EDITORIAL

Concurrent threats and disasters: modeling and managing risk and resilience

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The global COVID-19 pandemic has prompted policy makers to reassess the operations and management of society's critical functions, including infrastructure, health care services, supply chains, and emergency response. With COVID-19 as a backdrop, planning and response activities must continue to occur to be able to effectively deploy resources for other disasters which may unfold simultaneously. For example, the concurrence of severe hurricanes and the global pandemic presents unique challenges for disaster management.

The presence of concurrent threats requires an approach that considers both risk and resilience. While risk analysis answers the questions "what can go wrong?", "how likely is it?", and "what are the consequences?", risk analysis can only yield benefits in situations where one can reasonably predict the likelihood and consequences of an adverse event. In many emerging threat environments, or where there are multiple threats, it becomes difficult to parameterize the models necessary to conduct a reliable risk assessment. Resilience take a different and complementary approach, by considering how a system can plan/prepare, absorb, recover, and adapt to disruptions in such a way as to minimize the effect to critical system functions. Taking a resilience approach does not seek to identify every possible threat, but instead allocates resources to designing and protecting the system in such a way as to be able to bounce back quickly from disruptions. Risk and Resilience have been central themes of this Journal, including the topic of multiple Special Issues, including Volume 35, Issue 2 (Linkov et al. 2015) and Volume 38, Issue 3 (Kete et al. 2018). Risk and resilience have been discussed in other books and publications as well (see Linkov and Trump 2019 for review).

COVID-19 has unearthed some of the same issues discussed in the disaster assessment and management literature. While the previous special issue was focused on COVID-19, this issue of *Environment Systems & Decisions* presents a collection of papers which focus on various aspects of risk and resilience related to disaster management. These disasters include natural (e.g., severe weather events) and manmade (e.g., cyber threats, pipeline explosions) examples. Moreover, resilience is examined from the perspective of protecting against these discrete events, as well as long-term trends, such as climate change. These papers echo patterns from disaster management literature that can be useful in understanding and managing COVID-19.

COVID modeling presented a clear challenge and attracted media attention. In March 2020, the modeling forecasts (providing essential information on disease prevalence that society demanded) changed by orders of magnitude literally within the timeframe of a couple of weeks. "Can you trust a model whose output keeps changing?" ask Naeini et al. (2020). Of course the answer is "yes." Models could and should be trusted, but results should be appropriately communicated and understood. Model uncertainty is often hidden under multiple assumptions and is not communicated properly. For example, Linkov and Burmistrov (2003, 2005) observed that post-crises model uncertainty can result in orders of magnitude difference in predicting simple endpoints. This is what can be expected from models applied to new conditions without historical calibration data.

Following the general theme of resilience, Bellini et al. (2020) describe the concept of resilience in general, and apply resilience principles to critical infrastructure systems supporting urban transportation. They describe the processes involved in establishing resilience management guidelines, developing resilience tools, and defining performance indicators, all of which can be applied to a number

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of other contexts. Herrera and Kopainsky (2020) describe a methodology for involving stakeholders in a participatory assessment of resilience. The authors describe how system dynamics modeling can be used to design system interventions which build resilience into the system and account for stakeholder needs and requirements.

The next group of papers deals with the planning and preparation necessary for risk and resilience, prior to a disruption. For example, McIntosh and Becker (2020) develop a decision model which derives weights for sensitivity, exposure, and adaptive capacity indicators for maritime ports subject to disruptions from severe weather and climate change. These indicators were used to rank ports based on their vulnerability, which is useful for allocating resilience-enhancing resources to ensure continuity of port operations. An important component of risk management and resilience is the ability to collect relevant data, and Caruzzo et al. (2020) describe a decision model for supplier selection of weather radars. This has direct implications for disaster preparedness and response to severe weather events. Another important concern related to severe weather and climate change is flood risk management. Sandri et al. (2020) describe and compare governance frameworks applied to reducing accident hazards in natural gas pipelines. Proper governance and planning can contribute to the reduction in pipeline accidents and therefore reduce impacts to human lives, environmental degradation, and economic losses.

The final group of papers focuses on the response to disasters once they have occurred, and how the risks can be mitigated, as well as how society can absorb, recover, and adapt to disruptions. Ha (2020) compares the disaster management practices from developing and developed nations and provides recommendations about how disaster management can become more inclusive to involve stakeholders and to consider factors such as risks, politics, resources, and time. Maslen et al. (2020) explore the role of hazard and incident reporting in preventing health, aviation, and constructions disasters. They describe survey results which provide insights into how legal liability concerns impact hazard and incident reporting, and thus disaster prevention. Assmuth et al. (2020) describe approaches taken in Finland related to minimizing the impacts associated with flooding, especially related to the potential health impacts associated with flood events. Renwick (2020) applies a decision model to the topic of food security, which is an essential societal function which can be disrupted by disasters. Ensuring a stable food supply after a disaster is a multi-stakeholder endeavor involving government, farmers, local businesses, and international suppliers.

Together with the previous Special Issue on "Systemic Risk, Resilience, and COVID-19" (Trump and Linkov 2020), this issue of *Environment Systems and Decisions* provides a foundation for dealing with systemic crises like COVID-19. The principles and methods of risk and resilience represent

fruitful paradigms for planners and policy makers for ensuring that critical social, economic, and environmental systems are able to withstand and bounce back from wide array of threats – not only the current known threats of COVID-19, climate change, and global instability, but also the unforeseen threats of the future.

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