Transportation Research Part D 63 (2018) 421–432

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

Through the storm: Transit agency management in response to climate change

Qing Miao[a,*], Mary K. Feeney[b], Fengxiu Zhang[b], Eric W. Welch[b], P.S. Sriraj[c]

[a] Department of Public Policy, Rochester Institute of Technology, 3242 Eastman Hall, 92 Lomb Memorial Drive, Rochester, NY 14623-5604, United States

[b] Center for Science, Technology and Environmental Policy Studies (C-STEPS), Arizona State University, United States

[c] Metropolitan Transportation Support Initiative (METSI), Urban Transportation Center, University of Illinois at Chicago, United States

ARTICLE INFO

Keywords:
Public transit
Extreme weather
Risk perceptions
Climate adaptation
Climate change

ABSTRACT

The increase in extreme weather events due to climate change poses serious challenges to public transit systems. These events disrupt transit operations, impair service quality, increase threats to public safety, and damage infrastructure. Despite the growing risk of extreme weather and climate change, little is known about how public managers recognize, experience and address these risks. Using data from a national study of public transit agencies we investigate the types of extreme weather events transit agencies are experiencing, the associated risks, and how agencies are preparing for them. We find that while extreme events are commonly experienced by transit agencies across states and transit managers perceive increased risks from these events, most agencies rely on the traditional emergency management approach to address extreme weather *ex post* rather than taking a proactive approach to mitigating the adverse weather impact on transit assets and infrastructure ex *ante*. Managers report that a lack of access to financial resources is the greatest challenge for undertaking adaptation and preparation. We conclude with a discussion of what these findings mean for understanding organizational adaptation behavior as well as climate adaptation policy making.

1. Introduction

Extreme weather events such as floods, heat waves, hurricanes and severe storms pose serious challenges to public transit systems. Not only do they disrupt transit operations, impair service quality, and cause additional safety threats, but they also damage infrastructure and impose stress on the state of good repair. As demonstrated by Hurricane Sandy and other recent weather-related disasters, the weather impacts on transit can have significant ramifications for regional mobility and functioning of economic systems, given the public's increased reliance on transit systems for access to jobs and other services. How to effectively manage the risks of extreme weather is a question that constantly concerns transit managers. This issue has become increasingly urgent as climate change is resulting in more frequent and intense extreme weather events (IPCC, 2012; NOAA, 2017). While many transit agencies have experience and expertise coping with weather disruptions, they are confronted with the new challenge of identifying and developing appropriate long-term adaptation strategies to address greater risk and uncertainty associated with climate change (Thomson, 2017).

In this paper, we investigate how public transit managers perceive extreme weather risk and how their agencies respond to and prepare for these growing challenges. Using data from a national survey of 273 public transit organizations, we show how U.S. transit

* Corresponding author.
E-mail address: qxmgla@rit.edu (Q. Miao).

https://doi.org/10.1016/j.trd.2018.06.005

agencies are responding to extreme weather associated with climate change and document the potential barriers they face in the adaptation process. We draw from perspectives of managers in planning, operations, maintenance, and engineering to assess recent experiences with extreme weather events, the impacts of extreme weather on agency operations, strategies and approaches employed to manage and adapt to extreme weather risks, and managerial perceptions of agency capacity. While similar survey studies have been conducted in other sectors such as coastal management and public health (e.g. Tribbia and Moser, 2008; Bedsworth, 2008), our research presents one of the first few attempts to examine the current status of adaptation responses in the broader U.S. public transportation sector. Given the wide breadth of adaptation options, we are particularly interested in understanding whether agencies are primarily engaged in reactive emergency responses or proactive adaptation and planning activities, and how they interact and coordinate with other organizations in managing local and regional extreme weather events.

The paper is organized as follows. In the next section, we review the relevant literature. We then describe our research design and methodology in Section 3 and present the main results in Section 4. Section 5 discusses the implications of the results and Section 6 draws conclusions.

