NIST Community Resilience Planning / Assessment Tools – Flood Risk

Jennifer Helgeson, Ph.D.

Applied Economics Office, Engineering Laboratory,
National Institute of Standards & Technology (NIST), U.S. Department of Commerce

Commission for Environmental Cooperation
CEC Project: Costing Floods and Other Extreme Events

National Institute of Standards and Technology
U.S. Department of Commerce

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Our Research Objective and Plan

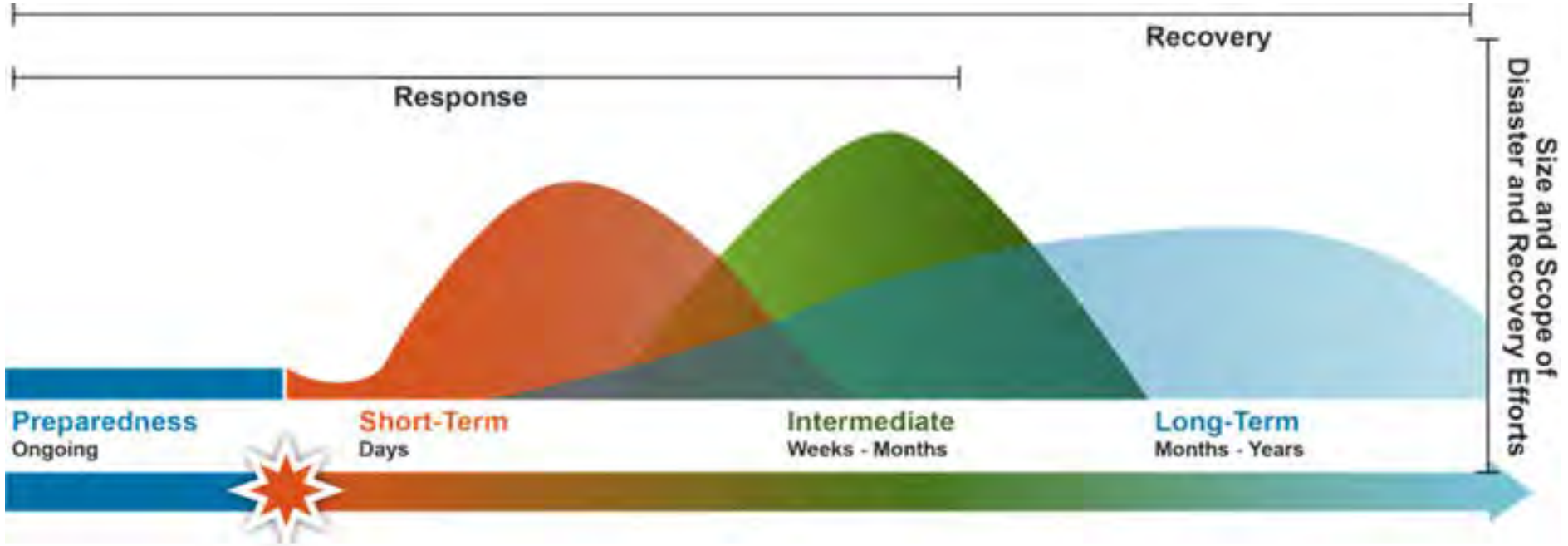
Objective: To support community resilience planning through the development of tools that evaluate the economic impacts of disruptive events, including accounting for uncertainties of future events and measuring the co-benefits from resilience planning actions.

Research Plan:

- Creation and formal acceptance of Standard Practices
- Measurement of disturbance and (direct) disaster-related costs and related perceptions
- Measurement of disaster losses, focusing on major indirect losses, such as business interruption, and distributional effects
- Quantification of the uncertainty (objective and perceived) affecting economic decisions
- Measure the 'resilience dividend,' the (non-disaster related) community co-benefits from investing in disaster resilience

Context

- We are increasingly in a VUCA state (VOLATILE, UNCERTAIN, COMPLEX, and AMBIGUOUS) (Millar et al., 2018; Gerras, 2018)
- “Utility in understanding multi-hazards that manifest as COMPLEX EVENTS from the concurrent pandemic and natural disasters…Operating in a multi-risk environment with slow- and rapid-onset disasters, persistent stressors, and economic shocks requires taking a whole-system approach to analyzing complex events that arise from compound* and/or cascading risks. ” (Helgeson et al., 2020).



*We take concurrent risks to be a subset of compound risks.

Fig. Natural Disaster Recovery Framework (FEMA)

Why Community Resilience Planning?

