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 homes, waterproofing basements) or culturally unpopular (high seawalls). 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 integratec 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).

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

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 perform tasks, rather than an outright lack of resources. This pattern is expected 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.

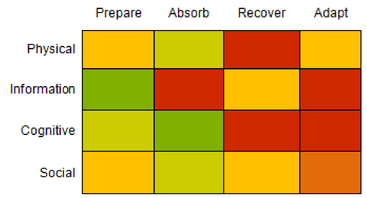

Figure 2. Heat map of matrix results for housing function at Rockaway Peninsula.

	Prepare	Absorb	Recover	Adapt
Physical	USACE	USACE	USACE FEMA	USACE
Information	NOAA	Mayor's Office FEMA	FEMA NYC OEM	NYC Planning
Cognitive	NYC Planning	NYC OEM FEMA	FEMA NYC	USACE NYC
Social	NYC OEM	NYC OEM FEMA	NGO/Non-Profit HUD	NGO/Non-Profit

Figure 3. Potential collaborative partners for Rockaway Peninsula resilience.

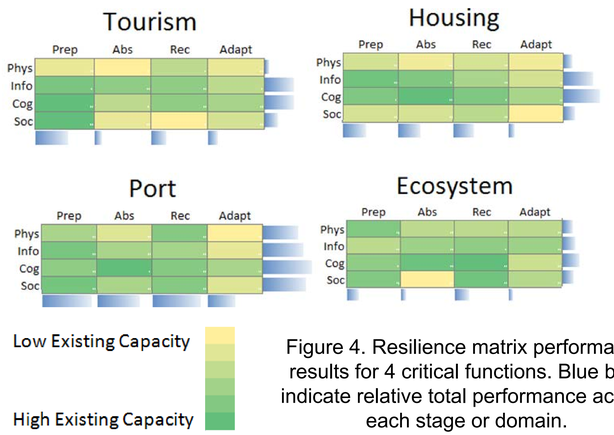

Figure 4. Resilience matrix performance results for 4 critical functions. Blue bars indicate relative total performance across each stage or domain.

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 simple 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.

Conclusions

Other community resilience assessment tools utilize an established set of demographic and community metrics to develop a relative resilience score. This approach allow comparisons across multiple communities, but does not necessarily help inform communities about how to move forward. The RM uses a stakeholder informed method that ensures metrics and scores are relevant to the immediate community. In addition, the RM is applied for each critical function of a community. This not only breaks down an aggregate score so that decision makers can see where they specific areas of low performance are but also allows federal and state agencies with specific missions to evaluate how proposed resilience improvement designs will perform with respect to their area of interest.

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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-tehcnology to humanitarian assistance, sustainable buildings, and military personnel recovery.