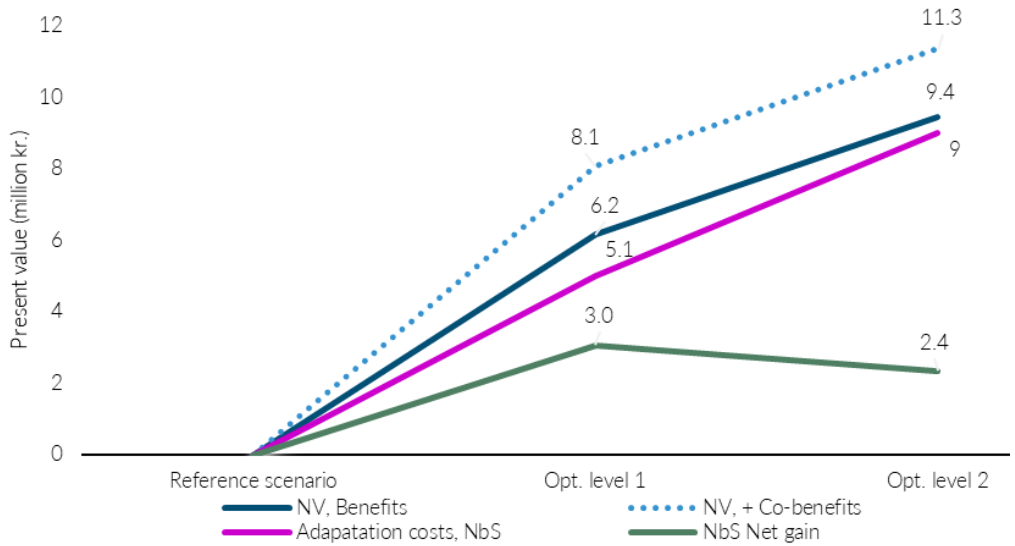


Climate adapation: Nature-based solution



Resilience assessment: not acceptable

Identify adaptation options relevant to the climate hazard

- Climate hazard: Flooding / extreme rainfall
- Selection of asset: Culvert / external drainage system

Find potential on adaptation options

- By determining the cost effectiveness, which explains the percentage of potential improvement compared to the investment or costs involved

Identify the (co)-benefits that result from that

- Linked to the decision-context
- Benefits will materialize directly. Co-benefits are the estimated benefits of averted damages associated with the climate hazard

Identify guidelines and apply this to relevant cases

- Identification of generic cases along the road network;
- Identify guidelines that are linked to the cases

quantify the costs and (co)-benefits of the different options

- Assess magnitude of identified costs and benefits (chapter 5 in D2.2) for the identified options.
- Perform Cost-benefit analysis or Multi-Criteria Analysis

Choose the option for which the costs and (co)- benefits are optimal

- Find optimal return period for external drainage design
- Assess cost-benefit-ratios to choose most optimal adaptation option.

Adapt all guidelines that influence performance of roads under climate hazards

- Ultimately implement climate adaptation in the guidelines

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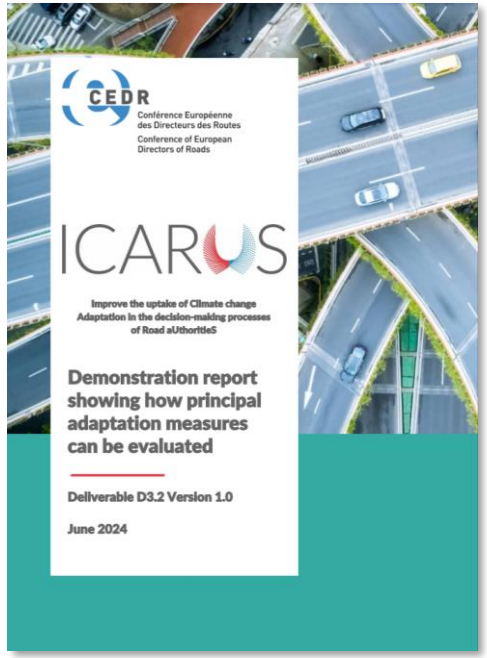

