A Tiered Approach to Resilience Assessment[i,ii]

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Introduction

The concept of resilience has become prevalent among scientists, engineers, and policymakers in a range of disciplines in various socio-ecological fields (e.g. ecology, urban planning, flood protection, drought management) and across public domains (e.g. city managers, state, regional, and federal officials). Key stakeholders within industry, government, and society-at-large consider its application to problems such as disruption from climate change or the challenge of ecosystem management, among others (United Nations, 2015; Walker et al. 2004). In this paper, we view resilience as a focusing concept to aid decisions centered on maintaining critical functions and services before, during, and in the aftermath of a disruptive event (NAS 2012). Given the need for resilience assessment in many sectors and the multiple scales over which such an assessment is necessary, agencies operating within a regulatory environment may benefit from guidance in the selection of the appropriate tools and methods for resilience assessment.

Objective

The proposed resilience management approach is not intended to supplant more conventional approaches of risk management or the many existing efforts of resilience quantification method development, but instead provides a guide to select tools that are appropriate for the given analytic need. We recommend that the tiered approach integrate work from the many agencies, organizations, and researchers who have built resilience indices, visualization tools, and modeling methods on the subject for various resilience-driven applications.

Instruments for resilience management

Regulatory agencies have long adopted a three-tier structure for risk assessment and risk management. We build on this structure by proposing a tiered approach for resilience assessment

[i] This paper is part of the IRGC Resource Guide on Resilience, available at: https://www.irgc.org/risk-governance/resilience/. Please cite like a book chapter including the following information: IRGC (2016). Resource Guide on Resilience. Lausanne: EPFL International Risk Governance Center. *v29-07-2016*

[ii] This is summary of paper resulting from Aspen 2015 workshop on Risk and Resilience. Other co-authors of the full paper include Laura Read, Craig R. Allen, James C. Arnott, Emanuele Bellini, Jon Coaffee, Marie-Valentine Florine, Kirk Hatfield, William Hynes, Aleksandar Jovanovic, Roger Kasperson, John Katzenberger, Patrick W. Keys, James H. Lambert, Richard Moss, Peter S. Murdoch, Jose Palma-Oliveira, Roger S. Pulwarty, Dale Sands, Jeffrey Taylor, Edward A. Thomas, Mari R. Tye, David Woods.

that can be integrated in the existing regulatory processes. Comprehensive approaches to assess resilience at appropriate and operational scales, reconciling analytical complexity as needed with stakeholder needs and resources available, and ultimately creating actionable recommendations to enhance resilience are still lacking. Our proposed structure consists of tiers by which analysts can scale a resilience assessment and associated management actions relative to the scope and urgency of the risk and the capacity of resource managers to improve system resilience.

Metrics

We view resilience management through a framework for making decisions with respect to how to maintain critical functions and services during and after a disruptive event- something that a tiered approach to resilience management must directly account for. Each tier of the approach manages uncertainty with increasing levels of precision (Figure 1). These include:

i. by identifying tools that do simple ranking at a screening-concept level (Tier I),
ii. to those that quantify based on metrics and performance in a systems model (Tier II),
iii. and finally methods to represent uncertainty probabilistically (Tier III).

The benefits of the approach are that each tier has a set of actionable items, but users can also move incrementally between the tiers as more detailed analysis is needed. Users can assess their system at each level, incorporate available data and stakeholder input, and then determine if the model employed is sufficiently accurate to describe the system and scenario. The tiered approach enables users to extract a range of responses from basic but practical, to sophisticated and predictive, in an effort to quantify the tactical steps needed to enhance resilience. Groups that seek an integrated strategy for assessing and communicating resilience, one that incorporates science into decision-making while working with limited funding, data, and timelines, may find this tiered approach yields a practical means of addressing pressing issues in a changing climate.