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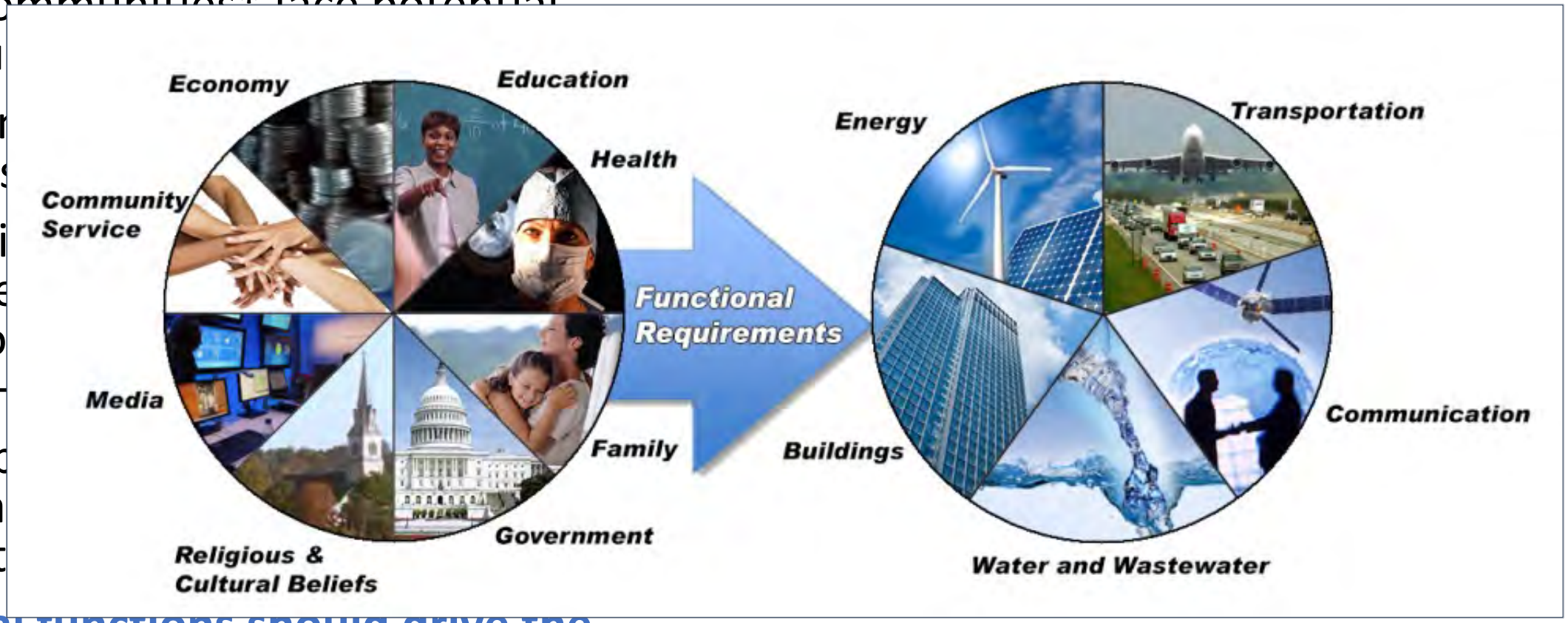
- **Social functions should drive the performance goals** of buildings and physical infrastructure.



*A community has a defined geographic boundary and some form of leadership structure