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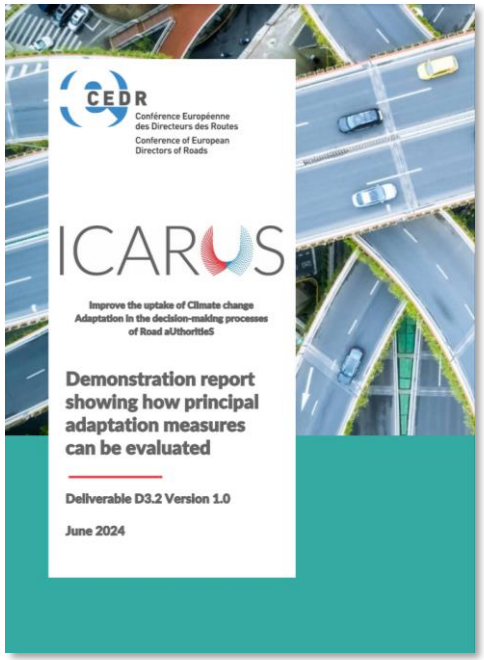

- Barriers to adaptation
  - Lack of information
    - Knowledge on climate change
    - Asset information
    - Network performance
    - KPI information
  - Lack of resources
    - Skilled personnel
    - Funding
  - Organisational barriers
    - Lack of engagement
    - Lack of planning
    - Lack of buy-in from others
    - Procurement challenges

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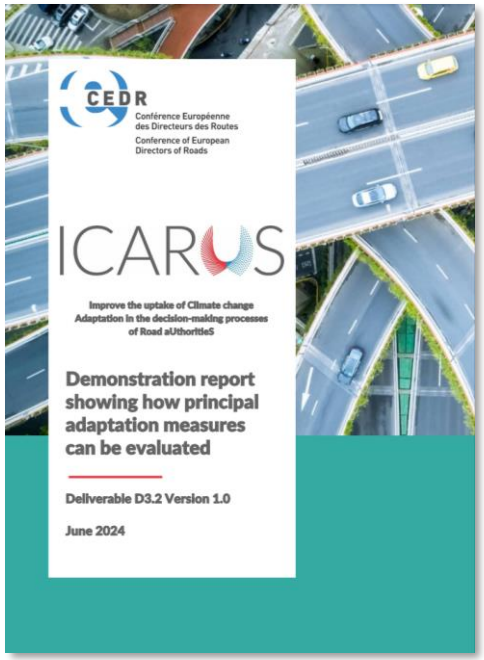

- Dedicated communication
  - Strategic
  - Tactical
  - Operational
- Depending on NRA maturity level
  - Getting started - awareness
  - Embedding process - building business cases
  - Processes embedded - good practices
- Several examples of communication; to be connected to objectives
  - Maps
  - Storylines
  - Flow charts, graphs
  - Factual tables
  - Etc.

