



# BUILDING BLOCKS FOR A NATIONAL RESILIENCE ASSESSMENT

## ABSTRACT

This study reviews existing literature and consults resilience experts to extract best practices to develop and conduct a national level assessment of resilience. The study revealed that many tools are available and many more emerging. They are intended for a broad spectrum of applications and purposes and represent a diverse set of capabilities. Therefore, one tool to assess resilience is not practical, but a common framework for resilience is essential. Multi-component frameworks seem to hold the most potential for providing value to a broad spectrum of users/applications for regional or national fiscal, planning and policy type issues. The process to build a national scorecard can take decades, but the process itself generates important dialogue. If done right, it can be a catalyst for changing behavior. The major goal, and equally major challenge, for a national scale resilience methodology is for it to be simple and affordable enough to be used, yet sophisticated enough to be relevant for the applications at hand.

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**COASTAL HAZARDS CENTER**

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# Building Blocks for a National Resilience Assessment

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## Building Blocks for a National Resilience Assessment

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## **Building Blocks for a National Resilience Assessment**

### **I. An Urgent Call for Resilience**

What is driving this new emphasis on resilience? In a world of growing disruptions and rising complexities, now more than ever there is a need to address the sustainability of our planet, and one path with significant potential is through the lens of resilience. One of the grand challenges of this century will be to ensure that the economic stability, natural resources, and social fabric of our world's communities are not compromised for future generations in the face of externalities putting them at risk. Communities around the world are in jeopardy of significant property damage, social disruption, and loss of life from the increasing risks associated with natural and man-made hazards.

The research conducted re-emphasizes the close relationship between resilience and sustainability. While they are considered different initiatives, they also have much common ground, especially with respect to their consideration of the social, environmental and physical aspects of our world. They appear to be two sides of the same coin with similar themes and complimentary objectives. One cannot exist without the other.

To this end, there is a growing emergence and intrigue with resilience among many circles of practice. Scientist, engineers, sociologists, emergency managers and agency administrators alike are migrating to resilience as a conceptual framework for integrating the domains of socio-cultural, economic, environmental, built and institutional systems of which communities depend upon to be sustainable in the face of escalating and more frequent risks.

Compounding the risks associated with natural and man-made hazards are changing demographics, aging infrastructure, climate change, economic security, ecological and human health vulnerabilities, and the competing demands for energy and natural resources. The urgency to better understand and quantify resilience is based on:

- Rising frequency and cost of disasters
- Increasing vulnerability of our most valued assets
- Growing need for thoughtful and timely recovery from hazardous events
- Limited investment in mitigating risk
- Narrowing options faced by our society

Disaster resilience, as adopted by the National Research Council (NRC) Committee report “Disaster Resilience: A National Imperative,” (NRC 2012) is the “ability to prepare and plan for, absorb, recover from or more successfully adapt to actual or potential adverse events.” This is an important conceptual advancement for a nation that dominantly invests in recovering from disaster events instead of adequately preparing for them and minimizing the losses, and the effort required to recover. It also allows the engineering profession to view its role in protecting the well-being of society through the lens of communities and their priorities.

Further, this move toward resilience is driving a need to characterize and measure it. As characterized by Dr. Susan Cutter of the University of South Carolina, a long-time leader in resilience and social vulnerability, there are two fundamental types of resilience tools, bottom-up and top-down. The bottom-up tools provide assistance to communities in identifying their vulnerabilities, what types of capabilities they have in place and those that need enhancement or creation to build their capacity to recover from both chronic and acute disruptive events and measure their progress. These range from self-help lists of questions to expert facilitated processes that involve more sophisticated analyses. The key is that the community is intimately involved in the analysis and defining resilience needs and goals. These tools best lead to plans and actions on a community’s part.

Top-down tools tend to provide a more strategic perspective of the resilience of an area or region based on information mined from available data bases (local, state and national). They allow comparisons among communities or regions and are best for stimulating conversations about resilience, creating dialogues among stakeholders, and supporting policy development and decisions. They are less effective with creating actions at the community level. The ideal would be to aggregate bottom-up data to regional and national scales to create the strategic perspective. However, the challenges of data availability and uniformity as well as the important individuality of needs and situations of communities has made this impractical to date.

This study provided an insight to the numerous and varied agencies and organizations that are engaged in disaster resilience. It examined a number of examples across the spectrum of resilience tools and measures that are under development or available and how they are being applied with an eye to creating a holistic framework for an effective national scale resilience scorecard.

## **II. A Study in Measuring Resilience**

### **A. Study Objectives**

In the face of a growing population, infrastructure deterioration, and the increasingly severe impacts of natural hazards, many of which are exacerbated by climate change, cities across the globe, including many in the United States, are in jeopardy of significant threats to public health and safety, property damage and community disruption (Hallegatte et al, 2013). This project sought to identify and evaluate the building blocks needed to develop a national resilience assessment that could assist in analyzing the health and vulnerability of our nation to natural and man-made hazards. The primary lens for this analysis was examination of existing and emerging methodologies that qualitatively and quantitatively assess resilience and the on-going applications of those tools. By reviewing the current state-of-practice, multi-disciplinary, multi-agency research and literature on resilience, and soliciting the expertise of subject matter experts, the study sought to identify the most promising attributes or characteristics, existing practices, or procedures that can be used to assess resilience, with particular attention to a national scale.

The first objective was to identify and assess the applicability and usability of existing resilience assessment methodologies in developing a local or national resilience scorecard. The concept was to review and have a broad discussion of the many kinds of rating schemes, scales, and methods being applied or developed to assess resilience or resilience-related factors, to understand their fundamental strengths and limits, and develop a perspective on what characteristics are most relevant to the local scale and to the national scale. The second object was to identify best practices and/or gaps in existing tools and recommend a path forward to inform the development a national resilience scorecard.

### **B. Study Approach**

The study objectives were achieved through a literature review, interviews and a subject matter expert workshop. Using the literature and the workshop, the first step was to examine other international, national or regional scorecard and/or assessment tools, outside of, but perhaps similar to resilience, to determine best practice. The second step was to examine and characterize the capabilities of existing and emerging resilience indices, metrics and assessment tools to understand their inherent uses, capabilities and capacities. The third step was to identify similarities and differences and determine if existing tools designed for communities or specific sectors could provide building blocks for a quality and relevant national resilience scorecard tool.

The research examined and considered end-user needs and requirements and expected assessment outcomes along with the data or input needs, the measured outputs and analytic approach taken in developing each of the tools that were reviewed. The workshop provided invaluable insights to the highly variable needs and requirements of quantifying and measuring

resilience and identified components and architectural features of methodologies that showed the most promise in developing a national resilience scorecard.

### C. Workshop Organization and Participants

A significant portion of the information described herein was presented and discussed at the workshop accompanying this study sponsored by the U.S Department of Homeland Security Science and Technology Directorate's Coastal Hazards Center of Excellence and hosted by the Center for Disaster Resilience, Department of Civil and Environmental Engineering, University of Maryland, on April 14-15, 2015. The workshop aimed to identify and characterize the steps needed to develop a national resilience assessment for analyzing the health and vulnerability of the nation to natural and manmade disasters.

The "Building Blocks for a National Resilience Scorecard" workshop brought together more than 35 resilience experts across government, industry and academia. The workshop included representatives from seven federal agencies and offices, three state agencies, four non-profits, four universities, and four consulting firms. During the workshop, participants outlined best practices, user perspectives and examples of key resilience tools, and broke into discussion groups to identify desired outcomes for a resilience scorecard. The questions that drove the discussions were:

- 1) Why might we need a national scorecard?
- 2) What objectives would we hope to accomplish with such a tool?
- 3) How (and by whom) can this best achieved?

The agenda provided ample opportunity for participants to share information and contribute to discussions in three panels and breakout sessions. Following presentations on national assessments and best practices, participants discussed the attributes, challenges and opportunities associated with users and sponsors, and the inputs, outputs and analytics associated with national assessments. The second part of the workshop, provided an end-user perspective on what is needed for a resilience scorecard and how it should be administered. Federal and state agency representatives gave an overview of their activities and needs regarding assessing resilience. The breakout focused on the objectives, key metrics, and spatial and temporal scales from the various user perspectives. The last panel drilled down to specific tools being developed, piloted and used. The workshop highlights included an excellent overview of resilience metrics and tools by Dr. Susan Cutter, University of South Carolina and a compelling summary of discussions and call for action by Dr. Gerry Galloway, UMD and both members of the National Academies Round Table on Disaster Resilience. The synthesis of results in Chapter IV encapsulates the essence and key results from the workshop. A complete list of attendees and the agenda is provided in Appendix A.



### III. Investigation and Analysis

#### A. Review of Agency and Organizational Efforts

##### Agencies and Organizations

Many federal agencies, including National Institute of Standards and Technology (NIST), United States Army Corps of Engineers (USACE), National Oceanic and Atmospheric Administration (NOAA), Federal Emergency Management Agency (FEMA) and Environmental Protection Agency (EPA), are building resilience into their mission areas and programs or leading initiatives addressing interagency requirements. Many are engaged in developing, piloting and applying specific disaster resilience tools that will assist them in their missions.

Further, non-governmental and international organizations such as National Research Council (NRC), American Society of Civil Engineers (ASCE), The Nature Conservancy (TNC), the Rockefeller Foundation and the United Nations Office for Disaster Reduction's International Strategy for Disaster Risk (UNISDR), are also engaged in resilience activities many of which involve development of metrics or tools. States such as Maryland, New Jersey, New York and Vermont have also been developing and applying resilience tools. (See Appendix B).

The reasons driving measuring or quantifying resilience are many, but most agency and organizations are typically developing their assessment tools to measure the effectiveness or value of resilience as it relates to specific mission or organizational needs. The composition and delivery of the assessments can vary depending on whether their mission or organizational perspective is based on say a community safety requirement, conservation or preservation of ecosystems, or perhaps the need to manage infrastructure. Whether federal or non-federal, the tools may be designed to relate to a specific hazard such as earthquakes (San Francisco Planning and Urban Research, SPUR, Resilient Cities Initiative), flood risk (FEMA's Community Rating System) or hazards related to climate change (NOAA's Coastal Resilience Index) or are disaster independent, like Baseline Resilience Indicators for Communities (BRIC).

##### Agency and Organizational Drivers

Given the urgency to ease the cost of disasters and the long recovery that accompanies them, a number of studies, policies and directives have emerged from the Executive Branch, Congress and others regarding resilience. Many of the federal agency initiatives are driven by White House initiatives and executive orders related to climate change and disaster resilience.

**The President's Climate Action Plan (Jan 2013)** established several directives toward resilience. The plan directs NIST to "convene a panel on disaster-resilience standards to develop a comprehensive, **community-based resilience framework** and provide guidelines for consistently safe buildings and infrastructure—products that can inform the development of private-sector standards and codes." As another initiative under the plan, the White House launched a **Climate Preparedness and Resilience Toolkit**, a website to help communities improve their resilience to climate change ([toolkit.climate.gov](http://toolkit.climate.gov).) Also, under the Climate Action

Plan, at the direction of the Council on Environmental Quality (CEQ), an advisory **Insurance Industry Roundtable** was formed to explore national approaches to measuring and influencing climate change<sup>5</sup>.

([www.whitehouse.gov/sites/default/files/image/president27climateactionplan.pdf](http://www.whitehouse.gov/sites/default/files/image/president27climateactionplan.pdf))

**Executive Order 13653, “Preparing the US for the Impacts of Climate Change” (Nov 2013)**

established the Council on Climate Preparedness and Resilience, an interdepartmental federal council which in turn established four priority strategies for making the Nation’s natural resources more resilient to climate change. (“Priority Agenda: Enhancing the Climate Resilience of America’s Natural Resources,” Oct 2014) The Priority Agenda calls for the design of an Ecosystem Resilience Index to track the progress of restoration and conservation actions on natural resource management. Agencies engaged in this are FEMA, NOAA, USACE and the Department of Transportation (DOT). Further, this is to be coordinated with the NIST efforts on developing a community resilience planning guide and other related White House initiatives.