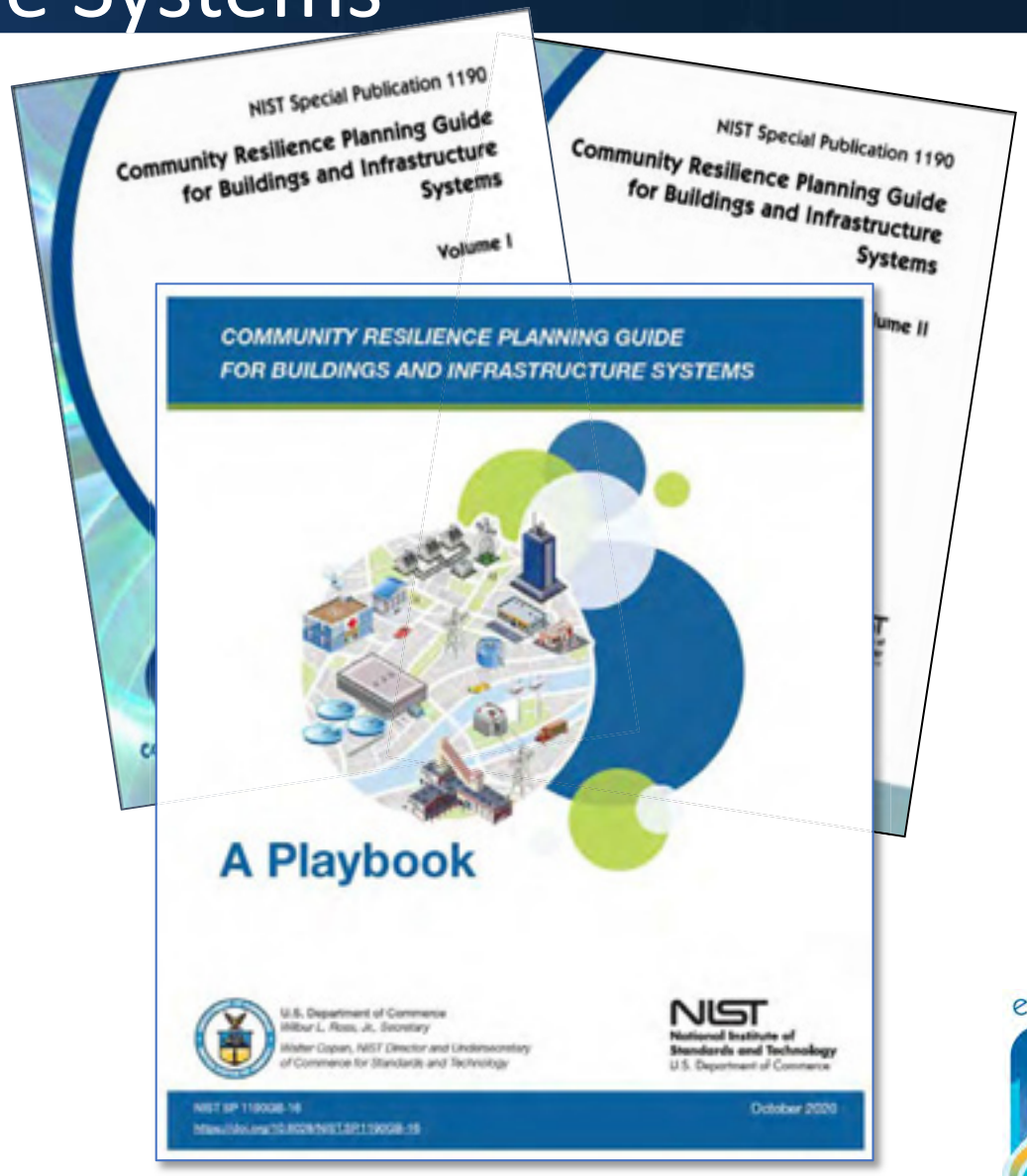
NIST Community Resilience Planning Guide for Buildings and Infrastructure Systems

A **practical, flexible methodology** to set priorities, allocate resources, and manage risks…improving resilience.

A way to **turn resilience concepts into action**: some actions may be near-term, while others may require a long-term planning horizon.

A suite of available planning guidance:

- Two volume planning guide
- **Action-oriented Playbook**
- Guide briefs
- Fillable templates



