Integrating the concept of limits in adaptation planning for the sector of infrastructure

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Integrating the concept of limits in adaptation planning for the sector of infrastructure

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Abstract: This report outlines how the concept of limits to adaptation can be integrated into plans of the sector of infrastructure.

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1. Why are limits to adaptation relevant for adaptation planning?

In the PROVIDE project (Paris Agreement Overshooting: Reversibility, Climate Impacts and Adaptation Needs), we look at what a temporary global increase above 1.5°C, namely an overshoot, means both for mitigation and adaptation measures.

In this report, we focus on how limits to adaptation can be integrated into sectoral plans under potential overshoot scenarios, specifically the sector of infrastructure. Alongside this report, we have released two additional reports: one that looks into how limits to adaptation can be integrated into plans for the sector of agriculture under overshoot and another one that discusses the importance of overshoot proofing adaptation plans and policies more broadly.

Adaptation to climate change has progressed in recent years but gaps between the levels of implementation and risks and impacts remain prominent[1]. Adaptation processes face numerous constraints and limits which hinder effective risk reduction. One of the concepts that is rarely considered in adaptation planning are limits to adaptation. The IPCC defines them as the points at which actors' and systems' needs can no longer be secured from intolerable risks[2]. Limits can be either soft (can temporarily not be overcome) or hard (will never be overcome).

Limits to adaptation are hard to identify, both due to their contextual nature and to the lack of scientific information available. Limits can be determined by biophysical characteristics but can also be set by decision-makers, for the limits that are closely linked to socio-economic aspects. For example, trees that have been planted in a city to cool specific streets but that cannot withstand the higher temperatures experienced due to global warming and therefore no longer cool the streets are an example of a biophysical limit. A socio-economic limit would occur when policy-makers are no longer able to invest in the construction of sea walls protecting a coastal city due to their high cost.

Limits to adaptation are relevant already today, as the IPCC reports that hard limits have been reached in some ecosystems and that soft limits are mainly caused by finance and governance constraints. They will be increasingly important to consider as global warming progresses and further limits are reached. When potential overshoot scenarios are taken into account in adaptation planning processes and risk assessments, it is essential to look into when limits to adaptation may be reached to adequately time the implementation of adaptation measures required in a changing climate. For this, adaptation pathways can be used, defined by the IPCC as "a series of adaptation choices involving trade-offs between short-term and long-term goals and values"[2]. They are seen as processes allowing to identify solutions that avoid potential maladaptation and are meaningful in specific contexts. In this report, we exemplify how this can be done below.

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[1] UNEP Adaptation Gap Report, 2023: https://unepccc.org/adaptation-gap-report-as-climate-impacts-accelerate-finance-gap-for-adaptation-efforts-at-least-50-bigger-than-thought/
[2] IPCC glossary: https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_Annex-II.pdf

2. Limits to adaptation in the sector of infrastructure

The remainder of this report focuses on the sector of infrastructure, more precisely the adaptation of rail transport to heat stress.

Due to the lack of precise scientific information and the novelty of these concepts for adaptation planners and practitioners, we focus on illustrative examples that are not backed by quantitative numbers.

2.1. Adaptation of rail transport to heat stress

The sector of infrastructure is facing increased weather-induced deterioration and failures due to the exacerbation of extreme events. In recent years, European railway networks have been exposed to increasing heat extremes[3]. High temperatures can result in buckling train tracks, catenaries being pulled down and air conditioning and electronic systems malfunctioning. Train staff and passengers are also exposed to extreme heat which increases the risk of accidents and health impacts onboard. Embankment fires affecting the rail infrastructure are more likely and frequent during heat stress. These impacts can result in significant train delays and cancellations with severe economic consequences[4].

In 2021, the European Commission published a Technical guidance on the climate proofing of infrastructure in the period 2021-2027. This document describes how adaptation and mitigation can be integrated into the development of infrastructure projects. For adaptation, it states that significant changes in the frequency and intensity of extreme weather events due to climate change during the intended lifespan of the infrastructure project should be taken into account. Infrastructure project promoters should conduct climate vulnerability and risk assessments and integrate these results into their plans to ensure the resilience of their projects for the years to come. The document mentions thresholds/limits to adaptation and states that an Environmental Impact Assessment (EIA) could help to determine whether they have been breached or are expected to be reached. It also lists climate change information sources that Member States could use to conduct these analyses.