([https://www.whitehouse.gov/sites/default/files/docs/enhancing\\_climate\\_resilience\\_of\\_american\\_natural\\_resources.pdf](https://www.whitehouse.gov/sites/default/files/docs/enhancing_climate_resilience_of_american_natural_resources.pdf))

**Presidential Policy Directive 21, Critical Infrastructure Security and Resilience (2013)** calls for a clarification of functional relationships across government and unity of effort in strengthening critical infrastructure security and resilience. DHS was given overall responsibility for leading and collaborating with public and private sectors to prevent and respond to attempted disruptions. Key actions under the directive are to create real-time situational awareness of infrastructure failures, update the National Infrastructure Protection Plan, understand the cascading impacts of failing infrastructure and develop a comprehensive R&D plan.

(<https://www.dhs.gov/sites/default/files/publications/EO-13636-PPD-21-Fact-Sheet-508.pdf>)

**Presidential Policy Directive 8, National Preparedness (2011)** established five frameworks for preparedness: Protection, Prevention, Mitigation, Response and Recovery. Following Hurricane Sandy, the President directed that the **Hurricane Sandy Rebuilding Task Force** be formed within the National Recovery Framework to coordinate a better recovery (HUD 2014). Within the national rebuilding strategy that resulted, a key goal was to ensure the region was rebuilt in a way to make it more resilient against future storms and climate change. A recommendation from that report directs DHS and the National Security Council (NSC) to take the lead in assessing the feasibility and value of applying a coordinated resilience policy at a national level.

(<http://portal.hud.gov/hudportal/documents/huddoc?id=HurrSandRebStratPRF2014.pdf>)

Concurrent with the development of the frameworks and operating procedures for the PPD 8, nine federal agencies and organizations sponsored a study by the **National Research Council** on resilience that culminated in the 2012 report cited above, “Disaster Resilience: A National

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<sup>5</sup> Factsheet as provided by Kathleen Boyer of FEMA: FEMA-NOAA Fact Sheet “National Community-Level Climate and Hazard Resilience Indicators,” 2014

Imperative.” That report recommended that it was important to have a quantitative measure of assessing resilience to prioritize needs, monitor changes and track progress. Further, it recommended that DHS lead the development of a National Resilience Scorecard in partnership with other federal agencies, state and local partners and professional organizations. The NRC report continues to provide fundamental guidance to the federal agencies in executing White House directives (NRC 2012).

**Congress** has also taken a keen interest in resilience and has introduced numerous draft legislative bills on electric grid resilience<sup>6</sup>, resilience to extreme events<sup>7</sup>, incentives for resilient construction<sup>8</sup>, drought resilience<sup>9</sup> and the like. Little has been passed in those regards though the importance of national resilience as it relates to the federal budget and national economy and security is front and center in many congressional offices and committee discussions in both chambers.

### **Agency and Organizational Efforts at the National scale**

Described below are highlights of some of the agency and/or organizational efforts that are being conducted regarding resilience and in particular efforts toward measuring it. This is only a subset of the many numerous ongoing efforts and is not intended to represent or imply coverage of all activities.

**DHS** through its Science and Technology (S&T) and Infrastructure Protection Divisions have developed a tool box, the Building and Infrastructure Protection Series Tools which contains rapid screening publications and software to assess risk and mitigate multi-hazard events<sup>10</sup>. Also, under the direction of PPD 21, DHS S&T is leading the effort to develop a comprehensive critical infrastructure security and resilience research and development plan that will help align federal efforts. The effort was still in development at the time of publication of this report. Further, under various DHS components, numerous resilience activities have been funded. Several are described below and listed in Appendix B.

**FEMA** has been working to identify a set of climate and hazard resilience indicators that give a national perspective of community-level resilience. Directed by the Council on Environmental Quality and driven by the Insurance Industry Roundtable, the effort is looking within existing federal programs at their roles in resilience to develop these indicators with a goal of ensuring they are federally actionable and supported by available data. The key factors will be built around economic, physical, societal and ecological parameters of resilience. (The effort was still in review at the time of publication of this report.) Their efforts are further codified through the 2014-2018 FEMA Strategic Plan. Within the plan, Strategy 4.1.2 established that a risk and

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<sup>6</sup> <https://www.congress.gov/bill/114th-congress/senate-bill/1243/text>

<sup>7</sup> <https://www.congress.gov/bill/113th-congress/house-bill/2322>

<sup>8</sup> <https://www.govtrack.us/congress/bills/113/hr2241>

<sup>9</sup> <https://www.govtrack.us/congress/bills/114/hr1710>

<sup>10</sup>For more information see DHS website for Building and Infrastructure Protection Series - <http://www.dhs.gov/building-and-infrastructure-protection-series-tools-0#>

threat exposure model be developed to measure the performance of risk reduction activities at the community and national level. (<http://www.fema.gov/media-library/assets/documents/96981>)

As directed by the President's Climate Action Plan to develop a community-based resilience framework, **NIST** has conducted five workshops around the country, and recently released "Community Resilience Planning Guide for Buildings and Infrastructure Systems." The focus of the planning guide is on the built environment, but from the perspective of community needs for resilience. The guide considers societal needs, building and infrastructure lifelines performance goals, emergency communication systems and plans, and communications and economic factors. ([www.nist.gov/el/building\\_materials/resilience/guide.cfm](http://www.nist.gov/el/building_materials/resilience/guide.cfm))

**NOAA**, as part of the many climate preparedness and resilience initiatives, has been working alongside its federal partners and stakeholders to help foster resilient coastal communities. In partnership with the Gulf of Mexico Alliance, EPA, Sea Grant and others, NOAA has administered a large number of community resilience pilot assessments along the Gulf Coast using the Coastal Resilience Index. This index is a bottom up self-assessment tool for community leaders, facilitated by trained professionals (see section below for more information). Using a partnership approach with other agencies and organizations such as TNC, Association of State Floodplain Managers (ASFPM) and USACE, NOAA's efforts include a number of coastal resilience initiatives.

**USACE** has been an active interagency participant in many resilience initiatives, many of which were driven by post Hurricane Sandy recovery. As part of the Disaster Relief Appropriations Bill, 2013, (<https://www.congress.gov/113/plaws/publ2/PLAW-113publ2.pdf>), USACE was directed to lead a large regional study, the North Atlantic Coast Comprehensive Study (NACCS). While this study does not explicitly develop a resilience index, it does follow a process and include many elements similar to regional or national resilience assessments. The study, conducted a coastal storm hazard assessment to develop a Risk Index applied at study reaches within nine states and the District of Columbia in the North Atlantic area. In addition to examining the hazard, a Composite Exposure Index was determined that included population and infrastructure density, social vulnerability and environmental and cultural resources. By examining risk and exposure, risk reduction and resilience options could be tailored to fit the needs of the region or local project. The report develops a tiered framework for conducting studies at a large regional scale down to a local scale. (USACE 2015).  
[http://www.nad.usace.army.mil/Portals/40/docs/NACCS/NACCS\\_main\\_report.pdf](http://www.nad.usace.army.mil/Portals/40/docs/NACCS/NACCS_main_report.pdf)

Recently, the USACE announced a Resilience Strategy aimed at mainstreaming resilience in both its Military and Civil Works programs. The strategy is designed to imbed the key principals of resilience: prepare and plan, absorb and withstand, recover and adapt, within the business and decision-making and design functions of the Corps.<sup>11</sup> As part of, and concurrent with this strategy, the USACE Engineer Research and Development Center (ERDC) is developing an R&D

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<sup>11</sup> Per discussion with Sheri Moore, USACE HQ, April 2015.

roadmap for assessing resilience. By developing a three-tiered analysis approach to quantify resilience, from easily applied to more robust, they are building resilience assessment tools to help support planning, engineering and design and operations and maintenance activities of the Corps. Going beyond expert elicitation, these tools model the fragility of systems and their ability to rebound (See Shultz, et al. 2012 and Linkov, et al., 2014). The tools are still under development, but have been piloted at two coastal communities and reviewed at a special workshop of the National Academies.

Beyond the federal program initiatives, many national and international activities by both private industry and non-profits have been working to increase resilience and build measures for assessing it. There are too many to describe in this study, but here are just a few.

**The National Academies**, based on the rising importance of resilience and the success of the National Research Council 2012 Report, *Disaster Resilience: A National Imperative*, are now embarked in an unusual activity for the Academies; a community-focused outreach program to help build resilience to extreme events. The *ResilientAmerica* program sponsored by the Resilient America Roundtable, included a workshop on measures of community resilience in September 2014 and now has expanded to four pilot project communities and online learning to reach a broader audience (<http://sites.nationalacademies.org/PGA/resilientamerica/>). While the NRC report highlighted the importance of a national assessment, the program is more of a bottom-up approach to increasing resilience at the community level.

**The United Nations**, in addition to the United Nations Office for Disaster Reduction's International Strategy for Disaster Risk (UNISDR)'s 10 Essentials Resilient Cities tool, described below and in Appendix B, is also part of an alliance between business, public sector, investors, insurance, civil society and education in a program called RISE. This effort is in response to global risk challenges and seeks to promote risk-sensitive investments around the world. ([www.theriseinitiative.org](http://www.theriseinitiative.org))

**The Rockefeller Foundation** has been a key player in building resilience internationally by providing support and leadership in numerous programs, including 100 Resilient Cities (<http://www.100resilientcities.org/resilience#/-/>). The Rockefeller Foundation with Arup International Development developed a City Resilience Index. This index has four key categories, 12 indicators and many more sub-indicators and variables. The four categories are 1) health and well-being of individuals- people, 2) Infrastructure and Environment- place, 3) economy and society- organization, and 4) leadership and strategy- knowledge. The index is being used to determine what matters most to communities participating in 100 Resilient Cities, to establish a baseline and to develop an agenda to be more resilient. (<https://assets.rockefellerfoundation.org/app/uploads/20150530121930/City-Resilience-Framework1.pdf>)

### **Agency and Organizational Needs and Perspectives**

As seen from the sampling of various perspectives above, the sponsors and developers of resilience assessment tools have a broad set of needs and requirements. Based on the analysis of the literature and discussions with resilience experts at the workshop and elsewhere, the observations regarding perspectives and needs are captured in the following discussions:

Resilience actions can be driven by federal, regional, state and local policies, but those actions have the most impact on the communities which must implement them. Therefore, any scorecard development and use must consider the cohesiveness of the community and its organizational structure. It must involve the community and its leadership. While it can take years or even decades to target and fund the best measures that lead to action, the process provides value. Building a scorecard or assessment can provide an opportunity to raise awareness and educate the public about resilience.

Perhaps an even more important perspective, is to focus on actions that can be done prior to a hazardous event. Many governmental and organizational dollars arrive after a disaster occurs. This results in more dollars expended and often leads to building back quickly to pre-event conditions. A better strategy would be to invest resources in pre-disaster and mitigation planning, capacity building and mitigation measures that reduce the impacts and high cost of disaster. Agency initiatives under the National Mitigation Framework and National Disaster Recovery Framework recognize the importance of breaking the cycle of costly disasters through pre-disaster recovery planning and mitigation projects.

A common framework for resilience and for reporting success does not exist even though agencies and organizations are collaborating. Agencies are actively exploring what is needed to incorporate resilience into their missions and programs, but because of different mission or applications focus, it is difficult to create consistency. A common framework should be logical, help tell the story of resilience and measure progress. Categories, elements or indicators of an assessment tool should be selected with the community in a way to provide meaning and inspire action. However the number of categories must be manageable. The ultimate goal of a resilience framework should be to assist communities to bounce back better from a disruption while looking forward at tomorrow's challenges.

The outcome or value of an assessment is critically important. It should reflect what is trying to be achieved: reduce risk, track action, drive sound investment strategies, influence policies, etc. Objectives of a scorecard should: identify common outcomes/values, be scalable, address acute and chronic events, have a common vision, be measurable, characterize long term gains and embrace innovation and resourcefulness. The tool should incentivize action, and be simple to use, but complex enough to be relevant.