Six Steps to Community Resilience Planning

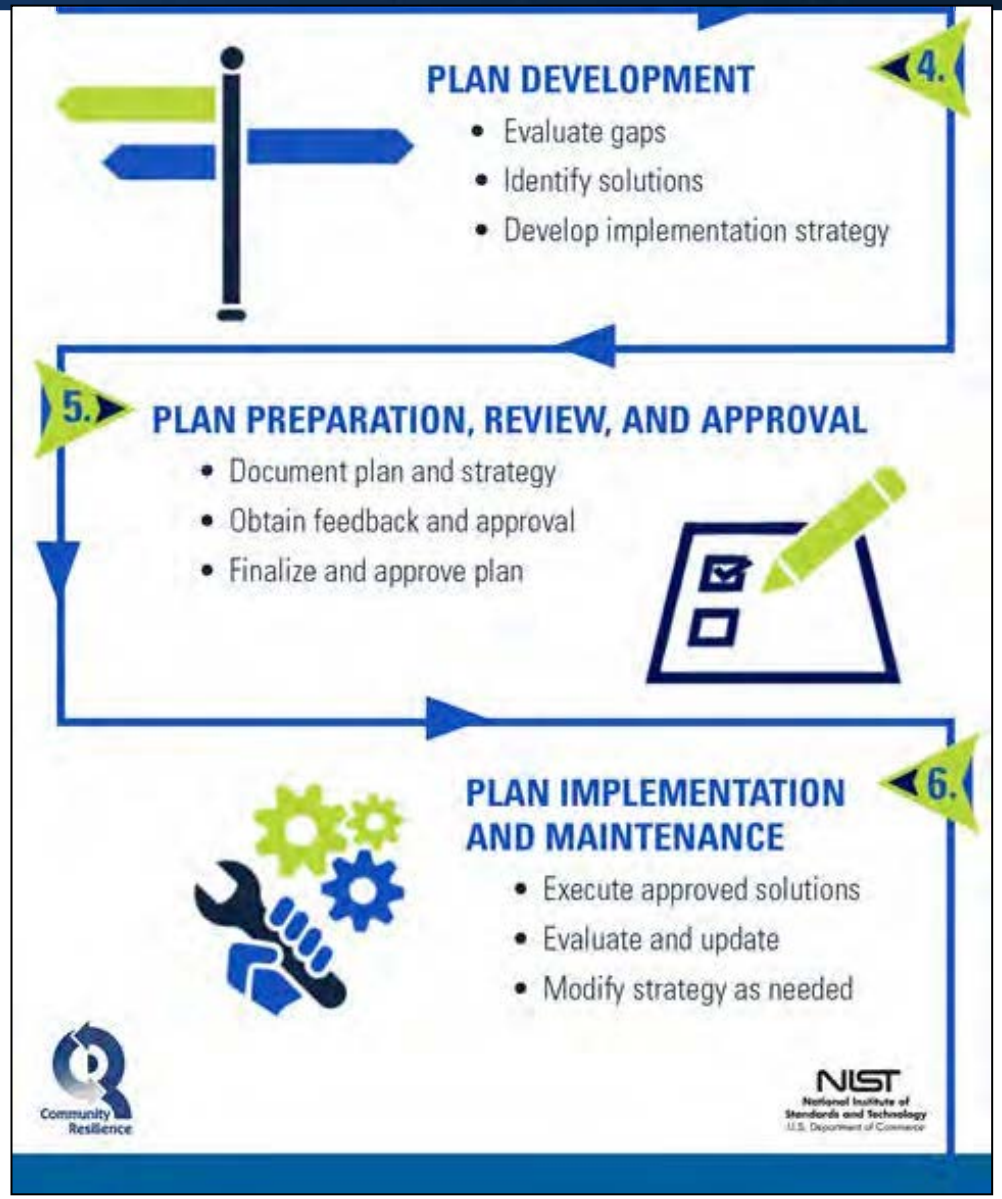


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Table 2-1. Example of linking the functional category of Critical Facilities and its Building Cluster to social functions and services (Action 2-4)

Functional Category	Building Cluster	Functions and Service Provided
Critical Facilities	Critical Medical	Acute care
	Acute Care Hospitals	Triage, emergency care
	Emergency Operations Centers	Transportation coordination
		9-1-1 services, dispatch
		Emergency Operations
		Incident response coordination (e.g., utilities, public safety agencies, etc.)
	Critical Government - First Responder Facilities	Transportation, road access, debris removal
		Communication
		Internal IT System functionality
		Fire, emergency services
		Police, public safety
		Building safety assessment
		Response services documentation and records
		Trash, debris landfill
	Non-ambulatory Facilities - Prisons, nursing homes, etc.	Shelter, food, care, security
		Adult care, nursing, custodial care

Action 2-5: Link Social Functions to Built Environment

Table 2-2. Example of linking social institutions and transportation systems (Action 2-5)

Social Institution	Purpose of Transportation within each Social Institution	How Actualized within Built Environment	Possible Impacts if Transportation Systems are Damaged	
			Direct	Indirect
Family	Access to and from housing	Roads, bridges, and tunnels Airports Railways and stations Seaports Pipelines Public transit	Displaced population (lack of access) Inability to physically connect with others	Demand for short-term/ nearby shelter
Economic	Distribute goods for processing Obtain labor and capital Distribute intermediate goods Distribute final goods for sale Bring sellers (providers) and consumers together Getting to and from work		Loss of access to raw materials Loss of employment Increase in commuting time and cost Consumers unable to obtain goods and services	Loss of taxes, market share Price increases

Action 3-4: Determine the anticipated performance of buildings and infrastructure systems

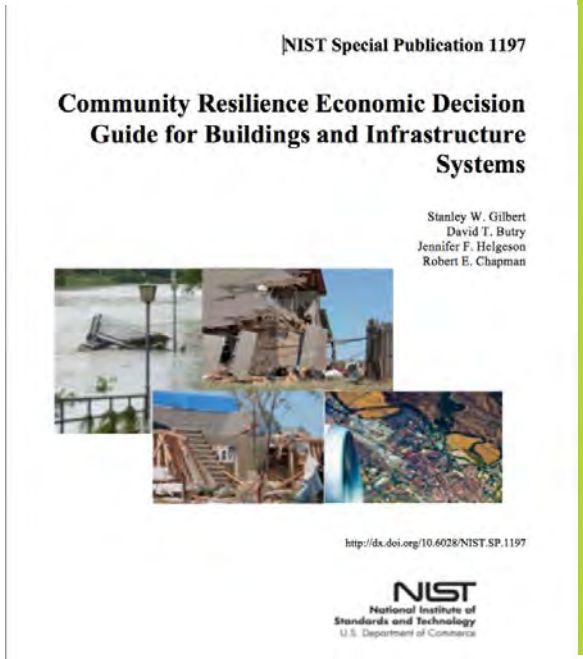
How long will it take to recover community functions for a hazard event given the current state of the built environment and the estimated level of damage and loss?

