2nd Meeting of the Scandinavian Mediterranean European Transport Corridor

Brussels

Thursday, 26 June 2025

7. Resilience and climate adaptation on the TEN-T network

European Commission

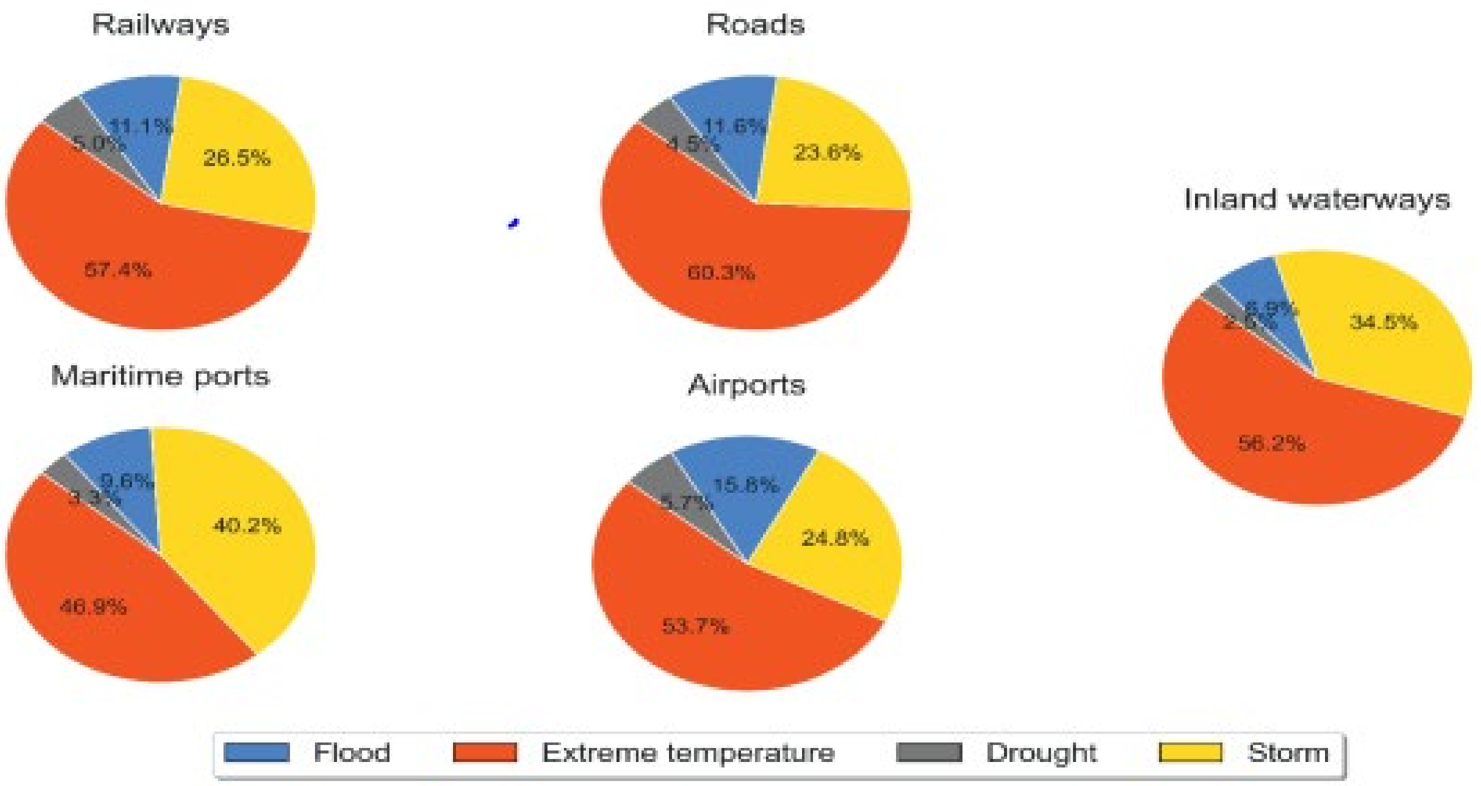
Study background

- The Green Deal and its follow-up (the European Climate Law and the new EU Strategy on adaptation to climate change) paved the way for Europe to become climate-neutral and climate resilient by 2050.
- The European Climate Risk Assessment (EUCRA) and the Communication on managing climate risks from March 2024 confirmed that Europe is the fastest warming continent in the world, with high climate risks for European infrastructure.
- Political Guidelines called for a European Climate Adaptation Plan, to support Member States on preparedness and planning and ensure regular science-based risk assessments.
- In December 2024, DG MOVE published a study to address these concerns in the context of the TEN-T network