An assessment must support the user's mission. The major lens from which a tool is developed is dependent entirely upon user need and how they define or perceive resilience. This can lead to multiple approaches by different agencies or stakeholders involved in developing and applying resilience information. This is a similar issue to that found in risk assessment methods and applications. For instance, the USACE and NIST efforts are focused more on the role of

critical infrastructure on resilience with the community perspective as a major consideration. A different tact might be taken by NOAA and EPA where they are more focused on ecosystem and community or organizational resilience. FEMA is defining the role of resilience through its programs that provide flood insurance, grants and emergency management. Private industry, such as insurers or investors, may look at it strictly from an economic recovery perspective. Given these differences, a mission-relevant tool may differ from a general nationally relevant tool.

Because there are significantly different needs for resilience information at local and national scales, one resilience assessment or rating method will not satisfy these different needs. The complexity of the analysis must be commensurate with the ability of the user and the need for its use. At a national scale, the geographic challenges for managing data inputs and outputs may require a simple analysis process. But to address a specific requirement such as assessing the resilience of an infrastructure system may require very specific data and complex analysis tools. A tiered approach to resilience assessment is attractive because it can provide relatively easy to assemble big picture information that leads or triages the need for a more detailed analysis. Workshop participants agreed that coupling or relating bottom-up with top-down information would be ideal, but difficult to achieve. Nested information and analysis that is scalable is also ideal, but may not be practical.

Beyond programmatic and mission differences, data inputs may be the single biggest challenge with respect to consistency and compatibility. Time and spatial scales are critical to the utility of resilience information to different users and drives the diversity in resilience assessment methods and data outputs. The ability to project resilience forward in time is important for life-cycle strategies and investments.

Partnerships are critical. The most successful application of tools has been when partners align their resources and capabilities. Federal agencies are working at partnering, but the drivers and dynamics are evolving quickly making it difficult to stay coordinated.

The programmatic success of a tool is tied to a number of factors. First, the assessment should inform programmatic performance and accountability. By identifying the relative need for resilience, the assessment should be usable by decision makers to prioritize approaches and specific project investments. The assessment should capitalize on the approaches and project alternatives that are often identified in state and local mitigation plans. Though often driven by an organization's ability to resource the assessment, time and cost must be considered when building and managing an assessment tool. The cost must include what it costs to build, implement and maintain the tool over an actionable and measurable life span.

The assessment should have a transparent and credible validation. Uncertainties should be stated and results validated. Using an advisory board or having an external assessment might be a way to achieve this.

## B. Review of National Assessment Tools

The question of a national resilience assessment is one that explores every avenue of the developing field of resilience. It would be imprudent to begin a journey towards a national resilience assessment without first examining prior efforts to create national level assessments for related purposes or objectives. The objective of this examination is to discover what constitutes “best practice” for this domain. The purpose of the definition of best practice is to incorporate those capabilities into the effort to develop a resilience scorecard. Since a national resilience scorecard or assessment method does not currently exist, it is necessary to examine methods that were designed for other purposes, but provide the opportunity to assess attributes that have made them successful. For the purposes of the workshop, a few key methodologies were highlighted to stimulate discussion concerning laudable attributes. While other methodologies were also considered and examined, these represent a characterization of a spectrum of successful national scale assessment capabilities. Appendix B provides a summary table of the national assessment methods examined for this study.<sup>12</sup>

### Institute for Sustainable Infrastructure Envision™ Infrastructure Sustainability rating system

The Institute for Sustainable Infrastructure (ISI) is a 501 (c) (3) not for profit organization, structured to develop and maintain a sustainability rating system for civil infrastructure. That system, called Envision™ ([www.sustainableinfrastructure.org](http://www.sustainableinfrastructure.org)), is a collaboration between ISI in Washington, D.C., and the Zofnass Program for Sustainable Infrastructure at the Graduate School of Design at Harvard University, Cambridge, Massachusetts. ISI was founded by the American Council of Engineering Companies (ACEC), the American Public Works Association (APWA), and the American Society of Civil Engineers (ASCE).

The Envision™ Rating System is an in-depth planning guide and rating system to improve the sustainability aspects of infrastructure projects. It includes a guidance manual and online scoring system and there is no cost to download or use for project planning and self-assessment. There is an optional independent, third-party review, called verification, offered by ISI which qualifies projects to become eligible for recognition and awards.

Envision™ has 60 sustainability criteria, called credits, arranged in five categories that address major impact areas. The categories are Quality of Life, Leadership, Resource Allocation, Natural World and Climate and Risk. It provides a mechanism to integrate the information and insights gained from application of more specific rating systems such as LEED for buildings, INVEST for roads and Sustainable Sites for landscapes into a more overarching perspective of sustainability. Since its launch in 2012, over 350 projects have applied Envision™ as a self-assessment tool and a number of projects have moved to the third party verification stage. An example of the self-assessment projects is application of the rating system to airports for which ISI has available a webinar available on their web site (<http://www.aci-na.org/content/now->

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<sup>12</sup> Note: In these discussions, and in the literature and conversations concerning resilience, there exists a relatively loose usage of terms such as metrics, measures, tools and methods. This effort has not tried to standardize these semantics, but rather attempts to be faithful to the dialogue that is representative of the latest discussions on each item and topic covered.



available-envision-sustainable-infrastructure-rating-system-webinar-recording-and-presentation). An example of a project advancing to the verification stage is Los Angeles County's Sun Valley Watershed Project (<http://www.estormwater.com/los-angeles-county-s-sun-valley-watershed-project-receives-envision-platinum-award>).

For more information concerning ISI or Envision™ see: [www.sustainableinfrastructure.org](http://www.sustainableinfrastructure.org)

#### Attributes:

1. Examines projects through lens of five major categories (impact areas) to capture multiple dimensions of sustainability
2. User guidance and on-line capabilities allow self-evaluations
3. Formal verification and certification process in place
4. Awards provide incentive to succeed.

#### Challenges:

1. Project orientation is indirect translation to communities but provides a framework for making consistent investments.

#### ASCE Infrastructure Report Card

Perhaps one of the most credible, comprehensive and consistent beacons of the status of civil infrastructure has been the American Society of Civil Engineers Infrastructure Report Card. Initialized in 1998 as a continuation of an initial assessment made in 1988 and published in the National Council on Public Works Improvement report, *Fragile Foundations: A Report on America's Public Works*. The ASCE goal for the Report Card is to educate the public and raise awareness of the status of the nation's civil infrastructure. The report card is released in phase with the presidential election cycle.

ASCE has a committee of about 30 engineers who manage the Report Card update process which takes approximately 18 months. Infrastructure is examined in 16 sectors that are shown in the table below which shows the ratings for each Report Card since the inception in 1998. Federal and State information bases are a key source for information for the Report Card process. These data include condition and performance reports, industry group opinions and analyses, capacity and safety reports, financial and budget information concerning budgets for maintenance and repair of infrastructure in each sector (See Table 1). The ultimate grade is weighted heavily on current condition and programmed infrastructure budgets. Individual State organizations are now beginning to do Report Cards for their state's infrastructure using the same process as the ASCE national Report Card Team. The results are presented through the ASCE web site and the national media. An on-line APP is available to assist with access to the underlying data and analysis that is the underpinning for the grades assigned. ([www.asce.org](http://www.asce.org))

Table 1

	ASCE Infrastructure Report Card Grade Trends *				
Infrastructure Sector	1998	2001	2005	2009	2013
Aviation	C-	D	D+	D	D
Bridges	C-	C	C	C	C+
Dams	D	D	D	D	D
Drinking Water	D	D	D-	D-	D
Energy Grid	-	D+	D	D+	D+
Hazardous Waste	D-	D+	D	D	D
Inland Navigable Waterways	NR	D+	D-	D-	D-
Levees	NR	NR	NR	D-	D-
Ports	NR	NR	NR	NR	C
Public Parks and Rec	NR	NR	C-	C-	C-
Rail	D-	NR	C-	C-	C+
Roads	F	D+	D	D-	D
Schools	C-	D-	D	D	D
Solid Waste	C-	C+	C+	C+	B-
Transit	D+	C-	D+	D	D
Waste Water	NR	D	D-	D-	D
Overall Grade	D	D+	D	D	D+
Cost to Improve	-	\$1.3 T	\$1.6 T	\$2.2 T	\$3.6 T

Source: ASCE \*[www.infrastructurereportcard.org](http://www.infrastructurereportcard.org)

For more information on this procedure, see: [www.asce.org](http://www.asce.org)

#### Attributes:

1. Simple and readily understood metric, grades A - F
2. Comprehensive method to generate repeatable and consistent results
3. Use of Categories (16 specific Infrastructure sectors) gives more detailed perspective on metric and greater context to users.
4. Web site provides analysis and recommendations that provide context to the grades in terms of cost to upgrade infrastructure and types of opportunities that may be appropriate.
5. Supported by a major national professional society, providing credibility and proponentcy.
6. On-line App provides access to underpinning data.

#### Challenges:

1. Not readily scalable below state levels (not applicable for map product)
2. Requires significant external assistance and expertise
3. Simple metric shields more detailed perspective of issues
4. Narrowly focused on infrastructure, not other elements of resilience (economic, environmental, and social)

#### Community Rating System

The Community Rating System, CRS, was initiated in 1990 by FEMA as an incentive for communities to achieve higher floodplain management standards. The reward for participating is lower federal flood insurance rates. CRS was modeled after building code rating methods using 90 separate elements to characterize 19 different activities that aggregate to four series.

The CRS process is highly quantitative, based on empirical data. FEMA has 16 field specialists that meet with communities and facilitate the rating process. They collect and verify data as well as executing the rating process. Communities are required to have significant documentation concerning implementation of new floodplain management actions. There is a large manual on the process but it is not a self-help activity.

Communities can get credits for a variety of activities and factors in place to facilitate more effective floodplain management. This includes outreach, open space, low density zoning, and aggressive drainage management.

There are approximately 22,000 communities participating in the National Flood Insurance Program, with only 1300 of these involved in the CRS. However, approximately 70% of all flood insurance policies are vested in CRS communities. The participation rate points out the challenge of achieving broad participation in a sophisticated assessment process that requires a significant amount of time and resources from the community.

For more information, see: [www.fema.gov/national-flood-insurance-program-community-rating-system](http://www.fema.gov/national-flood-insurance-program-community-rating-system)

#### Attributes:

1. Quantitative and rigorous
2. Standard process creates uniformity on data and analysis
3. Incentivizes good decision making
4. Guided by single agency, FEMA

#### Challenges:

1. Limited scope of involvement
2. Requires bottom-up data generation by community and FEMA
3. Significant community resources needed to participate

#### 4. Flood-centric focus

##### America's Rivers Initiative

The America's Watershed Initiative is facilitated by The Great Rivers Partnership which brings together diverse stakeholders and best science to work toward sustainable management and development of the world's most critical river systems. Founding partners include Caterpillar Foundation, Global Environment Facility, Ingram Barge Company, International Commission for the Protection of the Danube River, Monsanto Company, The Nature Conservancy, the McKnight Foundation, U.S. Army Corps of Engineers, the U.S. Geological Survey, World-Wide Fund for Nature, and the China's Yangtze River Basin Fishery Resource Management Committee. Earlier versions of this approach were used in Australia and the Chesapeake Bay. Current focus is on the Mississippi River Basin.

The ARI Report Card process uses 6 major goals or categories to incorporate the major factors that are examined for the resulting grade. These include Ecology, Recreation, Flood Control, Transportation, Water Supply, and Economy. Each of these categories is characterized by multiple measures. For example, Flood Control considers levee condition, number of people at risk (living in Special Flood Hazard Areas), and community preparedness (number of communities in NFIP and CRS). Current report card ratings are available for the Upper Mississippi River, the Ohio River, the Lower Mississippi River, the Missouri river, and the Arkansas and Red Rivers. The rating is provided in form of a six wedge wheel graphic that uses colors to contrast the status of the individual measures within each wedge and for the integrated measures. This provides more in-depth information than a single grade or color.

