



Climate change on the Italian railway: adaptation options to weather extremes

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Abstract Adaptation is required for enhancing railway resilience to face the consequences of weather-related events exacerbated by climate change. Railway owners need to identify, appraise, and prioritise the adaptation actions to undertake in a context of deep uncertainty. However, understanding what climate change adaptation (CCA) entails can be challenging. The Italian case is made even more complex by the lack of a consistent policy framework and of climate change scientific knowledge in a form useful for engineering purposes. This work aims to develop a framework, also based on institutional instruments, for the characterization and assessment of valuable CCA options for the railway transport sector in the Italian context.

Keywords: climate change, railway, climate change adaptation, extreme weather, adaptation options.

Methods

In this work, we identified a set of adaptation options and then applied the categorisation and qualitative assessment procedures proposed by the provisional Italian National Adaptation Plan (MATTM, 2018), adapting them to the specific context of the Italian railway network. In the Plan, two types of actions and five macro-categories are identified (Figure 1a). Five assessment criteria (Figure 1b) are considered (Flörke et al., 2011). Every criterion is judged for the specific measures assigning a value judgment (high, medium-high, medium, medium-low, low), expressing the corresponding relevance.

a)		b)	
Type	Macro-category	Assessment criteria	
Soft	Information	Effectiveness	Benefit
	Operation and Organisation	Economic efficiency	Cost-benefit
	Design and Planning	Side-effects	Win-win No-regret Negative
Grey/ Green	Infrastructure	Performance under uncertainty	Flexibility Robustness
	Nature-based	Politic implementation	Applicability Multidimensionality Urgency

Figure 1: Categorisation of adaptation actions (a) and assessment criteria (b). Adapted from the Italian National Adaptation Plan (MATTM, 2018) and from Flörke et al. (2011).

Results

The collaboration between academic partners and experts from the railway industry produced a comprehensive inventory of 71 suitable adaptation measures for railway to climate change weather effects (focusing on floods and landslides), based on literature review and expert judgment. We considered measures which should seek to reduce

- the exposure to the hazard,
- the vulnerability of the asset and/or
- the effect of a failure,

pursuing to increase robustness, provide redundancy and enable rapid recovery (Palin et al., 2021). The measures identified were assembled into categories (from Figure 1a) and a preliminary assessment exercise was conducted (according to the criteria in Figure 1b). The corresponding results (for a short list of measures) are shown in Table 1.

Table 1: Assessment results of 6 selected adaptation actions according to the criteria in Figure 1b: the most favourable are highlighted in dark green (high), and the least favourable in red (low).

TYPE	TITLE	BEN.	C-B	W-W	NO-REGR.	NEG.	FLEX.	ROB.	APPL.	MULT.	URG.
Soft	Installation of local weather monitoring stations	M-H	M-H	M	H	L	H	H	H	H	H
Soft	Coordination protocols with emergency services	M-H	H	M	H	L	H	H	M-H	H	H
Green	Soil bioengineering for slope protection/erosion control	M-H	M	H	M-H	L	M	M	M	M	M
Grey	Construction of dikes and flood detention basins	H	L	L	L	M-H	M-L	M-L	L	M	H
Grey	Rockfall and landslide protection systems	H	M-L	L	M	M	M-L	M-H	M	M-H	H
Grey	Elevation of inadequate bridges	H	M	L	L	M	L	M	L	M	H

Conclusions

This work constitutes a first significant step in the application of the procedures supported by the Italian National Adaptation Plan towards the enhancement of climate change railway resilience. The next step will be to apply a more detailed multi-criteria methodology for in-depth assessment and prioritisation of the selected adaptation measures.

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