[3] https://www.bbc.com/news/business-62182880
[4] https://www.bbc.com/news/business-62203809

2.2. Potential limits to adaptation

Through a review of grey literature on the topic of rail transport and heat, we identify a non-exhaustive list of potential limits to adaptation that could arise, presented in the table below.

Limits to adaptation for rail transport
• Electrical and electronic components failure (65°C is the highest temperature electronics can take) • Failure of AC • Failure of tracks • Failure of catenaries • Failure of signalling systems • Delays and train cancellations (+ their economic consequences)

2.3. Adaptation options available

We also identify adaptation options available for the rail transport through grey literature. For example, the SNCF, an enterprise operating trains in France and Europe, has published an article on the measures put in place when preparing for summer heat[5].

Examples of adaptation options
• Free water and ice cream for passengers and staff • Reduction in train speed • High-precision track temperature predictions/measurements • Painting tracks white • Heat-resistant electronics • Heat-resistant track design

2.4. Illustrative adaptation pathways

To design scientifically sound adaptation pathways, the duration of the benefits and effectiveness of adaptation measures must be considered and, consequently, limits to adaptation should be identified. In addition, the lead time needed for full implementation and effectiveness of the measures must be considered when looking at these timelines[6].

In *Figure 1*, we illustrate how Adaptation Option 1, namely reducing the train speed during heat stress will likely only be sufficient until 2065 (model median) under the selected global warming scenario. Beyond this adaptation limit, further options have to be explored such as changing and re-designing the track superstructure to avoid the buckling of the rails under heat stress (Adaptation Option 2). The planning and implementation time of this measure is expected to be lengthy: *Figure 1* highlights that the process would have to be initiated around 10 years before the first adaptation limit is reached (see orange

[5] https://www.sncf.com/en/group/behind-the-scenes/summer-heat
[6] https://doi.org/10.1007/s40641-020-00166-8

dotted line). This underlines the need to plan well ahead and the importance of looking into future impact projections, specifically in this context.

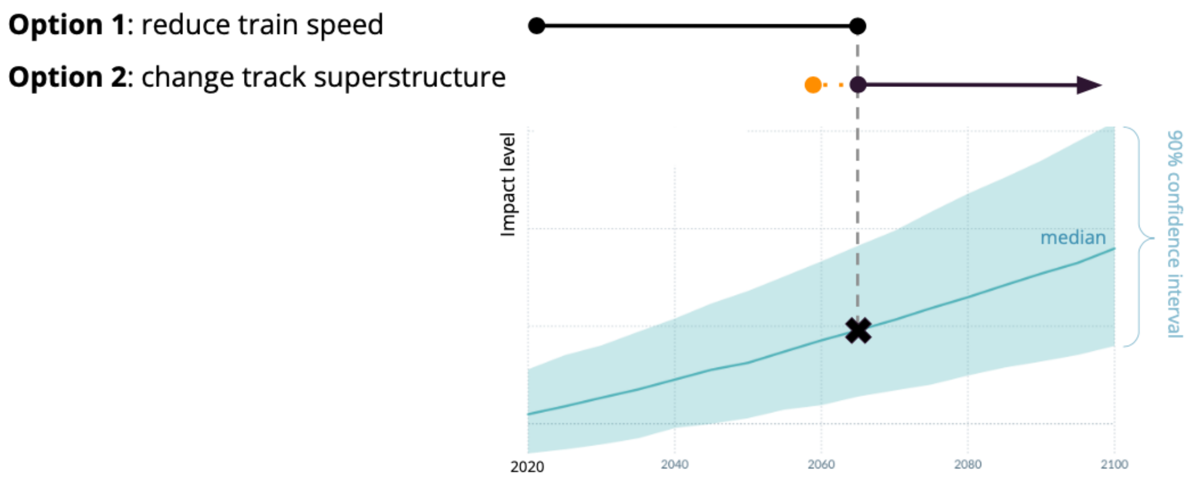

Figure 1: Representation of an illustrative pathway for rail transport adapting to heat stress

Figure 2 uses the same example as *Figure 1* but additionally highlights the uncertainties arising from impact projections. It shows that not only should the median value be considered (represented by the blue line) but also a range of results provided by the various climate models used to calculate the median value (represented by the light-blue coloured area). Here, the light-blue coloured area shows the 90% confidence interval that illustrates the breadth of model uncertainty.