For more information on the ARI Report Card, see: [www.americaswater.org/reportcard/](http://www.americaswater.org/reportcard/)

##### Attributes:

1. Categories provide separate accounting for major factors
2. Specific measures used to quantify status in each category
3. Quantitative measures assist with repeatability and consistency
4. Unique report graphic using wheel adds context to rating
5. River basin geo-spatial focus lends itself to regional assessments not tied to political boundaries.

##### Challenges:

1. Requires significant expertise to execute as well as extensive collaboration among a host of federal, state and local governments, non-governmental agencies, academia and the private sector.

## C. Review of Existing and Emerging Resilience Tools and Methods

The information below provides a brief snapshot of the spectrum of emerging and available resilience tools. Since this is a fast moving field with many participants, information presented could be outdated. The following discussion provides summaries of a number of resilience tools, most presented at the workshop. They are divided into top-down and bottom-up tools. Top-down tools are further subdivided into baseline (fundamental non-hazard specific) and focused (designed to address a specific hazard type or situation in more depth) tools. Bottom-up tools are further subdivided into self-help tools and tool-kits. Appendix B provides a table summarizing all of the resilience methods examined for this study.

### **Top-Down Baseline Tools**

#### **Baseline Resilience Index for Communities (BRIC):**

The BRIC was developed by the Hazards & Vulnerability Research Institute, University of South Carolina with support from the Oak Ridge National Laboratory Community and Regional Resilience Initiative (CARRI). Vulnerability arises from the intersection of human systems, the built environment, and the natural environment. The most obvious factor contributing to community vulnerability is location or proximity to hazard-prone areas. The ability of the community to recover and adapt is a complex combination of its physical, social, environmental and organizations capacities.

BRIC provides a framework for assessing the fundamental or inherent resilience of an area or community prior to a disaster event. It does not consider specific hazards or hazard events, but instead examines available data for an assessment of 6 broad categories (Infrastructure, ecosystems, institutions, economic, social, and community capacity) to examine the ability of the area to recover from a significant negative event. BRIC provides a resilience baseline index value for each category as well as a composite index which can be derived using equal or different weights for each category (Cutter et. al, 2013).

For more information see: <http://webra.cas.sc.edu/hvri/>

Attributes:

**Inputs** –The BRIC process uses existing available data bases as sources of surrogate metrics that allow estimation of specific factors used to estimate the score for each category. The metrics used have been vetted and peer reviewed to provide effective estimates that have credibility. Use of widely available data also provides some consistency and uniformity across geographical areas. Example surrogate metrics related to each category include the following:

Ecological: Percent greenspace, percent in 100-year floodplain, percent forested, percent wetlands and percent soil erosion.

Social: Racial inequality, educational inequality, doctors per 10,000 population, percent elderly, social vulnerability index, and crime rate.

Economic: Housing capital, percent homeowner, percent employment, median household income, number of large businesses.

Institutional: recent hazard mitigation plan, NFIP policies per housing units, municipal expenditures for emergency management.

Infrastructure: percent mobile homes, medical capacity, new building permits, evacuation potential, housing age.

Community Competence: Political fragmentation, previous disaster experience, social capital, dependency ratio (debt/revenue).

In summary, BRIC uses readily available data sources like the census and other government data sets, provides consistency and uniformity across geographical areas and metrics are selected and vetted to provide credibility.

Analysis – The analysis process is a simple consistent statistical normalization and summation for all metrics used as input for each category (sub-index). Scale values are from 0 to 1, where 0 reduces resilience; 1 increases resilience. Scores theoretically range from 0 to 49 (all variables used for all six categories); or from 0 to 6 (using sub-indices representing the six categories). The process creates means of each sub-index to reduce the impact of having a different number of variables within each sub-index. In summary, BRIC uses consistent statistical treatment of individual metrics for each category which allows for aggregation of indices into a baseline resilience index.

Output – The output for each category is an index, 0 to 1. These values are weighted and summed to create an aggregate resilience index. The indices can be presented in map format by using color coding for the geographical areas represented by the data input. This can vary from census tracts to counties. Scale for color coding is typically based on ranges of standard deviation above or below the mean. It is important to note that this output is a relative score. The absolute values of the scores will change based on whether the assessment is done over a state, region, or nationally. The results of this process are an easily understood and simple index that can be presented as a color coded map product. Dr. Susan Cutter at the University of South Carolina has applied BRIC to generate national maps of baseline resilience for each category and for a composite index. (<http://webra.cas.sc.edu/hvri/>)

Challenge:

Does not consider specific hazards or hazard implications; only indicates relative resilience across a region; difficult to identify opportunities for specific resilience improvement projects.

#### Resilience Capacity Index:

The Resilience Capacity Index (RCI) was developed by Dr. Kathryn A. Foster, co-PI of the MacArthur Foundation Research Network on Building Resilient Regions, assisted by graduate assistants at the University at Buffalo Regional Institute, State University of New York. The work

was accomplished under support from the Institute of Governmental Studies, University of California at Berkeley and funded by the John D. and Catherine T. MacArthur Foundation.

The Resilience Capacity Index (RCI) is a single value summarizing a region's status on twelve factors hypothesized to influence the ability of a region to bounce back from a future unknown stress. The index permits comparisons across metropolitan regions and identification of strong and weak conditions relative to other metropolitan regions. Capacity indicators are classified into one of three capacity types: Regional Economic, Socio-Demographic, and Community Connectivity. Regional Economic indicators capture concepts of industrial diversification, business dynamics, regional affordability measured as a product of housing costs and income levels, and income equality. Socio-Demographic indicators capture concepts of poverty, disability, educational attainment and the proportion of the region's residents with health insurance. Community Connectivity indicators capture how familiar with and civically active a region's residents are as expressed by voter participation rates, homeownership, organizational density, and metropolitan stability measured by resident tenure within the region.

The RCI incorporates each of the 12 underlying resilience capacity indicators in equal weight. To accommodate different indicator scales and metrics, indicator values are reported as z-scores, which quantify how many standard deviations—in a positive or negative direction—a region's performance on an indicator deviates from the all-metropolitan average. The RCI for any metropolitan region is the simple average of its z-scores for each of the 12 underlying RCI indicators. The RCI process has been applied to 360 metropolitan areas across the U.S. This methodology does not include consideration of specific hazards.

For more information go to: [www.brr.berkeley.edu/rci](http://www.brr.berkeley.edu/rci)

Attributes:

Inputs - Input data from government and local data bases creates some level of uniformity and consistency

Analysis – Uses categories to examine different key factors and specific surrogate metrics to characterize each category. Z-score approach allows normalization and combination of metric values for each category and for aggregate score. Statistical approach is straight forward and transparent.

Output - Single score backed by sub-element (category scores). Results are capable of presentation in map format, but applications so far have been restricted to metropolitan areas.

Challenge:

Ability to characterize non-urban areas; lack of consideration of hazards and their implications. Output is relative to other metro areas in the study. All of the metrics are applicable to non-urban areas, but the data may be harder to find.

## **Top-Down Focused Tools**

### **Argonne National Laboratory Resilience Index:**

Argonne National Laboratory, sponsored by the U.S. Department of Homeland Security's Protective Security Coordination Division, developed a highly focused and comprehensive approach to evaluate the resiliency of critical infrastructure or resource sectors to security threats.

Inputs to the process are gathered by trained interviewers who use an Infrastructure Survey Tool covering roughly 1,500 variables that cover six major physical and human components (physical security, security management, security force, information sharing, protective measures assessment, and dependencies). The approach is used for several types of critical infrastructure or key resource sectors such as banking and finance, dams, energy, etc. Data are subjected to elaborate quality control involving review by experts in critical infrastructure protection.

A five-stage aggregation process is used to combine the items into a single Resilience Index (called the Protective Measure Index PMI) that ranges from 0 (lowest resilience) to 100 (highest resilience) for the critical infrastructure or key resource sector being evaluated and for a specific threat. The aggregation process focuses on three major categories (Robustness, Recovery and Resourcefulness). At each stage, contributing measures are weighted by the opinions of experts, and the products are summed to obtain the PMI composite index. A resilience index is given (0 -100) for each major categories above as well as for the composite resilience index.

This tool is specifically focused on infrastructure and infrastructure systems and requires expertise in modeling and infrastructure systems, allowing it to be highly quantitative and comprehensive. There are no social or environmental components or geospatial elements included in the process. (Fisher, et al 2010)

Attributes:

Input - Very detailed with respect to the characteristics considered and the sophistication of the analysis that the data feed. Inputs are examined and collected by experts.

Analysis – Highly analytical, comprehensive; uses index concept, 0-100, for major categories to allow generalization of results

Output – Composite resilience index based on aggregation of sub-element (category) values.

Challenges:

Highly specific to terrorism hazard and infrastructure; requires extensive expert involvement; and does not consider social / cultural or environmental issues.

### **San Francisco Planning and Urban Research Association (SPUR) Resilient Cities Initiative:**



SPUR is a non-profit organization and their Resilient Cities initiative demonstrates the valuable role that non-governmental organizations (NGOs) can play in planning the future of a community (<http://www.spur.org/>). This initiative is all about the future of San Francisco with respect to its major natural hazard threat, earthquakes. SPUR defines San Francisco's "seismic resilience" as its ability to contain the effects of earthquakes when they occur, carry out recovery activities in ways that minimize social disruption, and rebuild following earthquakes in ways that mitigate the effects of future earthquakes. The specific recommendations that resulted from this effort were developed by considering: (1) the goals for seismic resilience for each component of the city, (2) the gap between current seismic performance and the goal, and (3) the cost of making the necessary improvements or retrofits. The basic inputs for the process are derived from available engineering and community records.

Seismic performance goals are stated in terms of the general states of damage and repair over an extended recovery period under the assumption that an "expected" earthquake. Priority is given to those actions that provide the best improvement to seismic performance and resilience with the least amount of cost and disruption. The framework for this analysis includes the following areas of emphasis:

- 1) The Dilemma of Existing Buildings: Private property, public risk
- 2) Improving the seismic performance of new buildings
- 3) Lifelines: Upgrading Infrastructure to Enhance San Francisco's Earthquake Resilience
- 4) Emergency Response and Preparedness
- 5) The Hub Concept: Infrastructure for a Community Disaster Response

For more information, see: <http://www.spur.org/>

Attributes:

Inputs: Very specific and quantitative descriptors related to seismic performance of infrastructure, allows in-depth analysis.

Analysis: Quantitative analysis considering specific hazard characteristics and infrastructure response.

Output: Specific recommendations concerning both disaster response and recovery activities tailored to the community evaluated and their hazard situation.

Challenge: Level of effort necessary to achieve recommendations; focus on one specific hazard type, needs expansion to deal with most areas where multi-hazard analysis is important.

### **Bottom-up Self-Help Tools**

#### **NOAA Coastal Resilience Index (CRI):**

The goal of the NOAA Community Resilience initiative is to develop guidance to help communities find the most suitable resources to benchmark and track their preparedness and response to coastal hazards. The NOAA Coastal Resilience Index is a part of the NOAA family of tools and provides a simple, inexpensive method for community leaders to perform a self-assessment of their community's resilience to coastal hazards, identifies weaknesses a community may want to address prior to the next hazard event and guides discussion within a community. It is not intended for comparison between communities.

The Index includes six sections (critical facilities and infrastructure, transportation issues, community plans and agreements, mitigation measures, business plans and social systems). Each section has a series of questions which are answered with a simple yes or no. The number of yes answers in each section is used to determine a rating index score. The CRI has been pilot tested in more than 20 communities across the five Gulf States (Texas, Louisiana, Mississippi, Alabama, and Florida). Focus has been on training facilitators from Cooperative Extension and Sea Grant Extension programs, National Estuarine Research Reserves, and other groups who work with community resilience. Although piloted in the Gulf, the CRI can be transferred to other coastal regions (NOAA CRI).

