USACE Resilience Assessment Methodologies - Engineering and Infrastructure[i]

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Introduction

The US Army Corps of Engineers (USACE) has a Civil Works mission to manage inland and coastal waterway infrastructure health, in which infrastructure includes a range of constructed and natural features as well as community characteristics and functioning in the vicinity of USACE assets. As a result, the USACE developed risk assessment methods to ensure that the project and system have an acceptable level of risk for the anticipated hazards. With the onset of natural disasters that are more frequent, unpredictable and are anticipated to be more severe, resilience (in addition to risk management) has quickly become a research priority for federal agencies. Presidential Policy Directive 21 (PPD, February 2013), "Critical Infrastructure Security and Resilience" defined resilience as "the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions." This definition was later echoed in the Executive Order 13693 (EO, November 2013), "Preparing the United States for the Impacts of Climate Change." In September 2013, the Chief of Engineers officially charged the Coastal Engineering Research Board, an advisory board for USACE coastal research, to "recommend a strategy to integrate risk reduction and resilience practices within USACE coastal planning, engineering, operations, and construction communities." This work was undertaken by researchers in the USACE's Engineer Research and Development Center (ERDC) and resulted in the adoption of a definition similar to EO 13693 and PPD 21 based on the National Academy of Science's (2012) "A National Imperative" in which disaster resilience is defined as the "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events." Within USACE ERDC, initial methods to characterize and quantify resilience focused on coastal storm damage. However, in 2014 the USACE Headquarters officially kicked off an initiative to mainstream resilience within all aspects of the USACE, for all both Civil Works and Military missions. In order to successfully implement resilience agency-wide, it is critical to align methods to assess the resilience of a structure, project, and system with the definition of resilience such that the assessment and subsequent mitigating actions to reduce the risk of hazards and increase resiliency

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can be readily understood and are defensible to USACE, cost-sharing partners, and the public. Standardized approaches to resilience are important to ensure equitable distribution of limited federal resources to USACE districts around the country. The purpose of this section is to summarize USACE activities with respect to assessing engineering resilience of built and natural infrastructure, primarily concerning resilience to coastal storm hazards and long-term change.

Objective

The distinguishing feature of the various definitions presented above is that they refer to specific stages of anticipating and responding to disruptive events – preparing, absorbing/withstanding, recovering, and adapting. Whereas traditional risk-based approaches to planning attempt to prevent or minimize losses during the "absorb/withstand" stage of the disruption, resilience-based management focuses on all stages of the disruption as well as the functioning of the system, and acknowledges that actions are necessary through the event timeline to minimize loss of function within integrated systems (e.g., commercial activity, telecommunications, ecosystem services, utility of built and natural infrastructure, etc.). Risk analysis should be undertaken where possible to evaluating options to reduce damages through prevention, but should be supplemented with, or integrated into, a larger plan for resilience management that enhances flexibility by considering the myriad ways to maintain a function of a community system to recover and adapt when the original organization of the system is disrupted. These system components include not only the engineered infrastructure or USACE project being studied but the community and ecological components that may affect or be affected by project decisions.

Instruments

The ERDC has develop a three-tiered approach to resilience assessment that mimics the tiered approach to risk assessment already widely used by regulatory entities in the United States and internationally; however, the resilience assessment incorporates recovery and adaptation of the surrounding community and ecosystem. The first tier is a screening or scoping level approach to identify the critical functions and describe the broad components and relationships within the system. The second tier takes a deterministic look at specific performance goals for various sub-systems that support critical functions. The third tier uses a network representation of the system in a probabilistic approach to model specific expected performance of the system during stages of impact and recovery and under various future scenarios. While the third tier gives a more nuanced view of performance, it requires significantly more data than Tier 1 or Tier 2 and can only realistically be performed for subsets of the full coastal community system. By utilizing stakeholder input and expert elicitation in the early tiers, a comprehensive but simple analysis can be performed to make many planning and investment decisions. Alternatively, Tiers 1 and 2 can aid in focusing subsequent analysis on the sub-system of greatest value to the community and with greatest vulnerability to disruption. Following Hurricane Sandy in 2012, the USACE's North Atlantic Coast Comprehensive Study (USACE 2015; Bridges et al. 2015) recommended an assessment of community resilience through application of a similar analysis as part of an integrated approach to reduce risk of future storm damages.

Metrics

For each tier of the analysis, qualitative and quantitative characterization of magnitudes for each stage of resilience are necessary to better focus the assessment and subsequent actions. Without documented governance to guide the implementation of resilience assessment, it will not be widely adopted as a standard assessment procedure. Tier 1 can utilize existing data collected at the macro level, including demographic data, climate data, and engineering data, together with expert elicitation to provide and initial screening level assessment. These metrics can be aggregated into indicator indices or scorecards. Tier 2 builds upon existing data and models, using functionality of the system through the resilience stages as the metrics through which resilience is quantified. Expert elicitation can both supplement performance ratings for the functions of a system for which data are not specifically available and stakeholder engagement can help assess the acceptability of system performance with respect to the preference and values of the system users. Formal decision analysis methods that integrate data from multiple sources are appropriate for a Tier 2 assessment. Tier 3 requires both robust—and potentially some new—data collection and numerical modeling, with a network representation of the system and local expertise to characterize the degree and nature of interactions between the subsets. Tools for this approach may include Bayes nets, agent-based modeling, network science, or system dynamics.

While we have focused primarily on the work of USACE, the body of resilience work across federal agencies is swiftly growing. Federal activities in resilience include the US Committee on the Marine Transportation System (CMTS), which seeks to leverage existing data and studies to develop federal consensus on resilience of the Marine Transportation System; the National Academy of Sciences' (NAS) Resilient America Roundtable, which teams federal, academic, and consulting expertise to help communities and the nation build resilience to extreme events; and the National Institute of Standards and Technology's Community Resilience Panel for Buildings and Infrastructure, which is focused on improving standards, guidelines, best practices, and tools for community infrastructure, utilizing representation by governing organizations (federal, state, local), academic, and others. Coordinating bodies like these are critical to facilitate communication between groups, leverage ongoing work, and guide consensus on resilience practice. For up-to-date information, readers are directed to sources listed in the annotated bibliography.

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