TEN-T study on climate resilience: Objectives and scope

- **Two interrelated objectives**:
  - ✓ To identify past climate impacts and their costs, future climate risks on the TEN-T (under 3 emissions scenarios), adaptation measures to address them, and corresponding investment needs
  - ✓ To identify cross-border investment gaps on the TEN-T core and extended core network
- **Scope**
  - ✓ TEN-T based on 2021 proposal for a revision (except RRTs and urban nodes)
  - ✓ Hazards analysed: droughts, heatwaves, river floods, wildfires, tropical cyclones, and sea level rise driving coastal floods
  - ✓ Out of scope: cold waves, landslides, flash floods, windstorms

TEN-T infrastructure exposure to climate extremes 2010-2018



Source: VUB's processing - GDIS database

Figure 4.2 The TEN-T transport infrastructure modes exposed to climate extremes in the period 2010-2018, considering the GDIS events polygons extensions.

TEN-T exposure to future climate extremes: RCP 6.0

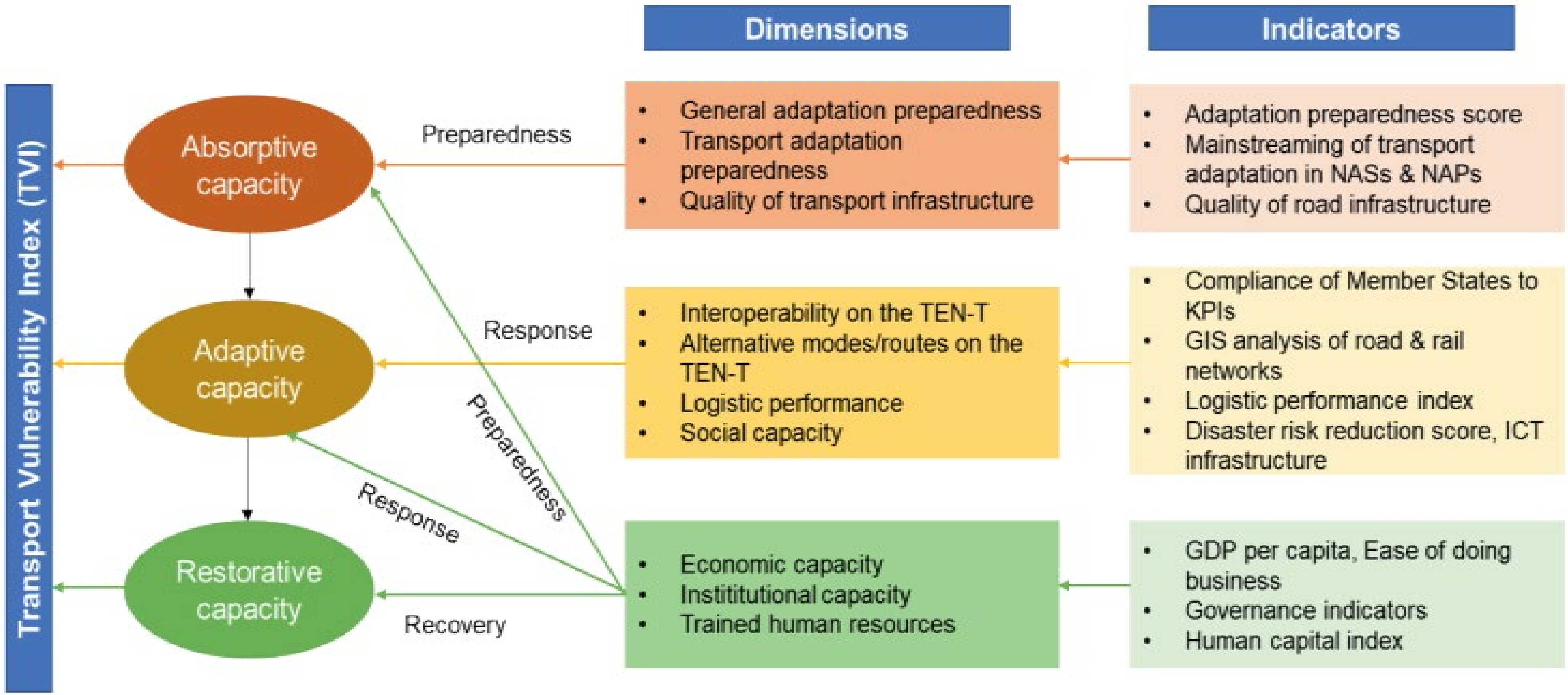
	Middle century (2024-2075)				
	Heatwaves	Floods	Droughts	Wildfires	Tropical cy clones
Airports	17.6 (16.0%)	1.1 (1.8%)	11.3 (38.2%)	1.8 (9.4%)	1.1 (2.8%)
Ports	21.1 (21.3%)	1.2 (4.3%)	11.0 (35.0%)	1.5 (6.2%)	1.0 (1.3%)
Railways	18.1 (16.3%)	1.2 (4.6%)	14.3 (47.3%)	1.6 (8.8%)	1.0 (0.2%)
Roads	18.0 (15.6%)	1.2 (3.5%)	13.3 (44.5%)	1.8 (10.2%)	1.0 (0.4%)
IWWs	18.0 (14.6%)	1.5 (9.5%)	9.8 (40.3%)	1.1 (2.6%)	1.0 (0.0%)