The goal of Tier I is to quickly and inexpensively identify the broad functions that a system provides to human society or the environment as well as the general pathways of system failure and change in performance over time following a disruptive event. Analytically, this framing and characterization analysis makes use of existing data, expert judgment, and conceptual models. Tier I considers type, frequency and intensity of shock events to define possible vulnerabilities and seeks to identify the major social-ecological-technological properties of the system. The decision of how to proceed is based on a conceptual model of the system with the following characteristics: simple system representation, easy consensus on major criteria from stakeholders, retrospective in considering historical records, and conservative in assumptions about the future.

The goal in Tier II is to describe the system or systems with more detail using a fundamental—but often still deterministic— model and observational data. Such a model can be used to compare resilience management alternatives that are not mutually exclusive to obtain the best outcome across the system. The conceptual model developed in this phase has increased fidelity in terms of representing infrastructure systems, ecosystems, and social institutions. Of course, introducing a more realistic model can also raise issues regarding how these components are represented; thus a comparative analysis is needed to illustrate tradeoffs between different representations. In this tier, we start to explicitly quantify model parameters and assess these tradeoffs.

The primary objective of Tier III is to develop a detailed model for the sub-systems that support those critical functions that are most sensitive to the threats of concern. The approach should consider interactions in ecological and technological components of the system along with an analysis of the impact of management decisions on affected social institutions and vulnerable populations. In this tier, stakeholders are central to framing the criteria, weighting of parameters and validating the model. Here a full range of scenarios can be tested to better understand system performance in an uncertain future, as the model only requires the mode of failure, not the cause. Tier III has internal feedbacks, it can be prospective in predicting how resilience may change given different system configurations under chronic and episodic shocks.

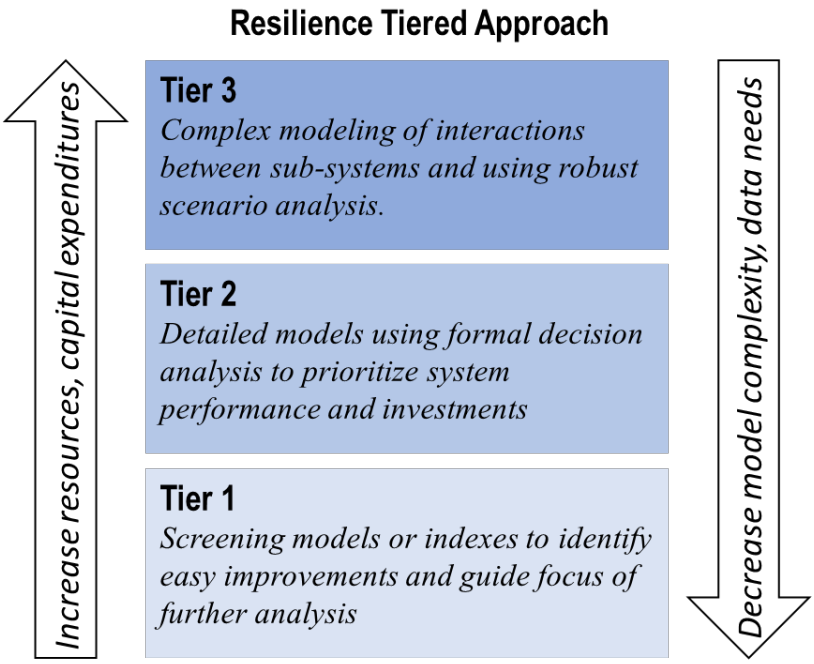

Figure 1: Overview of tiered approach to resilience assessment

Discussion

The benefits of the approach are that each tier has a set of actionable items so that users can move incrementally between the tiers as needed. Users can assess their system at each level, incorporate available data and stakeholder input, and ultimately determine if the model employed is sufficiently accurate to describe the particular system and scenario at hand. The tiered approach enables users to extract a range of responses from basic but practical, to sophisticated and predictive, in an effort to quantify the tactical steps needed to enhance resilience. Overall, stakeholders that seek an integrated strategy to assess and communicate resilience may find this tiered approach yields a practical means of addressing pressing issues in a changing climate.

Annotated Bibliography

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This document details The Sendai Framework which was approved by the United Nations in 2015. The Sendai framework seeks to improve understanding of disaster risk and support disaster resilience.