For more information see: <http://masgc.org/ri>,

Attributes:

Input – Community responses to a series of questions (divided into topical categories). Can be self applied or with facilitation by third party.

Analysis: Simple accounting of positive responses by topical area (category) compared to an established scale related to qualitative descriptors (such as high, medium, low). Can consider specific hazards and hazard scenarios suited to the location.

Output – Simple score and qualitative designation; results often associated with recommendations for possible types of actions that would improve scores and sources of more detailed assistance.

Challenges:

Difficulty in creating uniformity and consistency among communities to allow aggregation to larger scales for more strategic perspective.

#### **Maryland Coast Smart Community Scorecard:**

The goal of the Maryland Department of Natural Resources Coast Smart Community Scorecard initiative is to help local governments determine how well they are currently positioned to plan for coastal hazard impacts through a simple, practical self-assessment. The Scorecard also provides a mechanism for planners, natural resource managers, emergency management

professionals and other local officials to identify specific, realistic ways that they can prepare for these impacts by integrating coastal hazards into existing planning, management, and regulatory programs. Because each Maryland community is unique, the Scorecard is intended to identify areas that need improvement, not serve as a basis for ranking or comparing among communities.

The scorecard is organized into five major sections: 1) Risk and Vulnerability Assessment, 2) People and Property, 3) Infrastructure and Critical Facilities, 4) Natural Resources, and 5) Societal and Economic Impacts. Users go through each section and answer the questions to the best of their ability. After each section, the total 'yes' responses are used to check the CoastSmart ratings to see how well existing planning efforts are addressing current and future weather and climate hazards. To help determine responses, each section has a "Where to Start" box with a list of relevant planning documents, resources, and other tools to help assess preparedness.

For more information go to [www.dnr.maryland.gov/coastsmart](http://www.dnr.maryland.gov/coastsmart)

Attributes: See NOAA Coastal Resilience Index above.

Challenges: See NOAA Coastal Resilience Index above.

#### The Communities Advancing Resilience Toolkit (CART)©:

Communities Advancing Resilience Toolkit (CART)© is a community intervention designed to enhance community resilience through assessment, group processes, planning, and action. CART© was developed under Department of Homeland Security funding by the Terrorism and Disaster Center (TDC) of the National Child Traumatic Stress Network, at the University of Oklahoma. CART© brings community stakeholders together to address community issues in a process that includes surveys, group meetings, and strategy development and implementation. CART© builds on three key aspects of group behavior: (1) communication among group members to pool skills and knowledge, (2) learning and growing as a result of group interactions, and (3) facilitation of acceptance and implementation of group goals.

CART© addresses four overlapping, interrelated domains that both describe and affect community resilience. Three of the domains are common to all CART efforts:

1. Connection and Caring – which includes relatedness, shared values, participation, support systems, equity, justice, hope, and diversity;
2. Resources – which includes natural, physical, financial, human, and social resources; and
3. Transformative Potential – which includes data collection, analysis of community assets and capabilities, and skill building that create the potential for profound community change.

The fourth domain relates to the specific adversity that concerns the community, typically terrorism and disaster management.

The process begins with a survey that addresses the four resilience domains, participants' personal relationship to their community, demographics of respondents, and additional concerns developed and refined in conjunction with community partners. The CART© assessment survey provides a snapshot of strengths and challenges that are meaningful for the particular community and the organizations participating in the process. Results are used to develop a community profile that describes findings by and across domains (Connection and Caring, Resources, Transformative Potential, and Disaster Management). The initial survey is followed by a series of meetings in which participants interpret survey findings within the context of their community and identify potential information gaps.

Based on assessment results and knowledge of their community, group members identify community strengths and weaknesses, opportunities for improvement, factors outside the community that might advance or impede progress, and other relevant concerns. Groups then establish goals related to issues they choose to address, and they engage in planning to develop strategies and an action plan to enhance community resilience in support of the goals they have established.

For more information go to: [www.oumedicine.com/psychiatry/research/terrorism-and-disaster-center/interventions/community-resilience-\(cr\)](http://www.oumedicine.com/psychiatry/research/terrorism-and-disaster-center/interventions/community-resilience-(cr))

Attributes:

Inputs: Inputs are largely self-generated by community teams giving maximum input from diverse stakeholders.

Analysis: Largely a SWOT (Strength-Weakness-Opportunity-Threat) process, using a segmented taxonomy allowing examination of different aspects of resilience.

Output: principally a strategy for gaining resilience that can be used to develop specific plans and actions. Process enhances chances of success because of community involvement in development of strategy.

Challenges:

Lacks quantitative metrics and is not conducive for developing an index.

### **Bottom-up Tool Kits**

#### **Coastal Resilience Network:**

The Nature Conservancy, U S Geological Survey and NOAA have partnered to develop the Coastal Resilience Network. Coastal Resilience is a global network of practitioners who are applying an approach and web-based mapping tool designed to help communities understand their vulnerability from coastal hazards, reduce their risk and determine the value of nature-based solutions.

The primary mechanism for delivering the Coastal Resilience approach to communities is through a web-based mapping platform ([maps.coastalresilience.org](http://maps.coastalresilience.org)) and Coastal Resilience

“apps” that address specific coastal risk, restoration and adaptation issues. These are browser-based apps, not native apps on your phone or mobile device.

The network includes core data on social and economic assets and coastal and floodplain hazards, analysis support for risk, vulnerability and consequences, future projections of storm surge and sea level rise, coastal protection alternatives and habitat conservation, restoration and migration.

A core feature of the tool is the open source applications (apps) that integrate coastal hazards with social, ecological, economic and coastal engineering to identify solutions. Apps can be developed with or for partners, transferred to different tool platforms, and scaled to different types of information.

For more information see: [www.coastalresilience.org](http://www.coastalresilience.org) and [www.maps.coastalresilience.org](http://www.maps.coastalresilience.org)

Attributes:

Provides range of options (through variety of tools) to examine resilience for a locality more comprehensively and quantitatively than possible with self-help tools described above. Includes geospatial analysis (GIS) and quantitative consideration of hazards and consequences in some depth. Provides for customization of analysis and details for community or area of study.

Challenges:

Remains a community centric tool and information set, making it difficult to generalize or aggregate with information for other communities or areas to gain a strategic perspective at regional or national scale.

Community Resilience System:

The Community Resilience System (CRS) was created by the Community and Regional Resilience institute in conjunction with the Meridian Institute through funding from the U S Department of Homeland Security. It brings together the resources, tools, and processes needed to improve community resilience.

The CRS consists of:

- A knowledge base of what community resilience is, what makes communities more resilient, what tools can help communities assess their resilience, and what resources can help communities take action to become more resilient.
- A process that helps communities use the knowledge base to become more resilient.
- A web-based set of tools and resources to make the process and knowledgebase available to a wide array of communities.

The CRS helps communities create a vision for the future and establish the necessary actions to improve overall resilience to disasters and other disturbances. The information, the process, and the system will help them prepare for and recover from any challenge.

The CRS was piloted in seven communities where leaders and citizens were committed to engaging the full fabric of their society to foster preparedness and resilience. These communities are Anaheim, California; Anne Arundel County and Annapolis, Maryland; Charleston and the Tri-County Area, South Carolina; Gadsden, Alabama; Greenwich, Connecticut; The Mississippi Gulf Coast; and Mount Juliet, Tennessee.

For more information see: [www.resilientus.org/recent-work/community-resilience-system](http://www.resilientus.org/recent-work/community-resilience-system)

Attributes: Similar to those stated above for the Coastal Resilience Network.

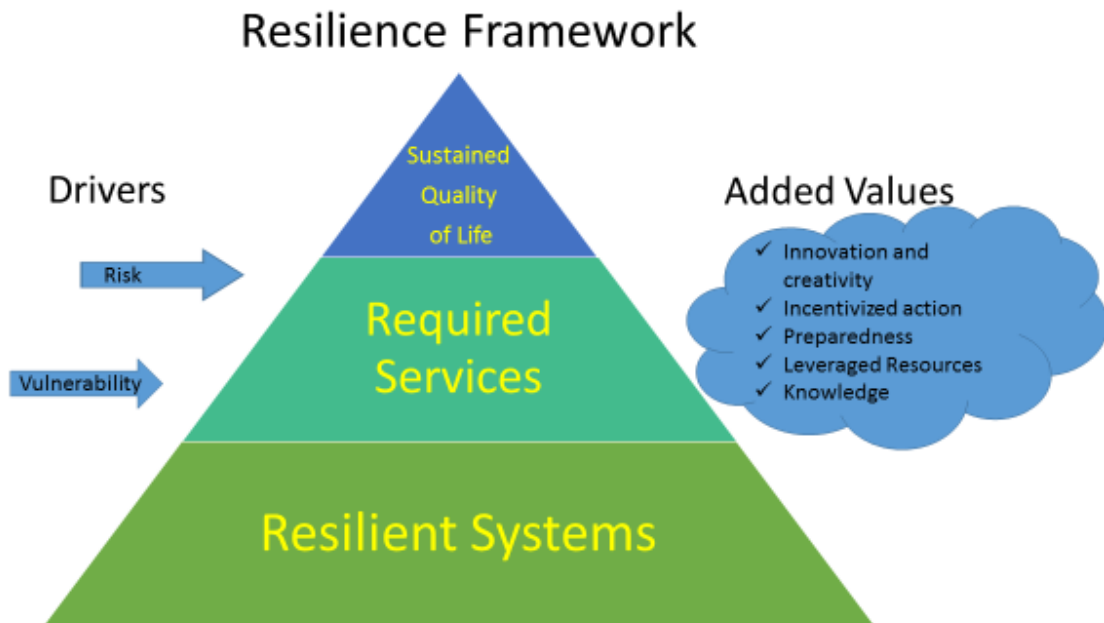
Challenges: Similar to those stated above for the Coastal Resilience Network.

## IV. Synthesis of results and recommendations

### A. Framework

#### Maslow's pyramid

After assessing best practices of national scorecards and resilience tools, a clearer picture of the best model for a national level resilience framework emerges. Establishing a common vision around the importance of resilience was an objective expressed by many of the users. From both discussions at the workshop and as found in the NIST “Community Resilience Planning Guide” ([www.nist.gov/el/building\\_materials/resilience/guide.cfm](http://www.nist.gov/el/building_materials/resilience/guide.cfm)), a higher level set of outcomes might best be framed or adapted in a context similar to Maslow’s Hierarchy of Needs (Maslow 1943). Starting at the bottom of the pyramid with fulfilling the physiological needs of the community and working upward to improve quality of life in communities, a resilience framework or national model should as a minimum reflect the systems (institutional and community networks, built/social and environment systems, supply chain networks, economic interdependencies, etc.) that support services (health, education, emergency services, ecosystem services, housing, transportation, water, utilities, etc.) important to the immediate and long term recovery of the community. Improving the quality of life through resilience requires protecting and restoring these systems and services when something bad happens. However, this cannot be done without understanding the unique risks and vulnerabilities that can threaten not only the systems and services, but the safety and socio-cultural wellbeing of a community. Further, a resilience framework should support and embrace a culture of preparedness, social equity, adaptation, innovation and transformation. Finally, a resilience framework should encourage sharing of lessons or leveraging of resources and most importantly, incentivize action.



### Overarching characteristics

Along with specific building block elements identified in section IV.B below, there were two overarching characteristics that were considered fundamental to development of a national resilience assessment, but introduced layers of complexity to actually building the tool: 1) balancing a top-down and bottom up approach and 2) embracing a tiered and/or multi-tool solution.

#### Top-Down and Bottom-Up

As discussed above, there are two basic approaches to measuring resilience: bottom-up and top-down tools. Bottom-up tools are focused primarily on helping communities help themselves. Top-down tools exploit available data bases (government, professional and private as available) to estimate metrics for individual categories or components of resilience (e.g., social, economic, ecological, infrastructure). These tools are more amenable to developing regional or national scale resilience data, but less amenable to creating action at the community level. They are an effective source of input to policy level discussions and national program budget considerations.