	End of the century (2049-2100)				
	Heatwaves	Floods	Droughts	Wildfires	Tropical cyclones
Airports	28.8 (16.0%)	1.2 (4.1%)	20.0 (48.9%)	2.2 (12.6%)	1.1 (3.2%)
Ports	33.0 (21.3%)	1.3 (5.8%)	21.3 (49.5%)	1.9 (10.9%)	1.1 (1.4%)
Railways	30.2 (16.3%)	1.3 (6.3%)	28.1 (61.3%)	1.8 (10.9 %)	1.0 (0.2%)
Roads	30.0 (15.6%)	1.3 (5.0%)	27.5 (59.5%)	2.1 (12.5%)	1.0 (0.4%)
IWWs	29.3 (14.6%)	1.8 (12.8%)	36.4 (64.0%)	1.2 (4.5%)	1.0 (0.0%)

Note: Floods refer to river floods in this table.
Source: VUB, own elaboration

In brackets: % of the TEN-T experiencing an extreme for the first time

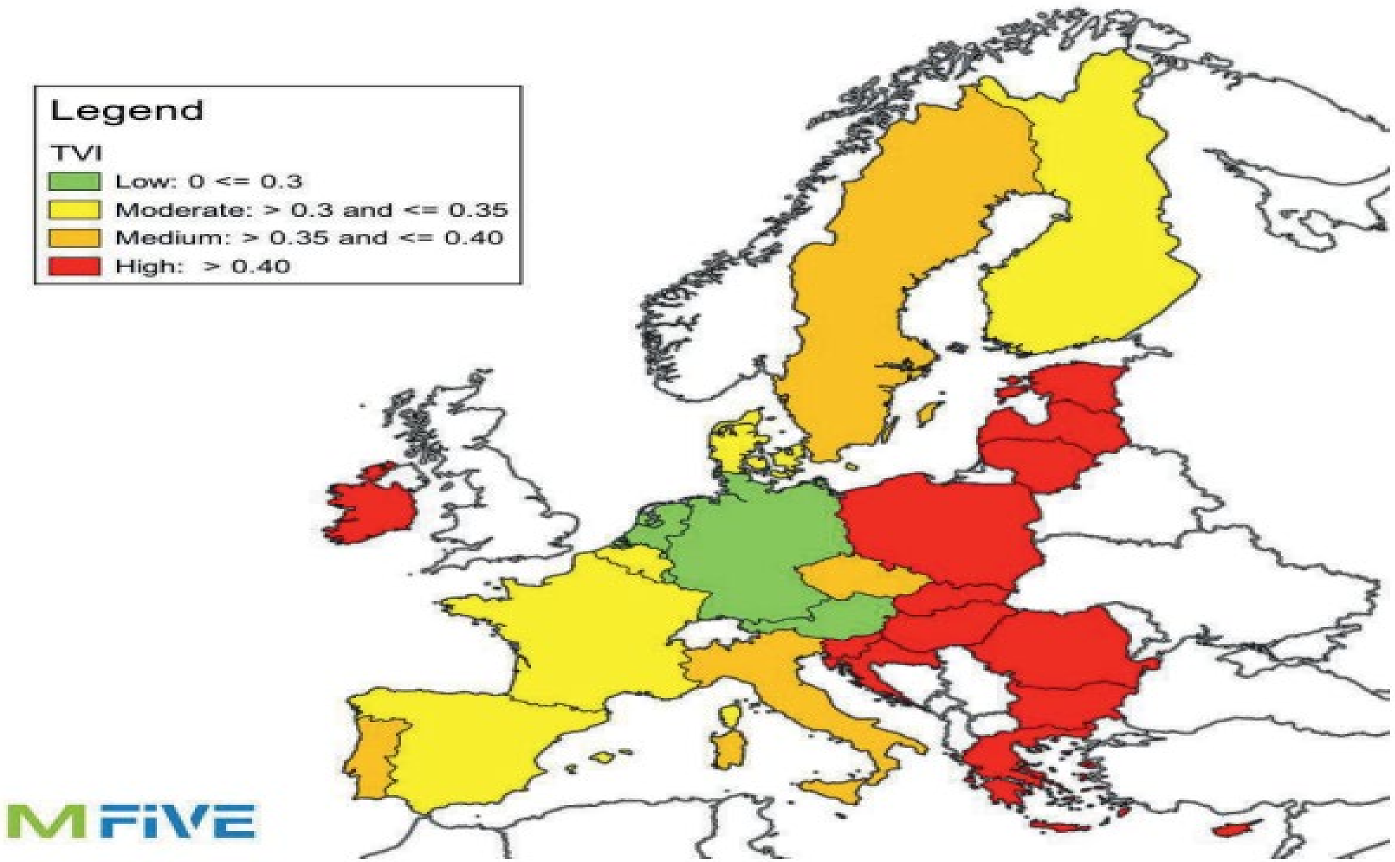
Transport Vulnerability Index (TVI): composite indicators



