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Group of Experts on Climate Change Impacts and Adaptation for Transport Networks and Nodes
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Item 2 of the provisional agenda
Climate Change and Transport Networks and Nodes:
Presentations of initiatives at national and international levels

Adapting French transport infrastructure, systems and services to climate change*

Transmitted by the Government of France

I. Introduction

1. This document presents an approach developed and tested in France to assess the risks of climate change for transport infrastructure, systems and services. At its sixteenth session, the Group of Experts requested that the report be submitted as an official document at the seventeenth session.

II. The National Plan for Adaptation to Climate Change: Measures concerning transport

2. Pursuant to article 42 of Act No. 2009-967 of 3 August 2009, which put in place a national round table on the environment (the Grenelle Environnement), in 2011 France published its first National Plan for Adaptation to Climate Change (PNACC), covering a period of five years. This cross-cutting, interministerial plan addresses 20 different fields, including transport infrastructure and services. It identified four adaptation measures to assess the impact of climate change, prevent vulnerabilities in transport systems and improve infrastructure resilience in order to ensure the continuity and security of passenger and freight transport:

- Measure No. 1: Review and adapt technical standards for the construction, maintenance and operation of transport networks (infrastructure and equipment) in metropolitan France and in the French overseas territories;

* The present document contains the text submitted to the secretariat, reproduced without any changes.

- Measure No. 2: Study the impact of climate change on demand for transport and determine the effects this has on the supply of transport;
- Measure No. 3: Develop a harmonized methodology to assess the vulnerability of land, sea and air transport infrastructures and systems;
- Measure No. 4: Take stock of the vulnerability of land, sea and air transport networks in metropolitan France and in the French overseas territories; and prepare appropriate strategies to progressively respond to the global and regional problems posed by climate change.

3. In December 2018, France published its second PNACC,[1] covering a further period of five years, with the objective of protecting the population against extreme weather events and building resilient economic sectors (for example, in agriculture, industry, tourism and transport). Unlike the first plan, which was structured on the basis of economic sectors, this one adopts a thematic approach; it continues the measures in respect of transport:

- Continue adapting technical standards for the operation, maintenance and construction of transport infrastructure and equipment;
- Continue to analyse risks and improve the methodology used, based on lessons learned; and encourage infrastructure and network managers to independently conduct vulnerability studies;
- Mobilize a network of contact points and experts;
- Carry out a forecast of changes in the major global trade routes;
- Analyse the consequences of voluntary restrictions of transport and movement in times of crisis.

4. Thus, as part of measure No. 4 of the first PNACC, risk analyses have been conducted on various transport systems, including the Interdepartmental Directorate for Mediterranean Roads, presented in the case study below.

III. Case study: Risk analysis methodology applied to the road network of the Interdepartmental Directorate for Mediterranean Roads (DIR Med)

A. Purpose of the study

5. In 2017/2018, under the supervision of Cerema[2] (the Expert Study Centre on Risks, the Environment, Mobility and Planning), Carbone 4[3] carried out a risk analysis of a highway network in the south-eastern part of France, applying the methodology developed by Cerema and entitled “Risk analysis of extreme weather events for transport infrastructures, systems and services – A conceptual anthology”. The Interdepartmental Directorate for Mediterranean Roads (DIR Med), three agencies under the Ministry for an Ecological and Solidary Transition and experts in transport infrastructure also took part in the working group. The aim of the study was to determine the vulnerability of the road network in the face of climate change and to test the methodology.

B. Scope of study and description of methodology

6. The network that was studied consists of 750 km of roads and contains approximately 1,000 works of infrastructure such as bridges, tunnels and viaducts. Some of

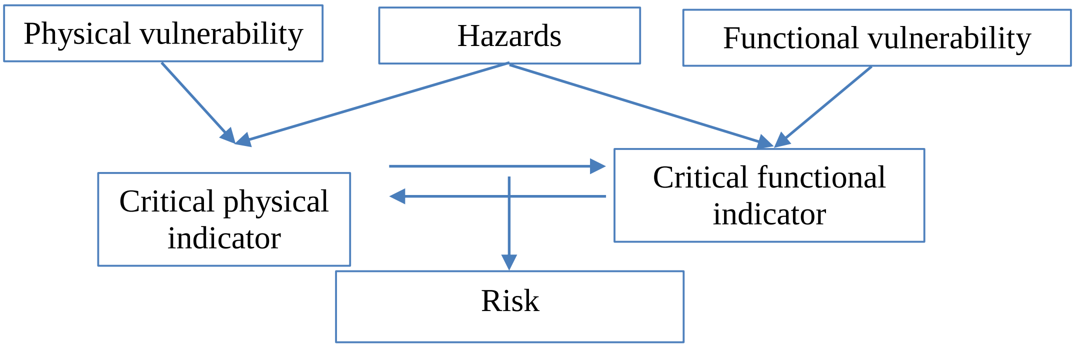
[1] www.ecologique-solidaire.gouv.fr/adaptation-france-au-changement-climatique.

[2] Cerema (the Expert Study Centre on Risks, the Environment, Mobility and Planning) is a public body providing support for public policies under the dual supervision of the Ministry for an Ecological and Solidary Transition and the Ministry of Territorial Cohesion.