Figure 2 shows that the adaptation limit projected to be reached in 2065 (model median) could actually occur before 2040 based on some of the models considered. Nevertheless, the graph also shows that the limit could be reached beyond 2065. The red lines highlight the entire timespan during which the impact could occur.

Decision-makers and planners must therefore be aware that there is a likelihood that this specific impact level (that in this example corresponds to an adaptation limit) arises earlier or potentially also later than indicated by the median value.

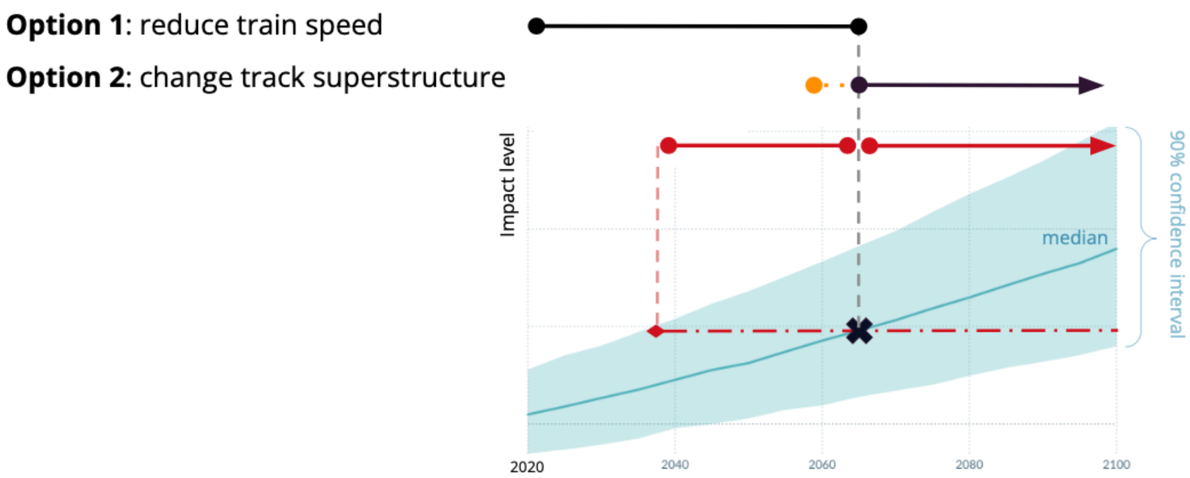

Figure 2: Representation of an illustrative pathway for rail transport adapting to heat stress, including the uncertainties arising from modelled impact projections

The graph used for illustration purposes in *Figure 1* and *Figure 2* is extracted from the Climate Risk Dashboard, an interactive online platform providing detailed information on different future global warming scenarios and their expected impacts on the climate, natural, and human systems. Relevant scientific information for adaptation planning and designing adaptation pathways can be found through this tool.

3. Key takeaways

In this report, we stress the importance of considering limits to adaptation when planning adaptation projects or policies, in particular under potential scenarios of further increasing global warming such as overshoot scenarios. We also illustrate how adaptation pathways can be used to adequately plan adaptation measures ahead by considering limits to adaptation.

Information on limits to adaptation should be included during the planning phase, when conducting risk assessments or climate stress tests for example. Monitoring and evaluation processes can also provide an opportunity to evaluate the adequacy of the plans and re-design or adjust them if necessary.

Despite the limited scientific information available on limits to adaptation currently, we expect the Climate Risk Dashboard to ease this constraint for a wide range of sectors and contexts. For the infrastructure sector, we expect these indicators (e.g. extremely hot and cold years and seasons, maximum and average annual values for estimated fire danger, length of heatwaves, days and nights with strong and extreme heat stress) to be particularly relevant.

Finally, it must be noted that limits to adaptation are just one of the many concepts that must be taken into account for sound adaptation planning that avoids maladaptation.