Source: M-Five, own elaboration

Figure 4.21 Dimensions and indicators of the TVI

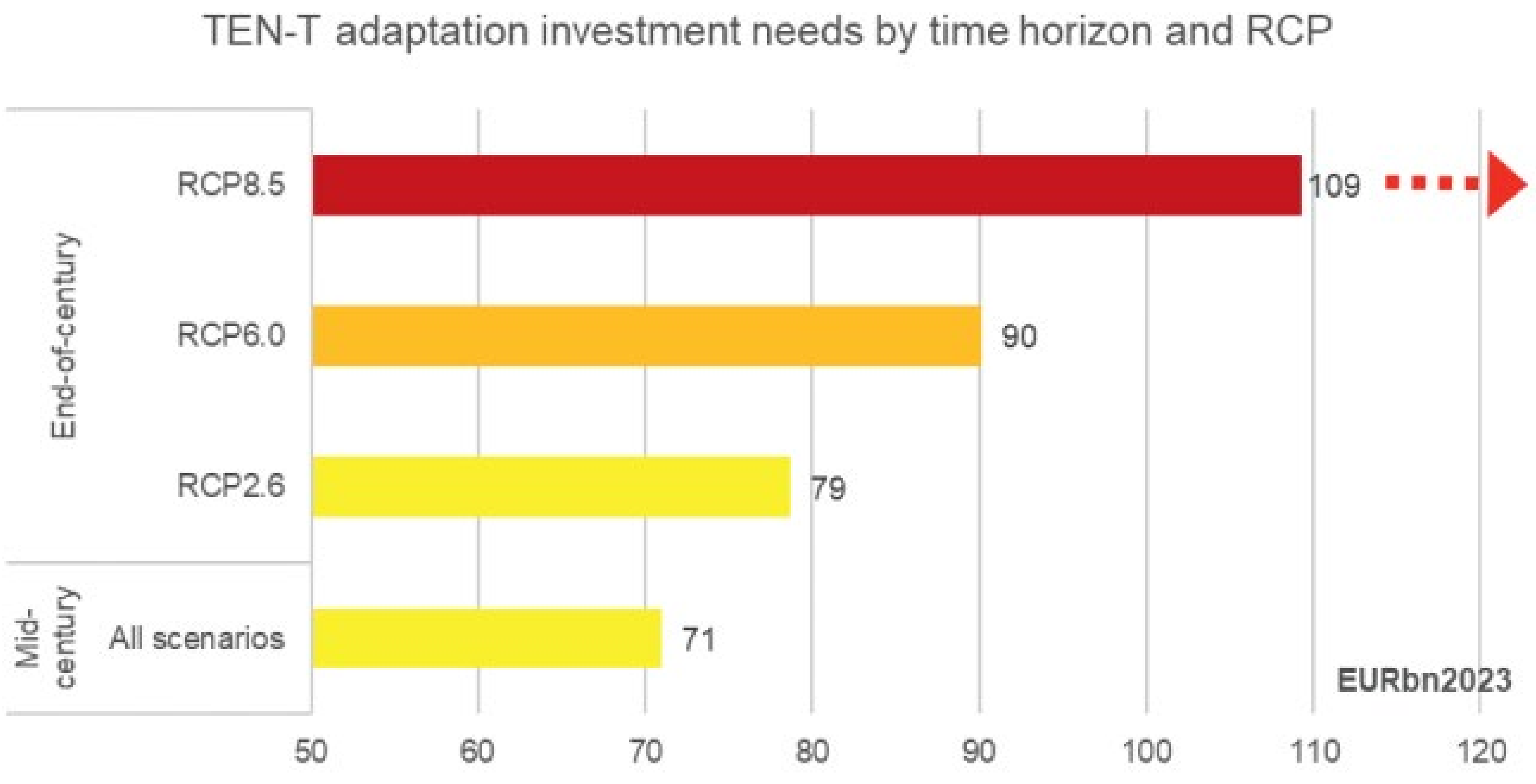
Main results: Transport Vulnerability Index