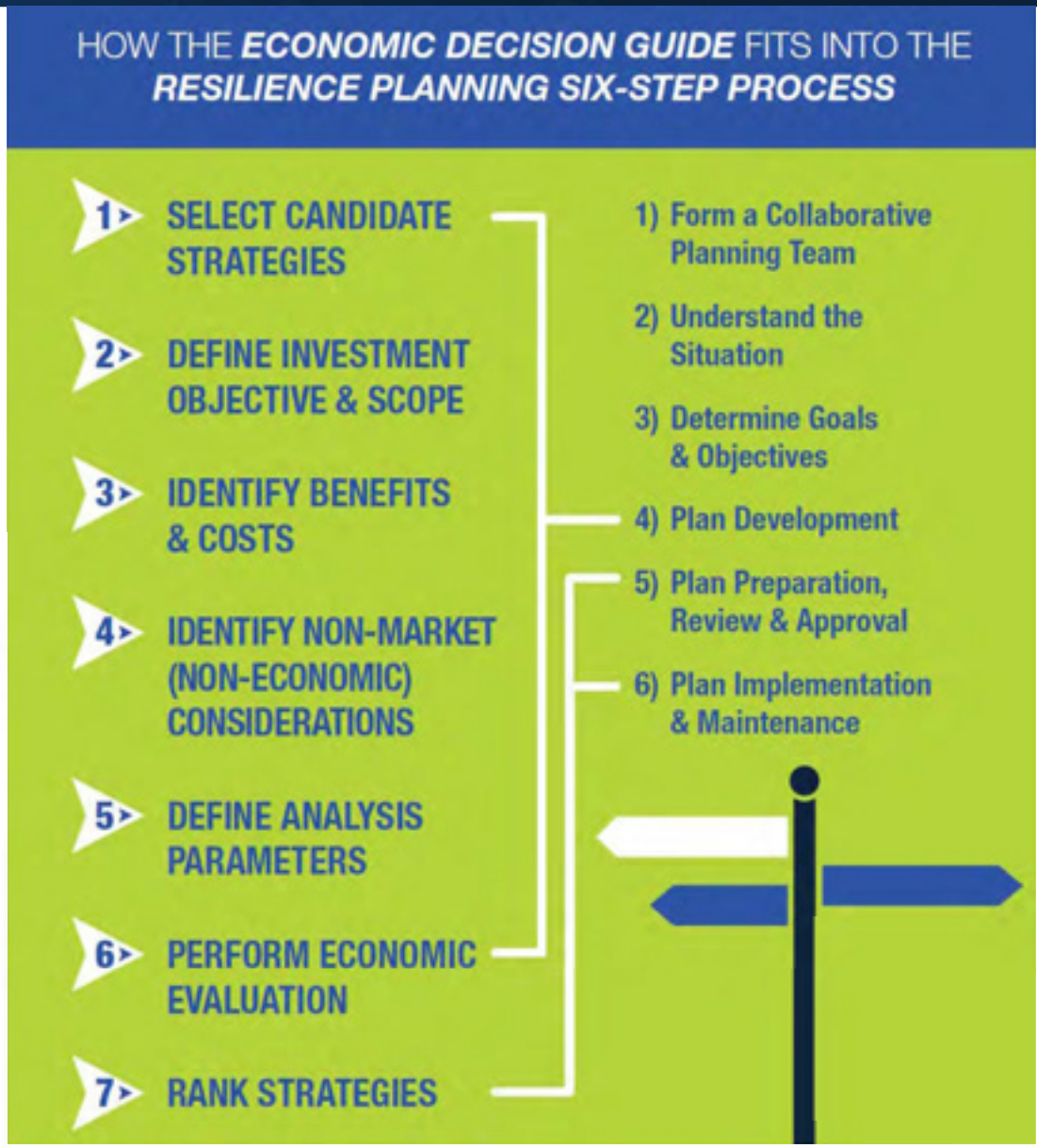
- Expert Judgement
- Past Hazard Experience
- System-Level Assessment
- Building or Community-Level Assessment

Economic Decision Guide

- Standard methodology for evaluating investment decisions to improve a community's resilience capacity
- Accounts for low-probability, high-consequence events – traditionally challenging for economic frameworks
- Mechanism to evaluate and prioritize efficiency of resilience actions/options.

- Can integrate community resilience plans with economic development, zoning, hazard mitigation, and other community planning activities that affect buildings, public works, and infrastructure systems