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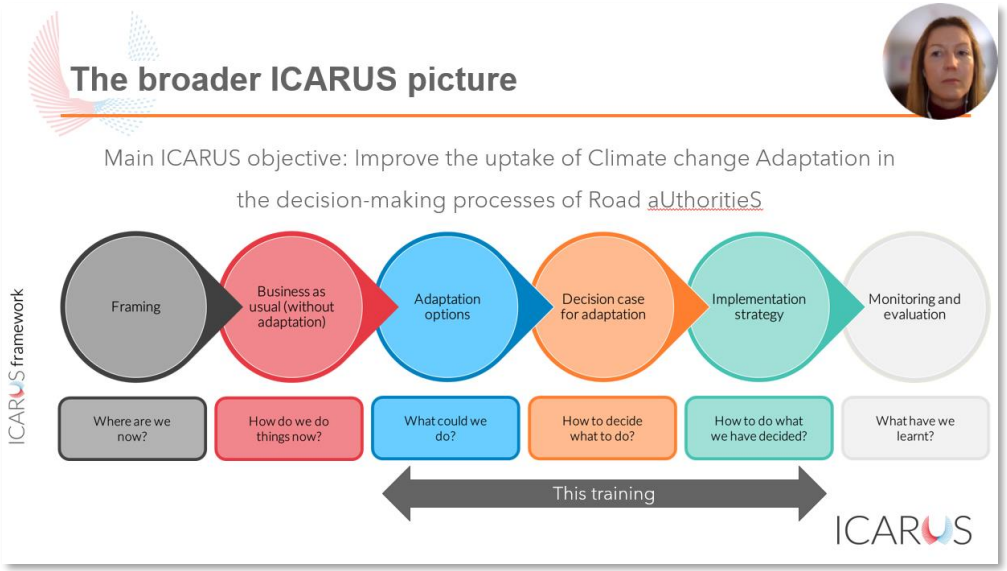
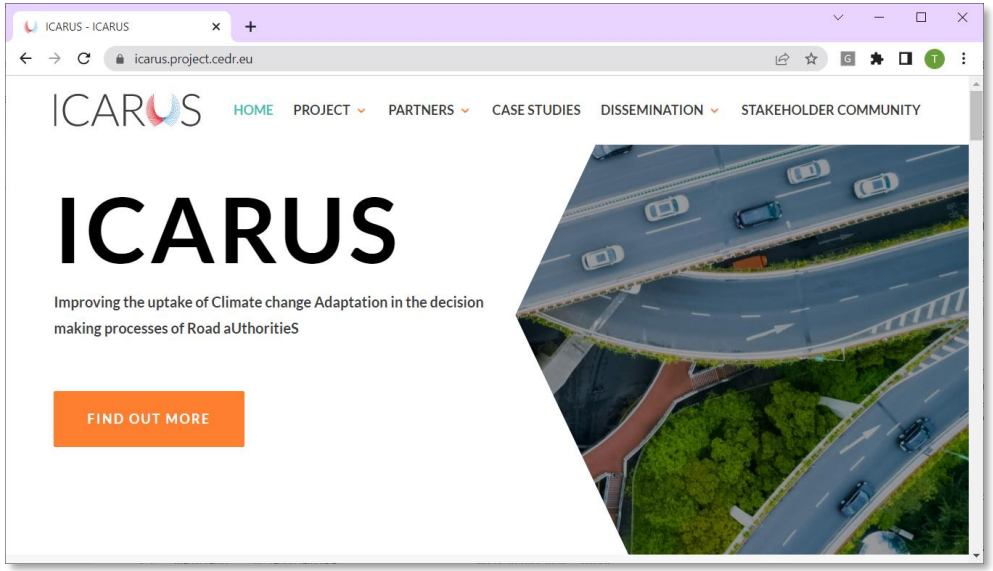
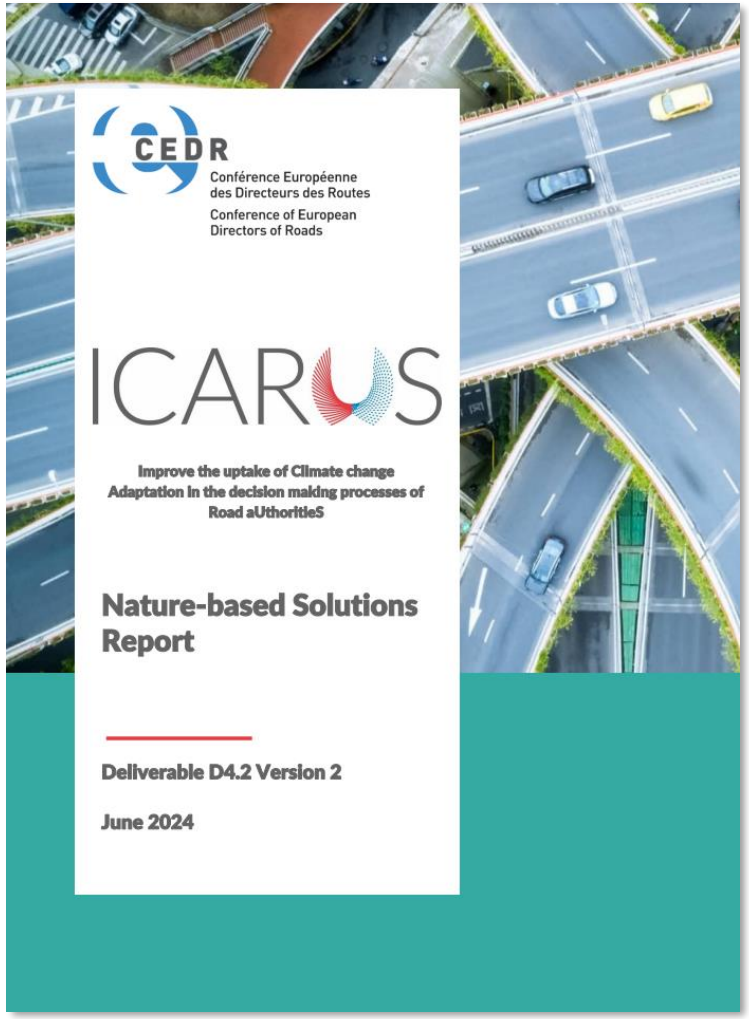
- Presentations to different audiences
  - Strategic and tactical level - short
  - Tactical and operational level – detailed
- Recorded as webinars
- Frequently Asked Questions
- Icarus Quiz





