

NAVIGATING THE ANTICIPATION-ADAPTATION SPECTRUM: EVALUATING THE DECISION-MAKING PATHWAYS OF CRITICAL INFRASTRUCTURE RESILIENCE PLANNING

ABSTRACT

In the past century, the concept of resilience has emerged as a critical element in sustaining the performance of critical infrastructure systems amidst various challenges. Traditionally, resilience has been practiced through a risk-based utility maximization approach, where strategies and investments for resilience are evaluated against the likelihood and intensity of potential threats. This approach, while effective in certain contexts, has recently come under scrutiny due to the rapidly evolving frequencies and intensities of threats. These developments have prompted the scientific community to reevaluate the effectiveness of the conventional resilience approach in safeguarding critical infrastructure systems. In the past decade, a novel school of thought emerged, advocating for the concept of adaptation as the foundation of resilience management efforts within critical infrastructure systems. Proponents of this paradigm distinguish between adaptive resilience and traditional practices by designating the latter as embodying the principles of reliability and risk management. The advocates of the adaptive resilience school emphasize the necessity of adaptation in the face of complex, unpredictable challenges (of which deep uncertainties and surprise shocks are the focus of this work). These recent developments have led to a variety of pathways in resilient practice, precipitating an already existing divergence in the conceptualization of the resilience of complex systems. Moreover, a notable gap exists in the literature regarding how these pathways can be effectively organized to optimize resilience outcomes, particularly in situations where knowledge is limited. This dissertation investigates multiple resilience

management pathways to understand the role of adaptation in the management of critical civil infrastructure systems. The dissertation is guided by the question: How can adaptive resilience be applied to macro-level complex infrastructure systems to facilitate the decision-making and planning of infrastructure assets and ensure the provision of sustainable and resilient systems?

This work employed a set of qualitative and quantitative research methods to achieve the following: (1) define what adaptive resilience is, categorize existing planning efforts, and develop a framework that facilitates future efforts in the field of adaptive resilience research, (2) investigate the emerging challenges that require adaptive resilience measures, and the implications that hinder the adaptation of these measures, (3) analyze current trends in adaptive resilience practice, and investigate the gap between the acknowledged need for adaptive resilience and the practical adoption of such practices, (4) investigate the implications emerging challenges have on the current practices and the risks associated with neglecting such challenges, (5) determine the capacities of adaptive resilience, and (6) provide a future direction for efforts directed towards fostering an adaptive resilience culture within organizations committed to the resilience of critical infrastructure systems.

This research expands the existing infrastructure resilience theory by investigating its limitations and redefining a number of critical concepts that -in our view- facilitate resilience efforts within these complex systems. The work provides a framework for agencies invested in resilience development to enhance their efforts, and provide a clarification about various misconceptions which result in efforts that may be counterproductive to the objectives that motivate them. Overall, the resilience research of critical infrastructure systems is at a developmental stage where agreements on foundational concepts that guide a unified commitment

for resilience are required to advance this important field of study, and create efforts that are not outpaced by the intensities and frequencies threats that motivate them