2. Relevant literature

Transit systems are highly sensitive to weather interruptions because of the nature of the service they provide and because many of their assets and infrastructure are exposed to the environment. There is a growing body of research examining the impact of weather and climate change on transportation (Suarez et al., 2005; Chapman, 2007; Koetse and Rietveld, 2009; Jochem et al., 2016; Pregnolato et al., 2017; Xia et al., 2013; Stamos et al., 2015). There is also increased research attention to understanding the relationships between weather and public transit. For example, several recent studies have investigated how adverse weather conditions (e.g. extreme high or low temperatures and excessive precipitation) affect urban transit ridership, finding an overall negative impact (e.g. Guo et al., 2007; Stover and McCormack, 2012; Cravo and Cohen, 2009; Changnon, 1996; Singhal et al., 2014; Arana et al., 2014; Kalstein et al., 2009). Such findings imply that unfavorable weather conditions result in a direct revenue loss for transit service providers.

Extreme weather affects the availability and the quality of transit service as well as the physical transit infrastructure (Chung, 2013; Flegenheimer, 2013; Hodges, 2011). Singhal et al. (2014) show that adverse weather conditions disrupt routine transit operation by increasing access time, prolonging trip duration, reducing service frequency, and causing vehicle rerouting. Climate change is expected to intensify the weather risks to the transit systems. In a recent report published by the Federal Transit Administration (FTA), Hodges (2011) identifies four primary climate stressors facing public transit including intense precipitation, heat waves, rising sea levels, and hurricanes. Specifically, intense precipitation, hurricanes, and sea level rise can flood tracks, bus ways, tunnels, and facilities, while extreme heat waves can cause track buckling and lead to delays or derailing. Overall, the revenue loss due to physical infrastructure damage and reduced transit usage may impair the financial conditions of most local transit agencies and also result in additional public spending at different levels of government. Furthermore, considering the populations who most likely rely on public transportation, extreme weather events give rise to social equity concerns due to their disproportionate impacts on the elderly, people with disabilities, and low-income individuals.

While there is a recognized need for organizations to adapt to the impacts of extreme weather and climate change (Linnenluecke et al., 2012; Winn et al., 2011; Nelson et al., 2007; Smithers and Smit, 1997), little research has examined how transit agencies have dealt with weather-related disruptions and in particular, the dynamics of their organizational decisions and responses related to extreme weather. It should be noted that extreme weather is not necessarily a new phenomenon. Many transit agencies have long experience coping with extreme weather events, with a traditional focus on an emergency management approach (i.e. treating these events as emergencies and developing emergency response plans). The existing literature on adaptation and resilience has represented a paradigm shift that places more emphases on developing anticipatory, planned strategies and building capacity to manage external changes including increased climate variability and disastrous weather conditions (Folke, 2006; Hegerl et al., 2007; Adger et al., 2011; Berkhout, 2012; Zhang et al., 2018).

With respect to the public transit sector, recent studies have proposed a variety of adaptation options based on their identification of climate and weather-related risk specifically concerning transit. For example, the 2008 report of the Transportation Research Broad (TRB) suggested transportation professionals take a comprehensive and risk-based approach by integrating climate factors to the planning, design, construction, operation, and maintenance of transportation systems (DOT, 2014). Hodges (2011) has classified transit adaptation strategies into four major categories, which include (1) maintain and manage: absorb the costs of increased maintenance and repairs while improving real-time responses to severe events; (2) strengthen and protect: develop new assets and infrastructure to withstand future events; (3) enhance redundancy: identify alternative services and routes to ensure service continuity during extreme events, anticipating and preparing for the loss of a link in the entire transit network; and (4) retreat: abandon transportation infrastructure located in indefensible or extremely vulnerable areas and relocate to areas less susceptible to extreme weather events.

Based on Hodges' (2011) framework, we examine the current status of adaptation across U.S. public transit agencies to provide the first comprehensive national survey of transit risks and responses related to extreme weather and climate change. Our research draws upon the study conducted by Koch and MacArthur (2013), which used an online survey and content analysis to empirically examine whether and how public transit agencies adapt to the impacts of climate change. They found that only 17 agencies were