Nature Based Solutions

- Drivers and barriers for NbS implementation
- Implementation guidelines
- Evidence base for effectiveness of NbS
- Making the case for NbS



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Nature Based Solutions

Defining Nature Based Solutions

- Is the measure inspired and supported by nature?
- Is the measure cost effective?
- Does the measure simultaneously provide environmental, social and economic benefits?
- Does the measure help build resilience?

Nature Based Solutions

Defining Nature Based Solutions

- Is the measure inspired and supported by nature?
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Why Nature Based Solutions

- Natural resilience
- Cost effectiveness
- Multiple benefits
- Adaptability
- Reduced environmental impact
- Enhanced social equity
- Community engagement
- Enhanced reputation

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Nature Based Solutions

Drivers

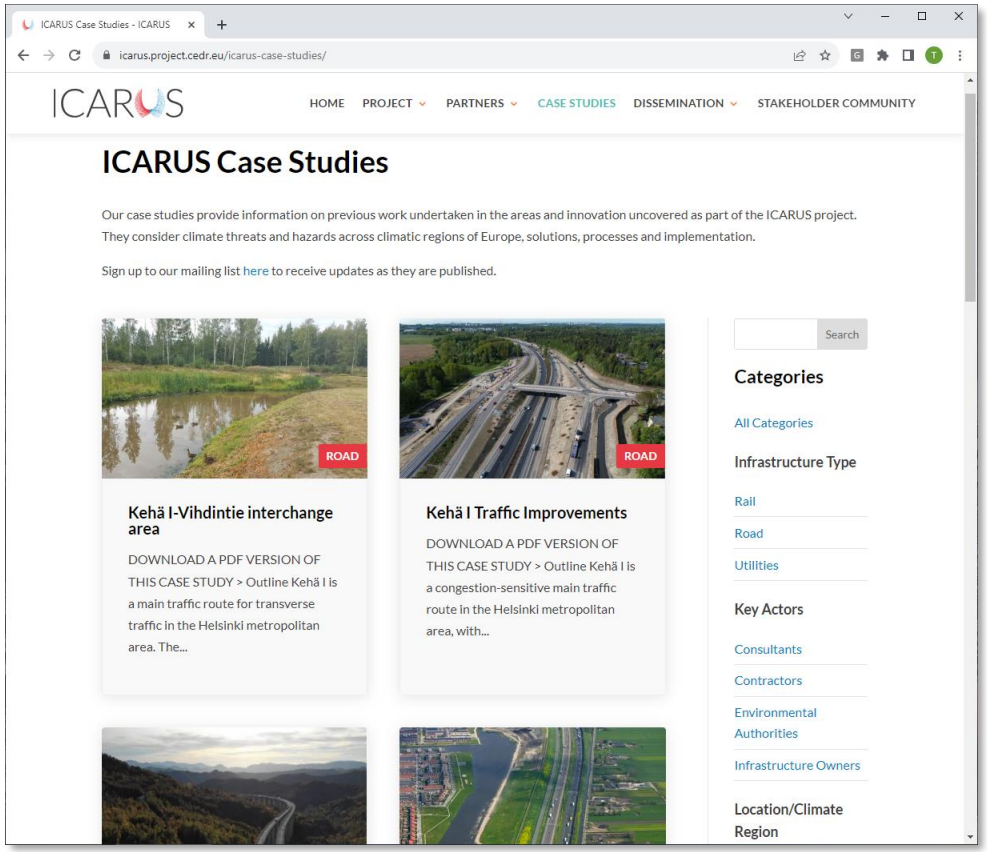
- Answers societal challenges
- Carbon storage
- Mitigating greenhouse gas emissions
- Biodiversity
- Ecosystem services

