EJTIR

Issue 16(1), 2016
pp. 95-97
ISSN: 1567-7141
tlo.tbm.tudelft.nl/ejtir

Editorial: Special Issue on Climate Adaptation of Infrastructure Networks

Lori Tavasszy[1,2]
Delft University of Technology, Netherlands; TNO, Netherlands

L. Andrew Bollinger[3,1]
Empa, Switzerland; Delft University of Technology, Netherlands

Gerard P.J. Dijkema[4]
University of Groningen, Netherlands

Climate change affects transportation infrastructures in different ways. Sea level rise and extreme weather may reduce the availability or the quality of parts of the network. Impacts may be felt by all modes of transport (e.g. roads, railroads, waterways, pipelines), by all transport motives (people, freight, utilities) and by different components of the system (the physical construction or user behaviour). Ultimately, failure of infrastructures can also occur at the system level, across modes, motives and components: infrastructures are connected and their performance is interdependent. On top of this wide variety of possible impacts of climate change, large uncertainties about the timing, intensity and location of effects also introduce the question of how to deal with uncertainty itself, in planning and design. This special issue deals with the identification of 1) of the expected impacts of climate change and 2) promising approaches to reduce its impacts.

Research on the effects of climate change on transport systems emerged around the turn of the century (see e.g. Decicco and Mark, 1998), with the first systematic inventories of the state of knowledge appearing a decade later (Koetse and Rietveld, 2009). As identified in (Bollinger et al., 2014), a notable gap in research concerns the relation between disturbance of individual infrastructure components and higher level system effects at the level of transport nodes, links, or the entire network. Here, a conceptual framework is proposed that focuses on these relations (Figure 1). Using this framework as a departure point, this special issue presents a selection of results of investigations in recent major research programs around the world.

The papers individually include more than one dimension of the framework and collectively cover a large part of the framework, thus working towards an integrative picture of design needs and opportunities for climate change adaptation. They include contributions on infrastructures for road and rail transport, trans-shipment in maritime ports, drinking water and electricity transmission networks. In all these cases, they relate at least two levels of failure, from components to links/nodes to the network level. In addition, two contributions treat overarching problems, related to network interconnectedness and multi-stakeholder planning approaches.

1 A: TU Delft, Mekelweg 2, 2628 CD Delft, Netherlands; E: L.A.Tavasszy@tudelft.nl
2 A: TNO, van Mourikbroekmanweg 6, 2628 XE, Delft, Netherlands
3 A: Empa, Ueberlandstrasse 129, 8600 Duebendorf, Switzerland
4 A: University of Groningen, ESRIG, Nijenborgh 4, 9747 AG Groningen, Netherlands

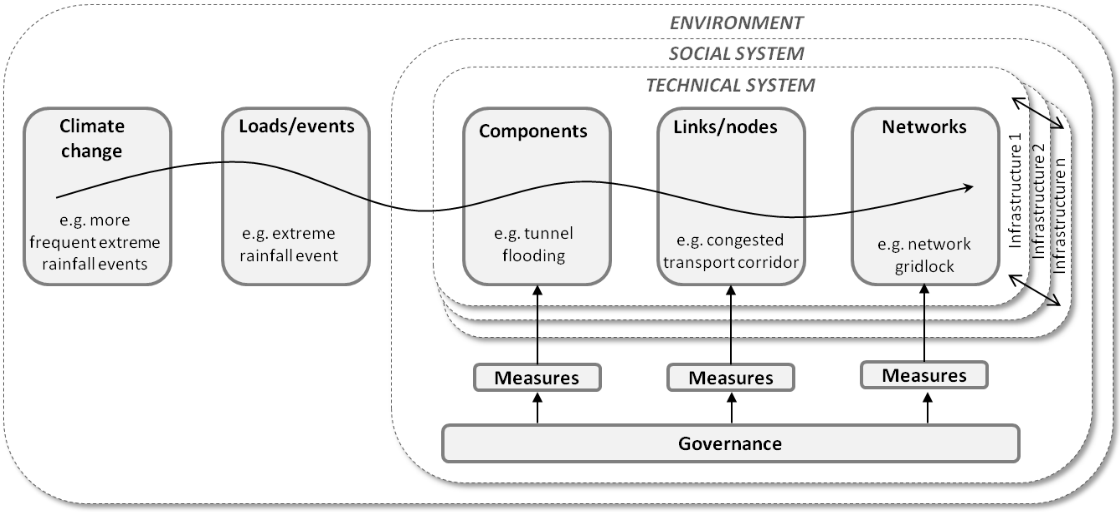

Figure 1. Conceptual framework for climate adaptation research (Bollinger et al., 2014)

The research reported in this special issue originated to a large extent from the 4 year project "Infrastructure Networks, Climate Adaptation and Hotspots (INCAH)" that ran as part of the framework program "Knowledge for Climate" in the Netherlands between 2009 and 2014. In addition to the contributions from the Netherlands, other researchers involved in major programs submitted manuscripts for the special issue. All papers have undergone the regular EJTIR refereeing process. A brief summary of the contributions is provided below.