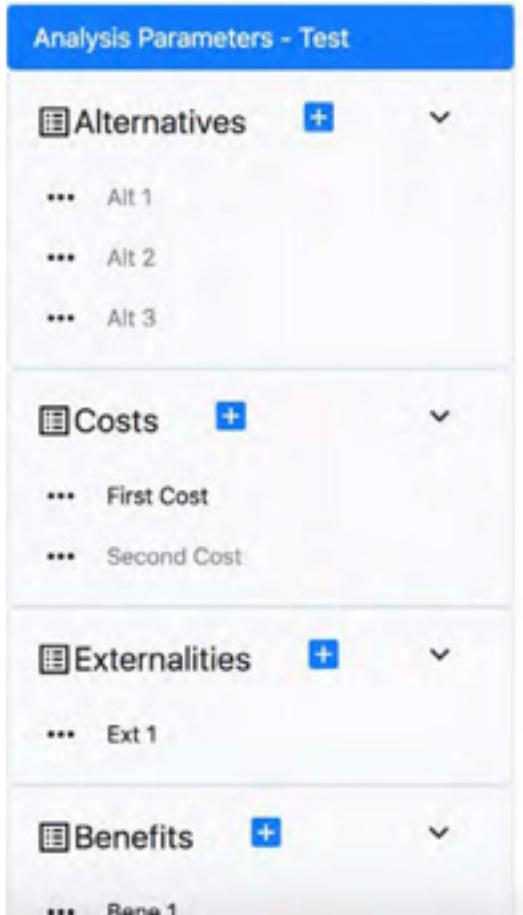


EDGe$ Online Tool V. 1.0

- Provides a standardized approach to weigh the benefits and costs of investments into community resilience
- Easy-to-use online, platform-independent app EDGe$ V1.0 newly released
- Step-by-Step User Guide with example community resilience planning scenarios
- Designed for community leaders to integrate resilience plans with other planning activities that affect buildings, public works, and infrastructure systems

  Mechanism to increase return-on-investment from community resilience planning

  Features include: low-probability, high-consequence events, uncertainty analysis, co-benefits of resilience planning



Available at: https://edges.nist.gov/

EDGe$ Online Tool V. 1.0

- ASCE Manual of Practice Chapter developed
- ASTM E3130 “Standard Guide for Developing Cost-Effective Community Resilience Strategies” to develop cost-effective community resilience strategies” developed in parallel.
- External interactions:
  - Federal level: FEMA BCA tool/Building Resilient Infrastructure and Communities (BRIC), NOAA Regional Offices
  - University Curriculum: UDC, UMUC, SMU
  - Technical support for users: e.g., Jackson County, MS and DelDOT
  - *Collaborating with East Carolina Uni. to test EDGe$ in the “Preparing for, Responding to, and Mitigating Compound Water Hazards for Resilient Rural Communities” project, funded under NOAA’s Climate and Societal Interactions Programs*