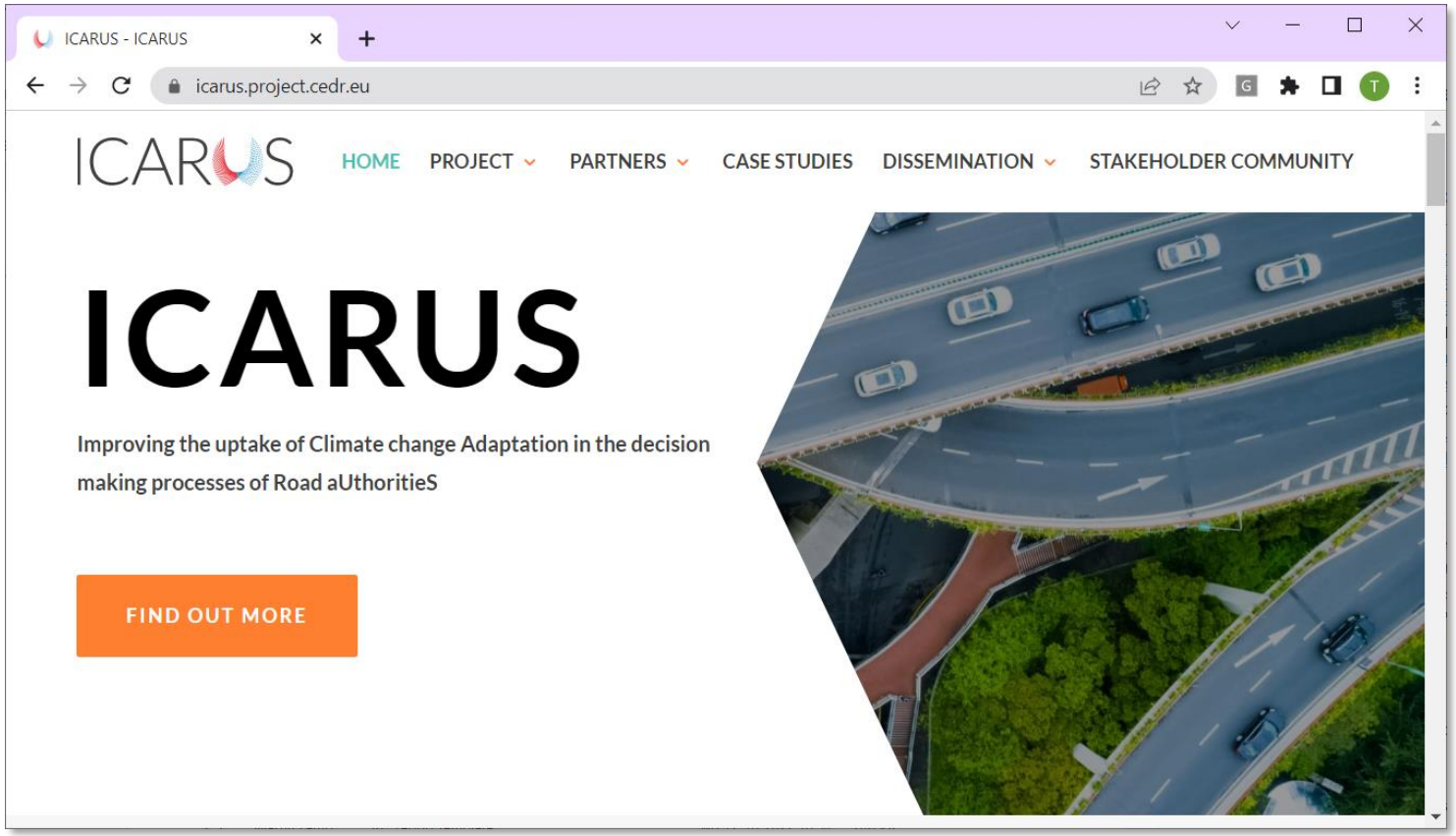
Barriers

- Lack of resources
- Uncertainty
- Organisational engagement, both internally and externally
- Integration in standards and specifications
- Maintenance