Huibregtse et al., Michalis et al., Snelder and Calvert and Pilli-Sihvola et al. focus on adaptation in **road networks**. Huibregtse et al. propose a framework and a quick scan tool for risk based design and management for the case of tunnel floods. Michalis et al. identify typical problems and opportunities for adaptation of rural roads. Snelder and Calvert make the link between weather phenomena and road network performance and study alternative dynamic transport models to quantify these relationships. Pilli-Sihvola et al. apply Weather Service Chain Analysis to study opportunities to inform drivers before and during a trip about expected traffic problems.

Pant et al. develop a comprehensive spatial vulnerability analysis methodology for national scale **railway infrastructure networks**, and apply the methods to Great Britain's railway infrastructure. The paper includes a novel framework for representing railway assets in a way that network vulnerability can be systematically assessed. A salient outcome is that the interdependencies of railway assets with telecommunication and electricity networks are critical to the overall vulnerability of the rail system.

Chhetri et al. analyse the vulnerability of **port operations** to extreme weather events, and propose a vulnerability assessment using Container Terminal Operation Simulation (CTOS), which simulates the vulnerability of port operations to extreme weather events. Strong wind, heavy rain and flooding all contribute to delays in operations and to a significant loss of efficiency overall. The CTOS allows quantification of these impacts, leading to the finding that, without additional measures, losses can be in the order of 10% in a 24 hour period.

Bollinger and Dijkema and Wols and van Thienen address utilities infrastructures. Bollinger and Dijkema apply structural vulnerability analysis to a national scale **electricity network**, propose a new model for assessing infrastructure resilience and test several measures to enhance robustness. Original features include the detailing of power system characteristics and the representation of cascading failures; this allows the identification of critical power stations in the network and the prioritization of protection measures.

Wols and van Thienen study the integrity of **drinking water distribution systems**, by developing a predictive pipe failure model based on historical failure registrations and weather parameters. A key result that expected changes in the number of pipe failures due to climate change depend on the material used. A detailed quantification predicts that failures in networks with high proportions of PVC and cast iron pipes can be expected to decrease under a climate change scenario.

Bhamidipati et al. present a layered framework for modelling interconnectedness between **energy and water infrastructures** for improved asset management, using an agent-based simulation model to demonstrate how actions of individual infrastructure managers influence system performance. As in the paper by Pant et al., the network structure of assets appears to be important for the propagation speed and extent of impacts. Importantly, their dynamic approach allows study of the speed of the degradation of the system's functions.

Schenck et al. highlight the dimension of **governance of network planning**. They evaluate the effectiveness of joint fact finding as an instrument to support multi-stakeholder decision making processes by means of a case in Rotterdam, The Netherlands. Framing climate relate issues as "wicked problems", their approach to assessing effectiveness combines earlier frameworks that include process and outcome related criteria. The Rotterdam case provides detailed feedback about the strengths and weaknesses of the new framework.

Altogether, the articles provide a unique, kaleidoscopic view of research on climate adaptation of national infrastructures, highlighting novel approaches and applications across different infrastructures and levels. We hope that, in addition to their research value, the papers will provide input for practitioners at the strategic and tactical level, including policy makers, asset managers and design engineers.

References

Decicco J, Mark J (1998) Meeting the energy and climate challenge for transportation in the United States. *Energy Policy* 26(5):395–412.

Koetse MJ, Rietveld P (2009) The impact of climate change and weather on transport: an overview of empirical findings. *Transp Res Part D* 14(3):205–221.

Bollinger, L. A., Bogmans, C. W. J., Chappin, E. J. L., Dijkema, G. P. J., Huibregtse, J. N., Maas, N., ... & Tavasszy, L. A. (2014). Climate adaptation of interconnected infrastructures: a framework for supporting governance. *Regional Environmental Change* 14(3), 919-931.