Source: M-Five, own elaboration

Figure 4.23 Vulnerability across the EU Member States

Main results: TEN-T adaptation investment needs



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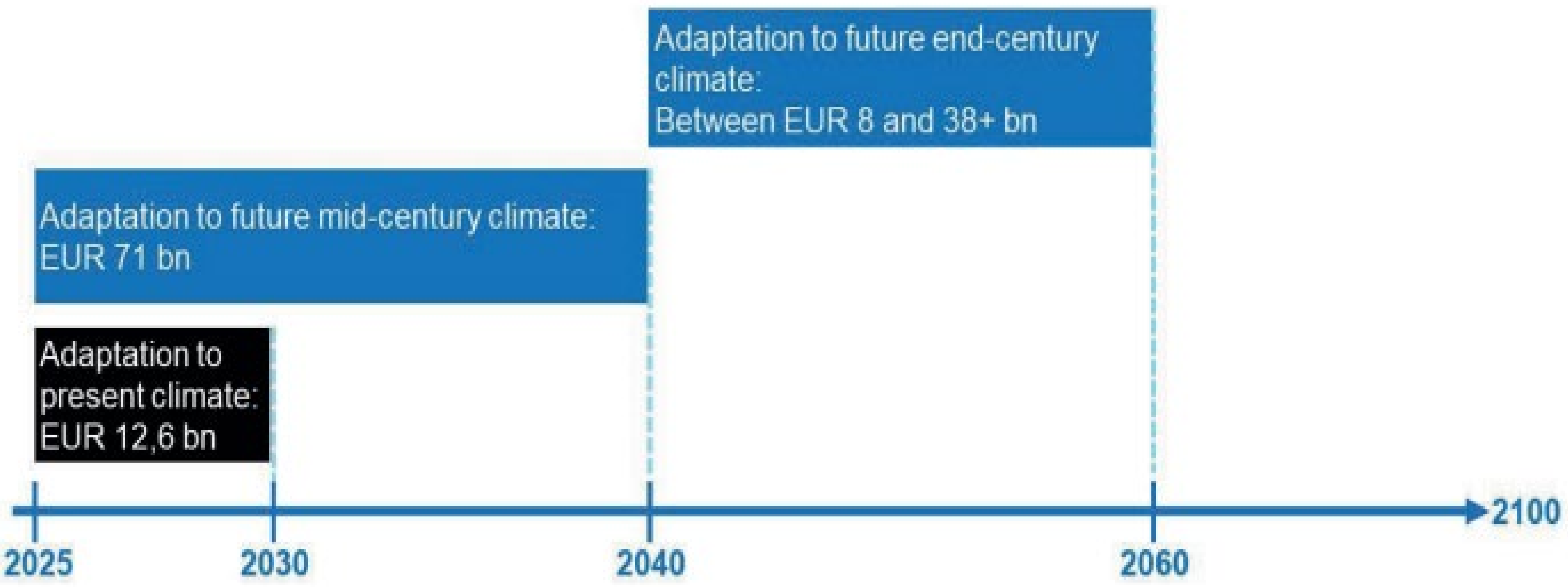
Source: M-Five