Dissemination of results

1. Website and case study portal
2. Presentations and workshops
3. Social media





Dissemination of results

1. Website and case study portal
2. Presentations and workshops
3. Social media

Outreach of ICARUS developments

- PIARC World Road Congress Prague
- TRB transport resilience conference
- UNECE group of experts on climate change adaptation
- Decision Making under Deep Uncertainty conference
- TRA Dublin
- Civil Engineering Research of Ireland conference

ICARUS

Dissemination of results

1. Website and case study portal
2. Presentations and workshops
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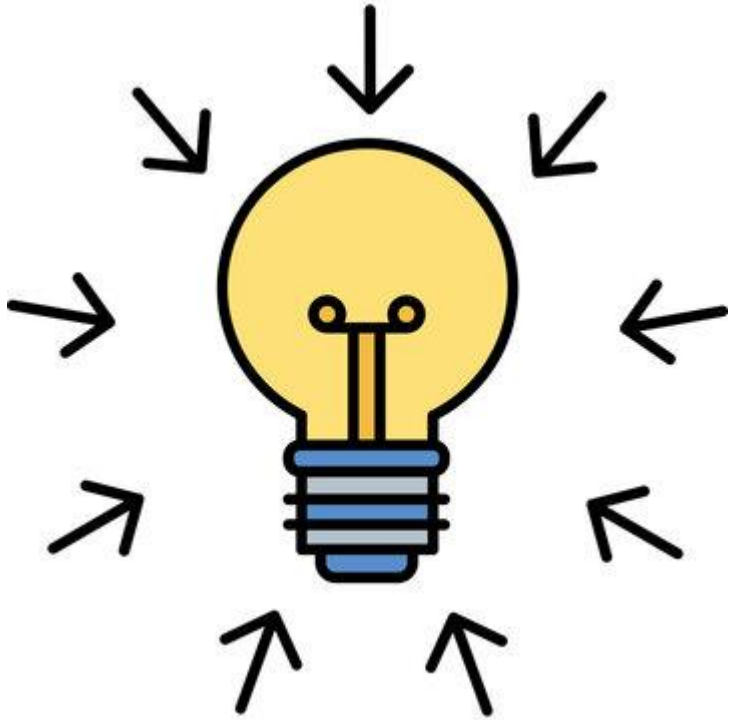
Key findings

1. Good resilience frameworks exist already!
2. Connect resilience and adaptation to decision context
3. Make sure to engage strategic, tactical and operational level
4. Understand and close the tactical gap
5. Consider nature based solutions



Looking forward to another great training!

ICARUS

Looking forward to another great training!

Programme Day 1 ***(in-person and online)***

13:00	Registration & lunch
14:00	**Welcome and introduction**
14:15	**Hybrid session - presentation of ICARUS project results with Q&A session:** **ICARUS** - Improve the uptake of Climate change Adaptation in the decision making processes of Road aUthoritieS
15:45	Break
16:00	Demonstration and training on the ICARUS climate change adaptation implementation process *(in-person only)*
18:00	**End of Day 1**
19:00	Dinner *(Restaurant La Tasca, Voldersgracht 13 & 14, Delft)*

CEDR
Conférence Européenne des Directeurs des Routes
Conference of European Directors of Roads

Programme Day 2 ***(in-person only)***

09:00	Demonstration and training on the use of impact chains to understand climate resilience
10:15	Break
10:30	Demonstration and training on the use of the adaptation options database and evaluation approaches of adaptation options
12:30	Lunch
13:30	Demonstration and training on specific recommendations to include Nature Based Solutions in climate change adaptation solutions
14:30	Break
14:45	Demonstration and training on overcoming implementation barriers
16:00	Summary of obtained feedback, open questions, implementation issues and Closing remarks
17:00	**End of Conference**