A national assessment should strive to balance a top-down and bottom-up approach. This would ensure that the assessment tool is both comprehensive enough to describe resilience across the country, and specific enough to be relevant to individual communities. It is most likely that national scale information will have to be developed top-down with readily accessible and reliable data sources, but should be tied, as closely as possible, to the typical



data being developed from bottom-up community-based resilience information. A nested hierarchy of approaches where the data and results are scalable from a community to a regional and national level would be ideal, but would be difficult to achieve. To successfully relate bottom-up and top-down approaches in future tools will require computational rigor and consistency and would best be done in an open data-open source environment that fosters continuous improvement.

### **One-size does not fit all**

It is clear that there are a variety of important applications and requirements for resilience information. There is likely no single tool or method that will serve them all. This is especially true concerning a national scorecard capability. A suite of tiered tools may be more appropriate to address a need for increasing complexity. National level data may not be of sufficient detail to provide local level assessments or spatially and temporally explicit to meet multiple user objectives.

- **Tiered approach.** A tiered approach to assessing resilience would provide for relatable information at different levels of complexity and resolution. A relatively simple analysis is attractive because it can provide a big picture perspective that leads or triages the need for more detailed analyses. Depending upon user needs, a more complex tool or suite of tools might be needed to, for instance, understand the resilience of communication or transportation networks, or to assess and design resilience measures for critical infrastructure. With that complexity there may also be a temporal need to balance speed of an assessment with deliberation.
- **Multi-tool (toolbox).** Several agencies and organizations have taken the approach to developing tool kits, that is, clusters of tools that can be readily accessed that are generated for specific community needs or mission requirements. Using the tools, independently or together, allows for more sophisticated options and customized analyses for communities or local areas, providing significant modeling and geospatial presentation capabilities.
- **Geographic Variability.** Because resilience is so closely tied to risk and vulnerability, as well as socio-economic perspectives, assessing resilience is really place-based. Geographic and environmental characteristics vary across regions making them more susceptible to certain types of hazards and/or more vulnerable to certain cultural and economic disruptions. Developing a flexible and adaptable assessment process is important to accurately establish a baseline for resilience and identify actions to improve it.
- **Mission specific.** Finally, an organizations mission drives how it views and measures resilience. Because an agency's mission can be as varied as to improve public health, protect lives and property, restore the environment, or effectively and efficiently manage infrastructure, resilience metrics should reflect the goals they want to achieve. The variability in missions should not, however, deliver conflicting requirements or provide mixed signals to communities and individuals.

## B. Key Building Blocks to a National Resilience Assessment

Resolving the paradox of developing an assessment tool that addresses the specific requirements of the overarching characteristics described above (national versus local and the need for tailored tools), yet generic enough to provide a framework that all can understand and communicate, is a daunting task. To that end, the following discussion seeks to disaggregate and describe elements common to model scorecards and assessments. Identified here as key building blocks, these are based on the analysis of the tools and best practices reviewed in this study.

- **Purpose or Relevance**
  - **Supports Mission/Purpose.** As discussed above, to measure programmatic success, the outcome of the assessment must be tied to some aspect of the mission of an organization or agency or a general purpose for the nation
  - **Relative Changes in Resilience.** Establishing a baseline assessment of resilience is needed to identify and track both actions and progress. By identifying relative changes in resilience, decision makers can set targets, prioritize approaches and investment decisions. This should include measuring learning and specific changes in behavior over time, an important, but often underemphasized element of resilience.
  - **Incentivizes Action.** There should be a means associated with the methodology to incentivize action on the part of decision makers and individuals. Few of the current resilience tools have built-in explicit incentives for application, such as tax credits, reduced insurance premiums, lower cost-share on projects, etc.
- **Quantifiable.** Quantitative measures provide the best opportunity for consistent, repeatable and comparable results, but they must be validated and provided by or derived from a reliable source.
  - **Repeatable.** Data inputs, outputs and analysis must provide repeatable and dependable results. A national resilience scorecard would be meaningless if it could not be updated and repeated as needed, as well as providing quantitative data that can have a realistic impact on policy and resilience decisions. Data must come from nationally available and reliable data sources. Uncertainties should be understood and quantified.
  - **Verifiable.** To measure resilience at any level, an assessment is necessary, but not sufficient to validate the scores. There should be an independent method for verifying not only the data, but the results. This could be done by an expert panel or review board (see governance.)
  - **Transparent and credible.** Related to good data and validation, is the need for transparency. This means that clear documentation, shared data platform, and a peer reviewed methodology is provided by a trusted source in a manner that

leads to acceptance and trust. A credible and transparent assessment can be an effective tool for engaging in a dialogue about the state of the nation's resilience and the actions needed to improve that resilience.

- **Usability** The best tools are easy enough to use, yet sophisticated enough to be meaningful and generate simple and easily understood outputs.
  - **User Friendly.** If the assessment tool is hard to use, it will be hard to convince communities to use it. Highly sophisticated methodologies may be valuable for very specialized analysis, but not practical for a broad analysis that would lead to a national scale index. User friendly also means that the data inputs and sources are accessible, the analysis is logical, and the outputs can be visualized or communicated for all to understand. Some of the bottom-up resilience assessments tend to be more user friendly in engaging responses, but may need to be broadened for national use.
  - **Simple.** It is easy to understand that some of the simplest tools to apply are often in the form of questionnaires that result in a relative scoring. However, these tools may lack the complexity to provide meaningful outcomes. The really good tools, may have more sophisticated analysis and supporting data behind them to build quantitative measures or metrics. In the end, however, these quantitative numbers may be aggregated into an index, score or branding label (such as gold, silver, bronze) that is easier to understand and communicate in the form of grades or color-coded map products. Many of the top-down methods accomplish this.
- **Content**
  - **Categories.** The most important, and perhaps time consuming, aspect of creating a resilience scorecard is the development of categories and elements or sub-elements that reflect the major goals and objectives of conducting the assessment in the first place. Characterization of resilience in terms of these multiple components or categories allows for a clearer picture of the relationship between key capacities or capabilities that enable resilience and relate it to a target or desired resilience level. Development of categories should be done in a way to avoid organizational or mission-specific stovepipes. Even though the need for multiple tools and specific elements may arise, the predominant categories of the tools reviewed herein were related to all or one aspect of socio-cultural or economic, environmental or built systems. Many of the top-down resilience and bottom-up methods use categories or sub-elements to allow examination of the output in more detail, providing greater insight for context of the index values.

- **Changing Landscape.** The resilience assessment must be adaptable to represent changes in risk imposed by a future landscape, such as imposed by changing population demographics, economies and climate change. Climate change has, and will continue to, drastically impact the severity and frequency of disaster events that have motivated the need for resilience plans and assessments. Growing population centers in vulnerable areas and global shifts in economies can also exacerbate the ability of regions and communities to be resilient.
- **Multi-Scale.** As described above, the ability to characterize measures and metrics at various scales and layers facilitates the ability to aggregate information to broader perspectives. Taking a tiered approach to quantifying resilience appears to be a practical approach to dealing with current needs while preparing for future challenges. It also allows the ability to tailor content to specific outcomes, such as site-specific infrastructure design or regional emergency planning. Many tools are based on deterministic or qualitative assessments, so understanding and tracking uncertainty of the data and assessments would be important in aggregation of information.
- **Governance.** Governance (who owns, who pays, who manages, who executes) of the national resilience effort needs to be clearly defined and resourced to enable the vital activities of validation, documentation, guidance, communication and continual improvement.
  - **Proponent.** Having designated organization and/or partnership responsible for management and administration of the methodology may be preferable for sustainability of the tool. Many of the current resilience methods have been under development and tested in pilot communities by non-governmental organizations and/or academia. While offering some promising results, this type governance may reduce the opportunity for wide spread application or sustained use of the tool. Having said that, purely federal proponentcy, while possibly leading to broader geographic applicability or a more stable funding stream, may not lead to the most effective adaption and use of the tool. Partnerships of federal and non-federal organizations to include state and local agencies, non-profits, private industry and academia could well provide the programmatic continuity, academic credibility and community support required to operationalize a sustainable resilience assessment methodology.
  - **Identification of Users.** Starting with the end in mind, the ultimate user of the assessment will guide not only how it is developed but how it is managed and implemented. There should be a clear definition of who the key users will be and how the information would be applied. Understanding the need of the user also effects the timing of its release and updates.

- **Guidance** It goes without saying, that succinct documentation and easy access to guidance for how to best apply the methodology is essential. Guidance must be kept up to date and current to new data and methodologies.
- **Peer Review and oversight.** To improve credibility and help validate the efficacy of the approach, the proponent of the assessment may choose to elicit the help of independent experts. Many of the best tools used panels of experts to validate and review their products. Further, to help in the overall management and operations a review board or periodic programmatic evaluations might be helpful.
- **Cost.** Another major consideration is the cost to apply the method, especially with respect to application, at a national scale. As part of the governance structure it must be determined “who pays” and how that can be sustained.

## C. Other considerations

### Respect for community

While resilience begins with community perspectives, aggregating information to regional and national levels should be done with the objective of providing decision makers with the necessary tools to make meaningful improvements in resilience without exposing or alienating communities and individuals. The process should be sympathetic to fear-of-the-score by those that are being assessed. Agencies and organizations should also be respective of how often they independently engage communities and work to coordinate their activities in a region to reduce assessment “fatigue.” Resilience assessments and scores should provide value to individual communities and drive action.

### Partnerships

Often, initiatives like a performance measure or index are spawned by one agency or organization and their need to support their mission objectives. There is little opportunity for cohesive, cross-agency dialogue about the needs of the tool and its application. Because, the biggest successes have come with partnerships and inter-agency cooperation, this will be a necessary requirement to develop a cohesive national scorecard. Partnerships are paramount to success and should embrace private industry, academia, for-profit and non-profit organizations, federal, state, tribal and local governments. The cost to collect, analyze and share data could be prohibitive if left to one organization or agency. Innovative partnerships not only help distribute the burden, but will lead to better solutions. Data inputs may be one of the biggest challenges in developing a scorecard and therefore sharing data and analysis methodologies is a critical need and will lead to consistent, comparable and compatible results.

## **Missions and Markets**

Agency and organizational missions and program requirements will, by necessity, drive assessment outcomes. However, coordination and collaboration will help all to communicate resilience in a common language and through an understandable lens at both national and local levels. Governmental, non-governmental and public-private partnerships can improve the success of both developing and delivering resilience measures. New efforts such as the RISE Alliance™<sup>13</sup> understand that risk management and resilience measures enacted prior to disaster impacts the bottom line. Further, the resilience movement appears to be migrating toward a market driven direction just as LEED™<sup>14</sup> has done in green buildings, ENVISION™<sup>15</sup> is doing in infrastructure and Energy Star™<sup>16</sup> did for energy efficiency. Professional accreditation or credentialing programs can also drive resilience through participation by practitioners. Incentivizing resilience by demonstrating its market value or its professional implications could lead to public and private investment opportunities.

### **D. Next Steps to building a national scorecard**

In closing, many tools are available and many more emerging. They are intended for a broad spectrum of applications and purposes and represent a diverse set of capabilities. Communities are likely viewed as the premier user of resilience information and their needs are best met with bottom-up approaches that allow customization to their situation and priorities and lead to local decisions concerning actions needed. It is unlikely that a national tool can provide this type of input. It is equally unlikely that a bottom-up derived assessment tool can provide the broad and generalized information necessary for regional or national assessments. Even at the national scale, the most insightful resilience information is that which portrays the geographical variations in resilience measures, not a single national metric value for individual resilience components or an aggregated index. The purpose and users of the resilience information will drive the requirements. Multi-component frameworks seem to hold the most potential for providing value to a broad spectrum of users/applications for regional or national fiscal, planning and policy type issues. The process to build a national scorecard can take decades, but the process itself generates important dialogue. If done right, it can be a catalyst for changing behavior. The major goal and equally major challenge for a national scale resilience methodology is for it to be simple and affordable enough to be used, yet sophisticated enough to be relevant for the applications at hand.