Future adaptation investment needs under the 3 examined scenarios



Source: M-Five, own analysis

Figure 4.34 Proposed timing of adaptation investments

Recommendations

- Fragmented information on implemented or planned resilience measures on the TEN-T and their costs: MSs/ Commission to close the knowledge gap
- Best practices on transport infrastructure adaptation are scattered – collect and exchange in the ETCs, dissemination and scale up
- No consistent set of climate risk assessment studies for the transport sector – needed as basis for adaptation planning, comparability of data and methodology important at TEN-T level
- TEN-T preparedness: holistic approach to resilience taking into account trade-offs, indirect costs/supply chain disruptions
- A closer understanding of TEN-T vulnerability to climate impacts: developing network/ local level indicators (e.g. age/ quality of the infrastructure)
- Prioritization of adaptation investments: based on e.g criticality of the infrastructure, infrastructure vulnerability/age, sections without suitable alternatives, sections with highest exposure
- Complement the results of the study with an analysis for flash floods and landslides; RRTs, urban nodes (as part of SUMPs)
- Funding for adaptation: available and resilience compliant, resilience by design

Commission follow-up

- Corridor work plans instrumental for streamlining climate resilience efforts into the ETCs:
  - ✓ Will include analysis of the prevalent risks and impacts of climate change on the corridor transport infrastructure
  - ✓ Can help identify and monitor measures already planned at corridor level, measures still needed to adapt the TEN-T, and their costs
- Dedicated ETC WGs on climate resilience: creating a knowledge base for the ETCs, serving as platforms of best practice exchange (so far: Valencia – ATL and MED ETCs, Genoa – NSRM ETC)
  - ✓ Tools and best practices for the TEN-T to be developed and scaled up– in risk assessment, management, costing, and adaptation
  - ✓ Sources of targeted input for the forthcoming European Climate Adaptation Plan (late 2026)
- DG MOVE/ JRC collaboration: analysis of the state of rail and road bridges and tunnels on the TEN-T to assist in prioritization of interventions
- Resilience by design: developing an LCA methodology for transport infrastructure construction with climate resilience and whole-life carbon accounting as a core element of the design process
- Assessment of indirect impacts of climate change on the TEN-T?

Commission follow-up: ETC WG workshops

8.1 Working Group of Valencia, March 11th

- + 60 people from National representatives from ministries, representatives from port and airport authorities, rail and road infrastructure managers from MED and ATL Corridors
- All methodologies include:

1) climate risk assessment based on scenarios and time horizons
2) vulnerability / sensibility assessment
3) trade-off between risks tolerance and infrastructure adaptation
4) definition of adaptation measures
5) Recovery

- Important to note so far there is no information on the adaptation costs

Areas for benchmark in EU, where we need comparable methodology:

- Climate risk scenarios and time horizons (e.g. widely use approach seem to be RCP 4.5 and stress test with 8.5)
- Vulnerability assessment methodology (incl. definition)
- inventory of assets and related maintenance per mode
- early warning system (weather forecast, oceanography, Copernicus, sensors in infrastructure, etc.)
- an inventory of the climate related incidents in order to determine which incidents are due to climate change (extraordinary – ordinary) (quid comparison per mode or at least road/rail together and airport/port together)
- Definition of the severity of risk (both physical and functional)
- an inventory of adaptation measures (quid EU online repository)
- costs estimation methodology of adaption measures
- To compare national (per mode or not) of contingency plans in case of disruption to ensure continuity of supply chain
- Quick responses procedures comparison

8.2 WG Resilience in Toulouse - Proposed agenda under discussion

1. **Definition of resilience and robustness?**
   Avoiding risk vs. restoring service : Should infrastructure be 100% operational at all times, or capable of rapid recovery? → Where do we set the bar?

2. **Local application of the 'resilience' and 'robustness' challenges:**
   Focus on LNSO and LNMP

3. **Thematic workshops based on risk typology: Water – Earth – Fire – Air – Network**

