Matrix Approach to Coastal Community Resilience Assessment

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Introduction

Coastal communities are subject to frequent disruptive events such as hurricanes but traditional risk reduction measures are difficult to achieve when physical improvements are voluntary (elevating, waterproofing basements) or culturally unpopular (high sea walls). Yet, coastal communities have no single managing authority in communities to clearly define optimal functionality and determine acceptable trade-offs to achieve resilience (Linkov et al. 2014). Instead, "soft" capacities such as collaboration, communication, and decision making can be an equally important factor in achieving resilience (Mendonça and Wallace 2006). Resilience is a property of a system that describes the capacity to continue performing critical functions through disruptive events. Resilience requires integration and performance of both physical infrastructure and soft functions.

Materials and methods

The Resilience Matrix (RM) is a framework for the performance assessment of integrative complex systems. The framework (Figure 1) consists of a 4x4 matrix where the rows describe the four general management domains of any complex system (physical, information, cognitive, social) as described in the US Army’s Network-Centric Warfare doctrine (Alberts and Hayes 2003) and the columns describe the four stages of disaster management (plan/prepare, absorb/withstand, recover, adapt) as defined by the National Academy of Science in their definition of resilience (Committee on Increasing National Resilience to Hazards and Disasters 2012).

Results

Case Study 1: Rockaway Peninsula, NY

The Rockaway Peninsula of Queens, New York City is largely residential. For the demonstration of the RM in this case study, the housing/shelter function is selected as the most critical function and extensive data from community workshops and federal and city task forces collected following Hurricane Sandy to complete the matrix. In this demonstration (Figure 2) we see that housing/shelter in the community has greater capacity to prepare for and absorb coastal storm events than to recover from them and adapt accordingly. Similarly, it has somewhat greater capacity across the social and physical domains compared to the information and cognitive domains. Low scores are largely due to the inadequately long time period to perceive, rather than an outright lack of efforts. This pattern is evident in many coastal environments.

In addition to the interpretation of the results, the RM approach provides the opportunity to open communication and establish relationships. Figure 3 displays a non-exhaustive list of the agencies and groups that may have responsibilities or capabilities related to supporting the function of the system components of a community. Establishing strategic partnerships may reduce costs by eliminating redundant efforts and enhance resilience by strengthening collaboration and lines of communication that can prove valuable in real-time disaster response.

Case Study 2: The Mobile region of Alabama has a nationally important port and rail transportation system in addition to an ecologically sensitive bay and robust beach tourism industry. For the demonstration of the RM in this case study, four critical functions were selected: housing/shelter, port industry, tourism industry, and ecosystem health. The matrices were completed using qualitative results from a regional stakeholder workshop held in the spring of 2015. In this demonstration (Figure 4) we see that different components of the system have different levels of expected performance. The baseline assessment can now be used to evaluate proposed resilience improvement projects to ensure that they are addressing the true needs (areas of low performance) nor simply the easiest, or most obvious actions. In addition, the stakeholder engagement at the workshop provides context and specific information to explain areas of high or low performance.

Figure 1. Resilience matrix framework of Linkov et al. (2013)

Figure 2. Heat map of matrix results for housing function at Rockaway Peninsula.

Figure 3. Potential collaborative partners for Rockaway Peninsula resilience.

Figure 4. Resilience matrix performance results for 4 critical functions. Blue bars indicate relative total performance across each stage or domain.

References


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Further information

The USACE ERDC Risk and Decision Science team integrates traditional academic research with expert elicitation on emerging concepts and decision maker’s value systems to support optimization of planning, investment and decisions making strategies across a wide spectrum of topics from nano-technology to humanitarian assistance, sustainable buildings, and military personnel recovery.