The following are steps that can be taken to move toward a national assessment of resilience.

- 1. Develop a common operating framework for resilience.** A national resilience assessment should have a common and coordinated programmatic framework. This

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<sup>13</sup> RISE Alliance™ - [www.preventionweb.net/rise/home](http://www.preventionweb.net/rise/home)

<sup>14</sup> LEED™ - [www.usgbc.org/leed](http://www.usgbc.org/leed)

<sup>15</sup> Envision™ - [www.sustainableinfrastructure.org/rating/](http://www.sustainableinfrastructure.org/rating/)

<sup>16</sup> Energy Star™ - [www.energystar.gov/](http://www.energystar.gov/)

does not mean that one assessment tool can apply to all situations. It does mean that, as a minimum, a national framework should have the means to evaluate the public services (health, education, emergency services, ecosystem services, housing, transportation, water, utilities, etc.) supported by the fundamental systems- social, environmental and built- that support resilient communities. The framework (as simply presented in the above figure) should drive conversations between a diverse set of stakeholders that inform the trade-offs between alternatives. Further, a national tool must be able to capture the relative changes in resilience based on a systems ability to withstand, restore or adapt to an adverse event. Finally the framework should help communities or organizations make plans and take action.

**2. Continue to engage in innovative partnerships to develop assessments.** There are clearly many partnering and collaboration efforts in motion regarding resilience. Federal agencies should continue the interagency efforts driven by White House and departmental directives to increase resilience, but partnerships should not stop there. Public-private opportunities should be capitalized upon to build and apply national assessment tools. Innovative partnerships not only help distribute the burden, but will lead to better solutions. Pathways forward should leverage existing and emerging capabilities (data, analysis, validation, communication) as much as possible.

**3. Leverage market driven solutions and/or adapt existing scorecard outputs as proxies for national resilience.** While federal programs have spawned the development of some of the tools and provide a basis for consistent data sources and programmatic continuity, market driven solutions could be the key to broad public application and support. Programs like LEED™ and Energy Star™ have incentivized behavioral changes and driven public demand that also generated revenue for private industry. New market concepts in resilience are emerging globally through unique partnerships and many assessment tools are under construction. To minimize investments in new tools, a detailed review of emerging efforts should be conducted. To the extent practical, existing scorecards or their particular components should be adapted and used to assess national resilience.

**4. Assess and build a hierarchy for scalable assessments.** An attempt should be made to develop a hierarchy of tools and methodologies and evaluate the ability to integrate and connect those tools in a way that minimizes cost and effort and maximizes scalability and use. In other words, can a suite of tools be developed that can be used for simple-to-complex and local-to-national applications? A more thorough evaluation of the most promising methodologies should consider how easily they scale, quantify the cost to build and implement, and identify uncertainties.

**5. Get started.** The development of an effective national resilience assessment could take years. The process of developing the assessment will open the dialogue with communities about resilience and be both informative and educational. Consider a national oversight team to organize and collect data and assessments executed at individual, community, state or regional levels. To get the process going, review and select an existing basic or easily used tool and apply it regionally or nationally to start the dialogue.

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## **Appendix A: Workshop Agenda and Attendees**

Building Blocks for a National Resilience Scorecard  
Workshop Agenda  
April 14-15, 2015  
90 K Street NE  
Suite 1200  
Washington DC 20002

**WORKSHOP OBJECTIVE:** *This workshop aims to help identify and characterize the building blocks needed to develop a national resilience assessment for analyzing the health and vulnerability of our nation to natural and man-made hazards by assessing the existing methodologies that qualitatively and quantitatively assess resilience. The following 3 questions will drive our discussion:*

- 1) Why might we need a national scorecard?
- 2) What objective(s) would we hope to accomplish with such a tool?
- 3) How (and by whom) is this best achieved?

**April 14: Day 1- Building a national scorecard**

**Morning**

8:00-8:30 AM **Registration**

8:30-8:40 AM **Welcome** (Charles Schwartz)

8:40-9:10 AM **Introductions/Overview** (Sandra Knight)

**Objective 1:** To review best practices for national assessments and identify primary attributes of a national assessment tool.

9:10-10:30 AM **Panel 1: National Assessments- Best Practices** (Ed Link)

Panel Members: Bill Dennison - UMCES, America's Watershed Initiative;  
Jennifer Rivers - ISI, Envision; Emily Feenstra - ASCE, ASCE Report Card; Bill Lesser - FEMA, Community Rating System

10:30-10:45 AM **Break**

10:45- 11:45 AM **Breakout 1: Best Practices and Scorecards** (Link, Knight, Galloway)

11:45 AM -12:30 PM **Lunch (provided)**

**Afternoon**

**Keynote presentation**

12:30-1:15 PM **Overview of Resilience Metrics and Tools** (Susan Cutter)

**Objective 2:** To get end-user perspectives on what is needed for a resilience scorecard and who/how it should be administered

1:15- 2:45 PM **Panel 2: User Perspectives for a National Resilience Scorecard Concept** (Knight)

**Panel members:** Stephen Cauffman - NIST, Sheri Moore - USACE, Kathleen Boyer - FEMA, Kate Johnson - DDOE, Mary Ellen Hynes - DHS S&T, Susan Julius - EPA

2:45-3:00 PM **Break**

3:00- 4:00 PM **Breakout 2: User requirements and key building block** (Link, Knight, Galloway)

4:00 PM Adjourn for day

### **April 15, Day 2: Portfolio of resilience tools**

8:30 – 9:00 AM **Group report outs** and summary discussion of Day 1 (Link/Knight/Groups)

**Objective 3: Identify characteristics and critical data elements important for a national scorecard**

9:00 – 10:15 AM **Panel 3 Case studies and examples of resilience tools** (Link)

Panel Members: Julie Rosati - USACE-ERDC, Coastal Resilience tools; Elizabeth Habic - MD, VAST; Mark Smith - The Nature Conservancy, TNC resilience kit; Ginger Croom - CDM Smith, NACCs Exposure and Risk Assessment; Kate Skaggs - MD DNR, Coast smart; Josh Murphy - NOAA, Community Resilience Index

10:15- 10:30 AM **Break**

10:30-11:15 AM **Breakout session 3: Characterizing the key building blocks** (Link, Knight, Galloway)

11:15-12:15 AM **Plenary discussion- Tying it all together** (Gerry Galloway)

12:15-12:20 PM **Closing** (Link, Knight)

**Center for Disaster Resilience  
Resilience Scorecard Workshop  
April 14-15, 2015  
Final Attendee List**

Emily Feenstra	ASCE DC
Get Moy	AECOM
Ginger Croom	CDM Smith
Katherine Johnson	DDOE
Mike Walsh	Dewberry
Jaelin Ali	DHS S&T
Mary Ellen Hynes	DHS S&T
Erin Walsh	DHS S&T
Eleanore Hajian	DHS S&T OUP
Brian Ambrette	Eastern Shore Land Conservancy
Susan Julius	EPA
Kathleen Boyer	FEMA-FIMA
Bill Lesser	FEMA-FIMA
Jonathan Westcott	FEMA-FIMA
Jennifer Rivers	Institute for Sustainable Infrastructure
David Vaughn	Integrated Resilience LLC
Elizabeth Habic	MD SHA
Kate Skaggs	MD-DNR
Stephen Cauffman	NIST
Josh Murphy	NOAA
Emma Roach	OMB
Janice Barnes	Perkins+Will
Doug Pierce	Perkins+Will
Mark Smith	TNC
Sandra Knight	UMD
Liora Miller	UMD
Jason Rohner	UMD

Gerry Galloway	UMD-CEE
Ed Link	UMD-CEE
Charles Schwartz	UMD-CEE
Alyssa Wolice	UMD-CEE
Bill Dennison	UMDCES
Susan Cutter	Univ. of S. Carolina
Sheri Moore	USACE HQ
Julie Rosati	USACE-ERDC
Katherine Touzinsky	USACE-ERDC
Kate White	USACE-IWR
Dave Robbins	USACE-NAB



## **Appendix B: Tables of National Assessment Tools and Current Resilience Assessment Methods**

National Scorecard

Tool	Type Score	Scope - Taxonomy	Scale - Frequency	Criteria	Inputs	Analysis	Outputs	Source	Reference
Healthy Watersheds Initiative	Criteria that watersheds have to meet	Based on EPA regulations for healthy watersheds	National/ local - Annual	Ecological conditions of a healthy watershed as described by the EPA	Data from local watershed organizations and governments	Watershed organizations, local governments, stakeholders, and EPA analyze results and develop conclusion	Flow chart marking key components, successes, and timeframes	Environmental Protection Agency, EPA funding and grants for individual watersheds	Watershed Index Online <a href="http://gispub.epa.gov/watershed/">http://gispub.epa.gov/watershed/</a>
ASCE Infrastructure Report Card	A-F simple grade for each infrastructure sector for the nation	16 Infrastructure Sectors	National - Every 4 years, Some States now creating their own report card	Capacity, condition, funding, future need, operation and maintenance, public safety, resilience, and innovation	State and federal reports and budget data; Economic Reports, Other studies and analysis, media	ASCE formed teams, consult with experts to assess inputs and reach scores/grades	Detailed report card with letter grades and explanations for each infrastructure sectors	Facilitated by American Society of Civil Engineers	<a href="http://www.asce.org/infrastructure/">http://www.asce.org/infrastructure/</a>
NFIP Community Rating System	Points awarded; can result in reduced flood insurance rates	19 Creditable activities in 4 categories	Communities may apply to FEMA for participation	Public information, mapping and regulations, flood damage reduction, warning and response	NFIP official collects data on-site from community, cadre of FEMA representative s trained to assist communities	FEMA CRS specialists, online resources, and volunteers; FEMA analyzes data and grants credit points	Credit points table marking achievements and areas to improve for communities	Federal Emergency Management Agency, National Flood Insurance Program	<a href="https://www.fema.gov/national-flood-insurance-program-community-rating-system">https://www.fema.gov/national-flood-insurance-program-community-rating-system</a>

National Scorecard

Tool	Type Score	Scope - Taxonomy	Scale - Frequency	Criteria	Inputs	Analysis	Outputs	Source	Reference
Envision Rating System	Improvement in each credit area	60 Credits in 5 categories - receive a score for each category	As requested, normally used to evaluate sustainability value of a project	Quality of life, leadership, collaboration, resource allocation, natural world, climate and risk	Data in each of the 5 categories - provided by the community or independent organization	Envision sustainability professional, third-party verification team	Scoring summary table plus award levels for points scored, awards provided by ISI	Institute for Sustainable Infrastructure	<a href="http://sustainableinfrastructure.org/rating/index.cfm">http://sustainableinfrastructure.org/rating/index.cfm</a>
Raising Expectations 2014	Ranking of states on Long-term Services and Supports for Older Adults, People With Physical Disabilities, and Family Caregivers	Rankings by 26 indicators in five different categories - Dimension Rankings	Funds provided by AARP and grant-giving foundations	Affordability and access, choice of setting and provider, quality of life and quality of care, support for family caregivers, effective transitions	Data from private homes, nursing homes, hospitals, and independent caregivers	LTSS professionals analyze based on indicators	Colored dimension ranking by state and indicators	AARP, American Association of Retired People;	<a href="http://www.longterm.scorecard.org">www.longterm.scorecard.org</a>
LEED: Leadership in Energy & Environmental Design	Certification Thresholds: Recognizes best-in-class building strategies and practices	Five rating systems with 9 credits to be earned within each system	As requested	Integrative process, location/transportation, materials/resources, water efficiency, energy/atmosphere, sustainable sites	Data provided by party interested in certification	Internal LEED evaluation	Levels of certification based on credits earned - Certified as Silver, Gold, Platinum	US Green Building Council	<a href="http://www.usgbc.org/LEED/">http://www.usgbc.org/LEED/</a>