4. **Financing challenges**

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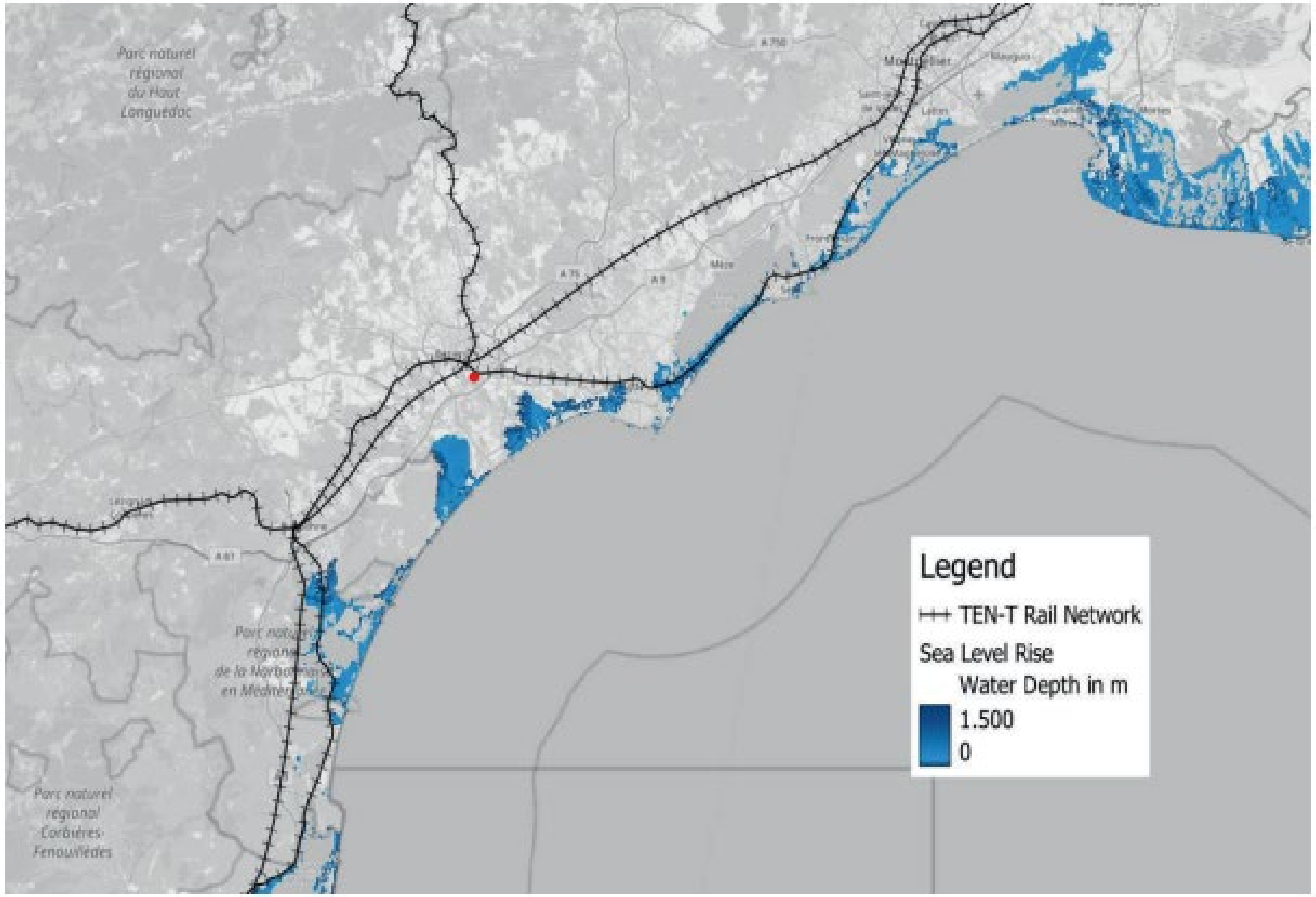
Case study: Conventional rail line Béziers-Rivesaltes



Source: Verschuur et al. (2023); OpenStreetMap and TENtec, elaboration by M-FIVE

Figure 9.4 Map of Coastal flooding and the TEN-T rail infrastructure between Béziers and Rivesaltes

Case study: Conventional rail line Béziers-Rivesaltes ctd.

- SNCF Réseau studies on the effects of climate change on the rail network
- Prioritistaion of ecodesign and sustainable practices (e.g. vegetation control around tracks)
- Organisational measures (live traffic updates, heat wave contingency plans)
- Decision support tools for better monitoring and maintenance: remote diagnostics, predictive maintenance sensors on tracks and rolling stock
- In parallel, enhanced drainage systems and stabilizing railways tracks
- New high-speed line will eventually replace the existing conventional line for passenger trains as part of the LGV Montpellier-Perpignan high-speed project.

Case study: Port of Rotterdam

Photo source: https://commons.wikimedia.org/wiki/File:Maeslantkering_northern_half_2.jpg

Figure 9.2 Maeslantkering storm protection barrier

Case study: Port of Rotterdam

- Located in an area which will be particularly affected by rising sea levels and storm surges – very vulnerable to coastal flooding and heavy rainfall
- 2013 "Climate Change Adaptation Strategy": measures to protect both the population and port and shipping operations
- Maeslantkering storm protection barrier: opened in 1997, cost EUR 450 million, 1st time closed in December 2023
- A 360 m-wide section of the inner port approach, protecting the city and parts of the port or Rotterdam from storm surges.
- Inner-dykes and outer-dykes areas, emergency flood barriers, terrain elevation at terminals, insulation of building facades, raising electrical installations and other assets to higher locations
- Dedicated website, seminars and webinars to increase stakeholder awareness, online maps showing the areas which are most impacted by extreme water levels