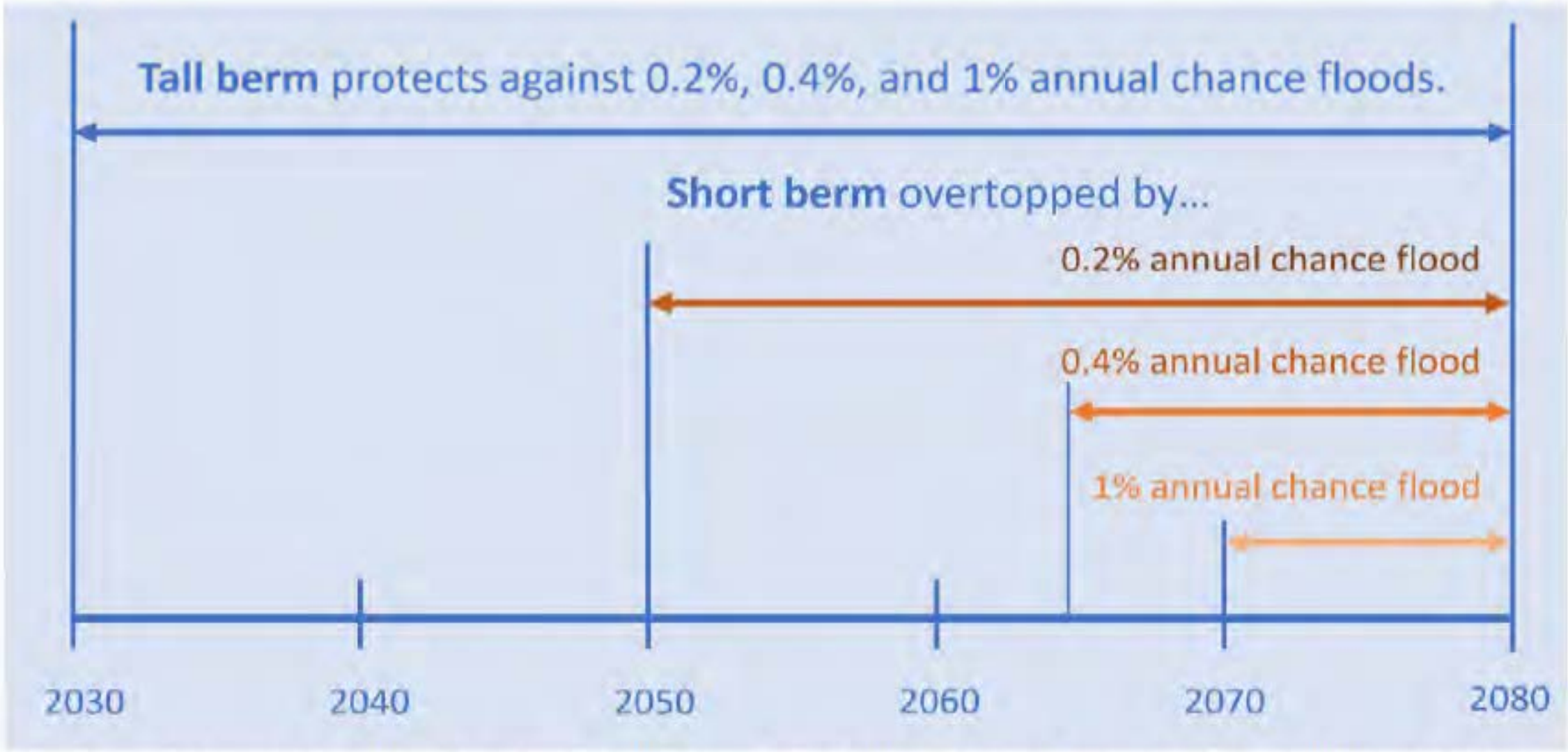
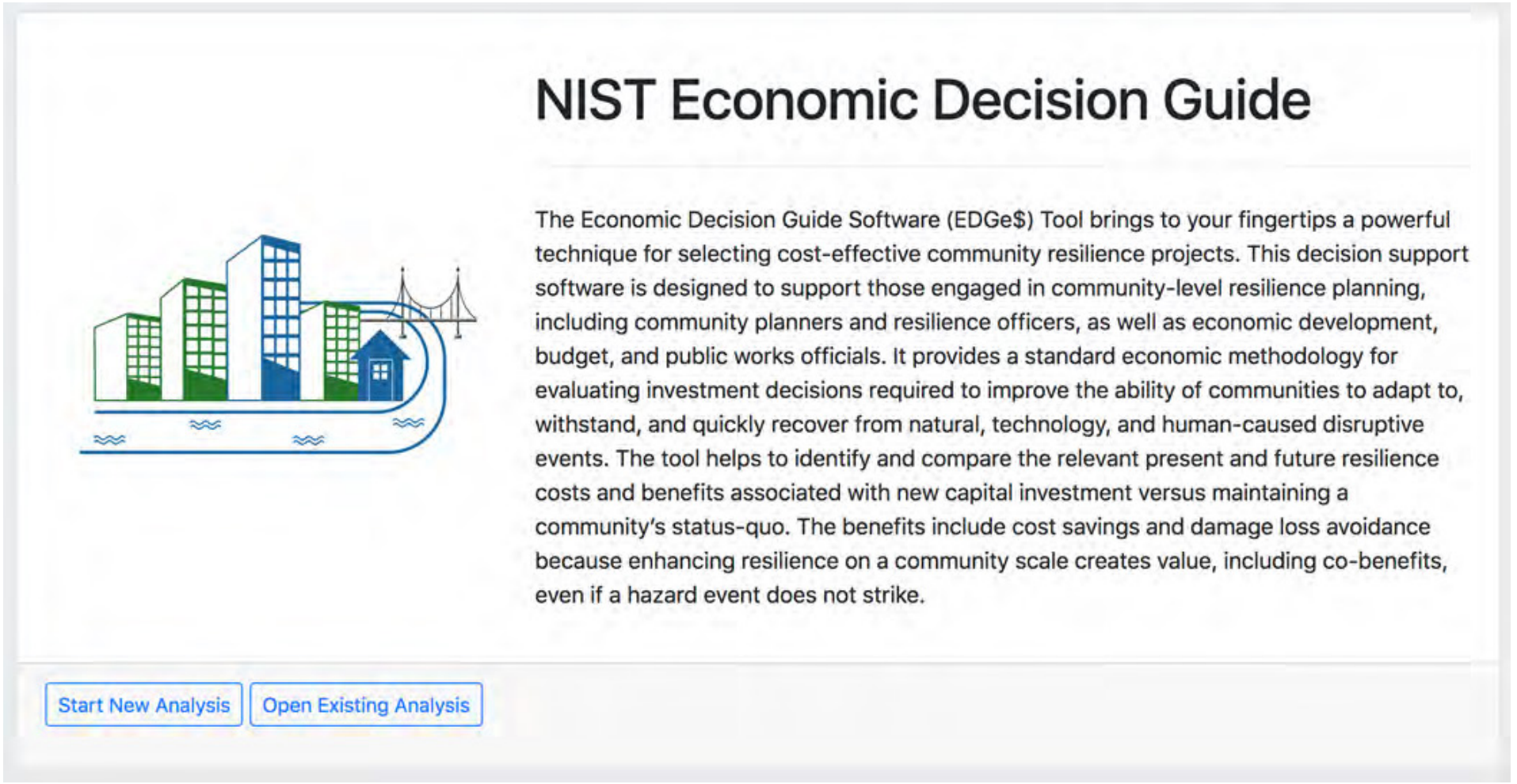