[3] Carbone 4 is a consulting firm that specialized in energy transition and adaptation to climate change.

its segments are part of the European road network (A7/E714, A51/E712). The area of study includes a wide variety of both terrain (such as mountainous areas, coastal plains, forests, calanques and ponds) and climates (Mediterranean, semi-Mediterranean, semi-continental and high-mountain climates).

7. The methodology consisted in rating extreme weather events, physical vulnerabilities and functional vulnerabilities so as to determine risk levels by combining the ratings. It is of interest to look at the critical physical and functional indicators separately. They can subsequently be cross-checked if care is taken to avoid counting the same hazards twice.



C. Rating of extreme weather events

8. The area that was studied is exposed to various types of weather hazards: sea flooding and fires along the Mediterranean coast, flooding in Camargue, a significant number of days of freezing weather in the Hautes-Alpes region and heat waves in Isère.

9. Each extreme weather event is associated with one or more climate change variables that characterize the event's intensity, frequency, duration or location. For example:

Extreme weather event	*Associated variable*	*Characterization*
Extreme heat	90th percentile of Txi (Tmax for day i)	Intensity
Number of days of freezing weather	Number of days when Tmin ≤ 0 °C	Frequency
Floods	Number of days with accumulated precipitation ≥ 20 mm)	Intensity + duration
	Location of flood-prone areas (indices of levels 0–1)	Location

10. The climate data are extracted from DRIAS[4] and the model used is CNRM 2014 (ALADIN), with a spatial resolution of 8 km. Each climate variable is rated from 1 to 4 to take into account the road network's exposure in each scenario and time horizon:

- Time horizons: 1961–1990 (reference period), 2021–2050 and 2071–2100;
- Climate scenarios: RCP 2.6, RCP 4.5 and RCP 8.5.

D. Rating of physical vulnerability of infrastructure

11. Analysis of the physical vulnerability of infrastructure is carried out in four steps:

(a) Classification of the road network by category of infrastructure (road, bridge, tunnel, retaining wall, etc.) and their components (surfaces, road signage, etc.);

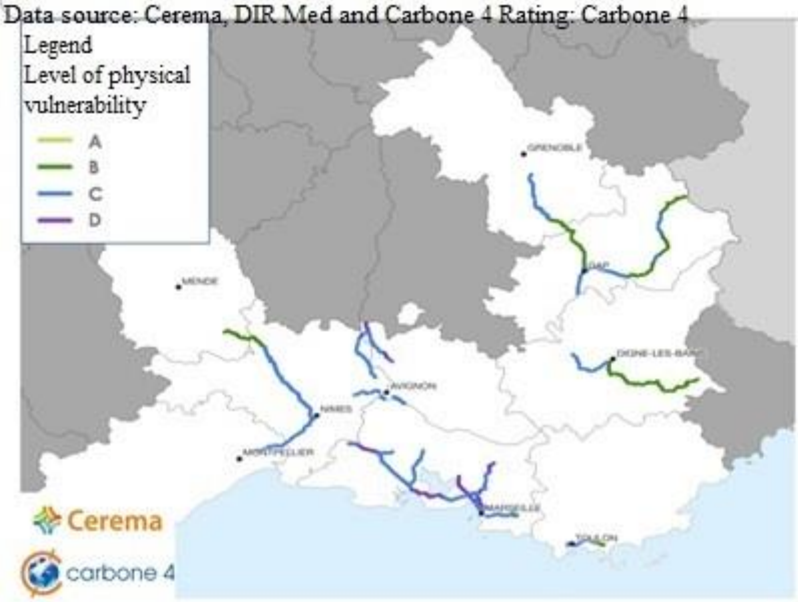
[4] www.drias-climat.fr/.

(b) Identification of the physical impacts of extreme weather events on systems. For example, landslides can cause the complete or partial destruction of the road and roadway structures, and freezing and thawing cycles produce potholes on roads and corrode metal fittings of roadway structures;

(c) Identification of aggravating factors, based on the type of material (concrete, steel, etc.) and the conditions of the infrastructure (sealed surface, high-traffic area, etc.);

(d) Assignment of a rating corresponding to the type of response necessary for the operator to deal with the potential physical damage resulting from extreme weather events.

An example of a vulnerability rating of DIR Med road segments in the event of heat waves in a distant time horizon (2017-2100) for the pessimistic RCP8.5 climate scenario - with modification of the actual results
Data source: Cerema, DIR Med and Carbone 4 Rating: Carbone 4



E. Rating functional risk for roads

12. The functional risk for roads is evaluated in two steps:

(a) Identification of the actual impact (complete blockage or slowdown of traffic) and the economic stakes for each road segment, based on traffic data, in order to obtain ratings of functional vulnerability;

(b) Combination of vulnerability ratings with climate hazard ratings.

F. Conclusions and way forward

13. The use of the methodology on the Mediterranean DIR road network has made it possible to take stock of the network’s vulnerability to climate hazards, to make recommendations for further development of that methodology and to make the methodology available to all network operators wishing to carry out risk analyses of their road networks. There are still some methodological issues to take up in subsequent studies, in particular how to select and prioritize adjustments, and also how to analyse the economic importance of the segments of a road network. Traffic indicators have made it possible to approximate their economic importance, but such an approach does not take into account the presence of users and sites that are of strategic importance to the economy and the network’s absorption or re-routing capacities in the event of disruptive weather events.