## National Scorecard

Tool	Type Score	Scope - Taxonomy	Scale - Frequency	Criteria	Inputs	Analysis	Outputs	Source	Reference
America's Watershed Initiative	A-F, simple grade	Six broad social, environmental and economic goals, watershed or river basin scale	As requested	Transportation, Water supply, flood control, economy, ecosystems, recreation	Provided through local and regional experts and stakeholders	Collaborative team representing groups engaged in watershed, facilitated by Univ of Maryland Institute	"Circular" report cards displaying color coded scores individual metrics in each of the six major criteria and composite grade	The Great Rivers Partnership, a collaboration of private sector, non-governmental organizational and govt. agencies	<a href="http://www.greatriverspartnership.org/en-us/Pages/default.aspx">http://www.greatriverspartnership.org/en-us/Pages/default.aspx</a> and <a href="http://www.nature.org/ourinitiatives/habitats/riverslakes/programs/great-rivers-partnership/index.htm">http://www.nature.org/ourinitiatives/habitats/riverslakes/programs/great-rivers-partnership/index.htm</a>

### Resilience Tools

Tool	Type Score	Scope - Taxonomy	Criteria	Inputs	Analysis	Outputs	Source	Reference
Corps of Engineers Tier I Resilience Method (Developmental)	Quantitative, 0-100 score, similar to NOAA SeaGrant procedure	Focuses on the critical Functions, Facilities, and Features (FFF)	Engineering, environment, community sectors with respect to planning, resisting, recovering, and adapting cycle	Self-Assessment by area or project; Bottom-Up, Expert Elicitation	Coastal Resilience Tool used to produce overall resilience scores for both a present-day (50 year) and a future (75 year) storm	Resilience Scores from 0-100 for Present and Future storm hazards. Produces Good, Marginal and Poor ratings for Engineering, Environmental, and Community resilience	U S Army Corps of Engineers Engineer R and D Center; Indevlopment	Changing the resilience paradigm Igor Linkov, et al, NATURE CLIMATE CHANGE   VOL 4   JUNE 2014   <a href="http://www.nature.com/natureclimatechange">www.nature.com/natureclimatechange</a>
Resilience Capacity Index (Metropolitan Areas)	Quantitative, Relative z-Scores for metrics	Regional Economic, Socio-Demographic, and Community Connectivity sectors	12 RCI Indicators or metrics used to characterize the three sectors	data derived from public records, municipalities	In-depth, top-down tool that compares and ranks communities based on statistical analysis of metric values	Quantitative z-Scores aggregated for ssectors to create single score for major metropolitan region	University of Buffalo Regional Institute	<a href="http://brr.Berkeley.edu/">http://brr.Berkeley.edu/</a>
UN Resilience Scorecard for Cities	0-5 Scoring, Used as baseline for recent UN R!SE initiative for risk sensitive investments	Research, organization, infrastructure, response capability, environment, recovery	34 sub categories for 10 primary categories	Self-Assessment	Simple Bottom-Up Tool that asks the user to rate their community for each sub-category	Each individual sub category is rated on 0-5 scale, data are aggregated for a composite score.	United Nations International Strategy for Disaster Risk Reduction (IBM and AECOM)	<a href="http://www.unisdr.org/campaign/resilientcities/toolkit/essentials">http://www.unisdr.org/campaign/resilientcities/toolkit/essentials</a> and <a href="http://www.preventionweb.net/rise/sites/default/files/R%21SE%20Program%20Summary%20V2.pdf">http://www.preventionweb.net/rise/sites/default/files/R%21SE%20Program%20Summary%20V2.pdf</a>

# Resilience Tools

Tool	Type Score	Scope - Taxonomy	Criteria	Inputs	Analysis	Outputs	Source	Reference
Baseline Resilience Indicators for Communities (BRIC)	Min-Max rescaling to calculate Resilience Values	Community, infrastructure, environmental, and economic resilience	Ecological, Social, Economic, Infrastructure, Institutional Capacity, Community Competence	Census data, top down	Tool used to calculate relative resilience scores by community. Scores are used to rank communities as they compare to others	Resilience scores, sorted by mean and standard deviation to rank communities/counties within a resilience map	Susan L. Cutter, University of South Carolina	Cutter, SL, CG Burton, and CT Emrich (2010). Disaster Resilience Indicators for Benchmarking Baseline Conditions, J. Homeland Security and Emergency Management 7(1). Available <a href="http://www.bepress.com/jhsem/vol7/iss1/51">http://www.bepress.com/jhsem/vol7/iss1/51</a> . Cutter, S. L., K. D. Ash, and C. T. Emrich, 2014. The geographies of disaster resilience. Global Environmental Change 29: 65-

# Resilience Tools

Tool	Type Score	Scope - Taxonomy	Criteria	Inputs	Analysis	Outputs	Source	Reference
Coastal Resilience Index, SeaGrant	Resilience Index Score: Low, Medium, or High Resilience	Community resilience (housing, infrastructure, businesses)	Critical infrastructure and facilities, transportation, community plans and agreements, mitigation measures, business plans social systems	Self-Assessment, Expert Analysis and Public Records	Simple and inexpensive method of predicting if a community will reach and maintain acceptable level of functioning after a disaster	Low, Medium, or High Resilience for each of Section 2-6, as well as Critical Infrastructure and Critical Facilities	NOAA; Mississippi-Alabama Sea Grant Consortium Phone: 228-818-8829 Email: tracie.sempier@usm.edu	<a href="http://masgc.org/ri">http://masgc.org/ri</a>
Maryland CoastSmart	Sums # of "Yes" per category to determine if a community is "Coast Smart".	Coastal communities: Risk, People and Property, Infrastructure and Critical Facilities, Natural resources, Societal and Economic Impacts	Risk and Vulnerability, People and Property, Infrastructure and Critical Facilities, Natural resources, Societal and Economic Impacts	Bottom-Up, Expert Elicitation	Bottom-Up Tool used to show how resilient a community is within each of the main criterium.	"CoastSmart" Rating for each criterium. Sum categories rated CoastSmart, On The Right Track, and Getting Started to see where your community stands	Department of Natural Resources, Maryland	<a href="http://dnr.maryland.gov/CoastSmart/">http://dnr.maryland.gov/CoastSmart/</a>
TNC Coastal Resilience 2.0	Quantitative and Qualitative; Can produce different types of results	Coastal areas, natural resources, floods, storm surge, sea level rise, economic assets, socio-economic	Assess risk and vulnerability, identify solutions, take action, measure effectiveness	Expert Elicitation in order to use application	Interactive application that allows user to control all inputs	Layered maps to learn more about coastal regions	NOAA Digital Coast / The Nature Conservancy	<a href="http://maps.coastalresilience.org">maps.coastalresilience.org</a>

# Resilience Tools

Tool	Type Score	Scope - Taxonomy	Criteria	Inputs	Analysis	Outputs	Source	Reference
Vermont - Resilient Communities Scorecard	Qualitative Ranges: "Resilient Community", "In Transition", or "Needs Your Attention!"	Downtown/villages, energy costs, transportation costs, public health, climate change	Business & residential development, reduced carbon emissions, environment protection, public health, renewable energy	Bottom-Up, Expert Elicitation	Bottom-Up Tool used to categorically show how resilient a community is within each of the main criterium.	Each of the 12 categories produces 3 score ranges to see if your community is Resilient Community, In Transition, or Needs Your Attention!	Vermont Natural Resources Council	vnrc.org
FHWA Climate & Extreme Weather Risk Management Tools	Graphical, Quantitative	Resilience of Transportation Systems: Railroad, Airport, Highway	Exposure Indicators, Sensitivity Indicators, and Adaptive Capacity Indicators	Expert Elicitation and Engineering, Request Data from DCHP Database, FEMA Data	Multiple Data-Processing Tools that produce detailed graphics about a community. User can set preferences to their specific community for best results.	Charts and graphics of communities	US DOT, FHWA	<a href="http://www.fhwa.dot.gov/environment/climate_change/adaptation/publications_and_tools/">http://www.fhwa.dot.gov/environment/climate_change/adaptation/publications_and_tools/</a>
Characteristics of a Disaster- resilient Community	Qualitative	Characteristics of a Disaster-Resilient Community	Governance, risk assessment, knowledge & education, risk management & vulnerability reduction, disaster preparedness & response	Local Community Leaders	Detailed report of characteristics for a disaster-resilient community	Options for gaining resilience	UK DFID Disaster Risk Reduction Interagency Coordination Group	<a href="http://www.abuhrc.org/research/dsm/Pages/project_view.aspx?project=13">http://www.abuhrc.org/research/dsm/Pages/project_view.aspx?project=13</a>



# Resilience Tools

Tool	Type Score	Scope - Taxonomy	Criteria	Inputs	Analysis	Outputs	Source	Reference
San Francisco Planning and Urban Research Association (SPUR)	Categories: A-E	EQs: Contain effects when they occur, minimize social disruption during recovery, rebuild such that future effects are	Category A-E for all new building infrastructure; Breaks down critical response into three categories: Category I, Category II, Category III	Existing Engineering Info, Expert Analysis	Rates communities based on critical response times after an earthquake	Communities are gauged based on their placement in each of the categories	San Francisco Planning and Urban Research Association (SPUR)	<a href="http://mitigation.eeri.org/files/SPUR_Seismic_Mitigation_Policies.pdf">http://mitigation.eeri.org/files/SPUR_Seismic_Mitigation_Policies.pdf</a>
ResilUS: A Community Based Disaster Resilience Model	Quantitative	It focuses on critical services and how they return to a similar or better level of service in a reasonable amount of time. Earthquakes.	A number of different MATLAB variables for the community and neighborhood, households and business	Expert Analysis & Engineering	Uses complex data and variables to produce a myriad of graphics via the software MATLAB	A number of different graphics to measure how resilient a community is to an earthquake	University of British Columbia, Vancouver, Canada	Miles, SB and SE Chang (2013). ResilUS: A Community Based Disaster Resilience Model, Cartography and Geographic Information Science 31 (1):36-51.

# Resilience Tools

Tool	Type Score	Scope - Taxonomy	Criteria	Inputs	Analysis	Outputs	Source	Reference
The PEOPLES Resilience Framework	Quantitative and qualitative	Holistic framework for designing and measuring resilience	Population and demographics, Environmental/ecosystem, Organized governmental services, Physical infrastructure, Lifestyle and community competence, Economic, Social-cultural capital	Expert Elicitation, Community Leaders	In-depth tool used to graphically portray communities based off the PEOPLES category headings	Layered maps based off the PEOPLES category titles	US Dept. of Commerce; National Institute of Standards and Technology	Renschler, CS, AE Fraizer, LA Arendt, G-P Cimellaro, AM Reinhorn, and M Bruneau (2010). A Framework for Defining and Measuring Resilience at the Community Scale: The PEOPLES Resilience Framework. Washington D.C.: NIST <a href="http://www.esf.edu/glrc/library/documents/FrameworkforDefiningandMeasuringResilience_2010.pdf">http://www.esf.edu/glrc/library/documents/FrameworkforDefiningandMeasuringResilience_2010.pdf</a>

# Resilience Tools

Tool	Type Score	Scope - Taxonomy	Criteria	Inputs	Analysis	Outputs	Source	Reference
Communities Advancing Resilience Toolkit (CART)	Creates basis for planning, no index	Community centric	Four Domains: Connecting and caring, Resources, Transformative potential and Hazard or Adversity	Input from community stakeholders and advisors, collaborative meetings	SWOT Analysis by Community team	Goals to achieve resilience through four domains	Department of Homeland Security funded, Terrorism and Disaster Center (TDC) of the National Child Traumatic Stress Network, at the University of Oklahoma.	<a href="https://www.oumedicine.com/psychiatry/research/terrorism-and-disaster-center/interventions/community-resilience-(cr)">https://www.oumedicine.com/psychiatry/research/terrorism-and-disaster-center/interventions/community-resilience-(cr)</a>