Case study: Road network Hesse and North Rhine-Westphalia

- Flood disaster in the Ahr Valley in July 2021 (> 220 lost lives; > EUR 40 billion financial damages; > 100 bridges destroyed)

Source: Thomas Frey / Picture Alliance

Figure 9.6 The destructive power of the river flooding in Ahr Valley on the road infrastructure

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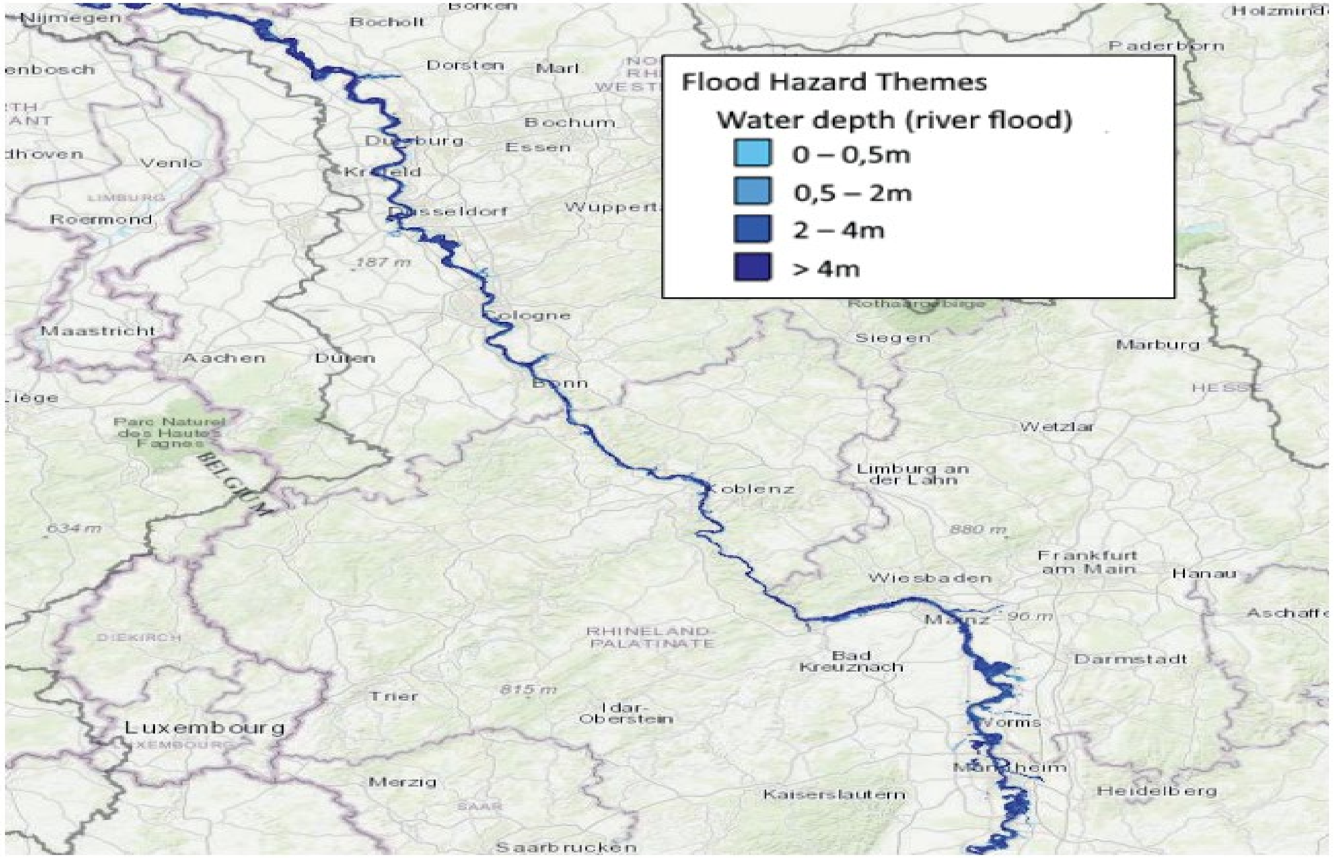
Case study: Road network Hesse and North Rhine-Westphalia

- Hesse and NRW exposed to higher number of extreme heat days and floods



Source: IKSR Rhine Atlas 2021[13]

Figure 9.5 Water levels for extreme event with a medium likelihood (1-in-100-year event)

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