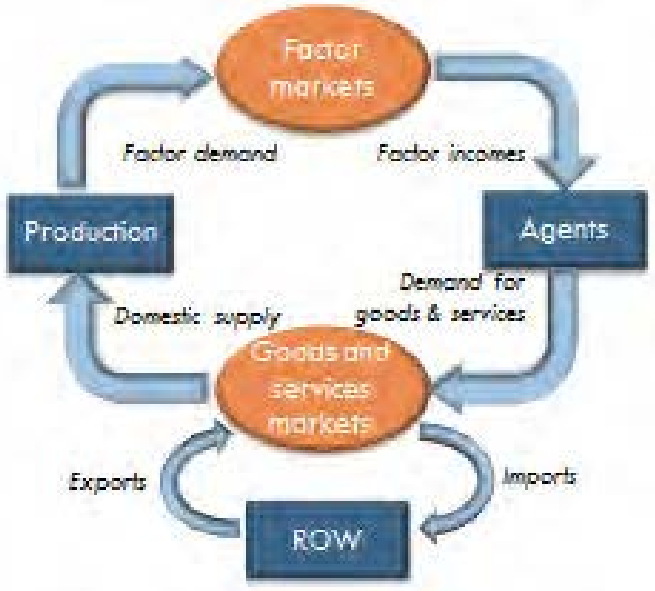
Fig. 1: Performance of the short and tall berms over the planning horizon. The tall berm protects against the 1%, 0.4%, and 0.2% annual chance flood events throughout the planning horizon. The short berm is projected to be overtopped by: the 0.2% annual chance event by 2050, the 0.4% annual chance event by 2065, and the 1% annual chance event by 2070.

EDGe$ Tool Online Demo



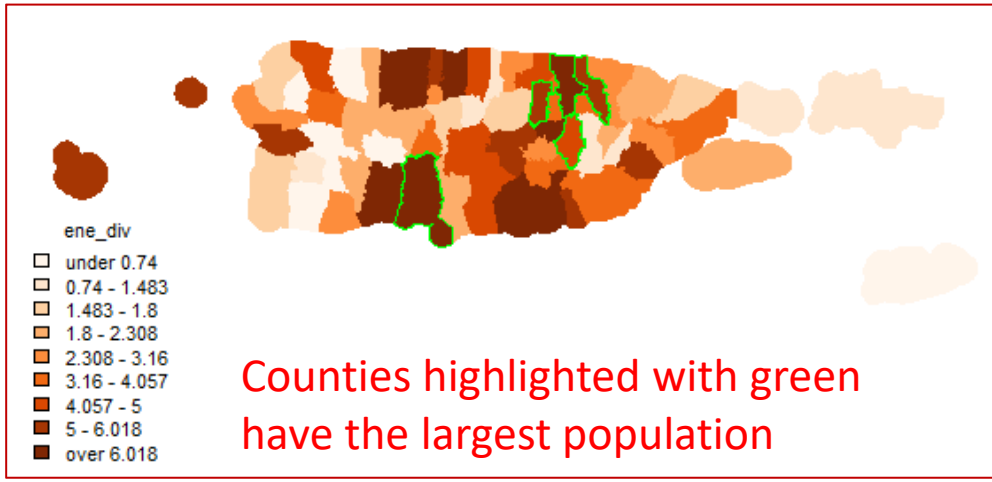
Valuing Co-Benefits / CGE Model

- **Resilience** dividend is the net **co-benefit** (**or co-cost**) of investing in enhanced **resilience**, in the absence of a disruptive incident. (Fung and Helgeson, 2017)
- Developed process to quantify the resilience dividend
- Case study based on flooding in Cedar Rapids, Iowa
  - Flooding (severe): 2008, 2016
  - Data available to compare 2007 and 2015 snapshots of the economy
  - Co-benefit example: Increased revenue from build-up of downtown areas (able to differentiate downtown from other areas in the CGE model)



Tracking Community Resilience (TraCR) Database

- **TraCR (Tracking Community Resilience) Database Development**
  - Database of existing and new data/indicators for social, economic, and physical systems (e.g., energy, water, communications, etc.)
  - Foundational source for developing analytical methods for indicators
  - Web-based tool *TraCR* v0.2
    - Drop-down menus with downloadable CSV files
    - "Click by State" and "Click by County" data selection and download
    - Contract awarded to develop automation scripts for data updates
- **New data collected for *TraCR* v0.2** (2000-2016)
  - New indicators for economic and physical systems
    - 93 variables
    - 25 unique sources
    - 3230 counties (50 US states, USVI, PR)



Counties highlighted with green have the largest population

Energy Diversification Measures

Transmission network produced by transmission lines using spatial analysis and R software

Distance between nodes (e.g., substation) is computed with unweighted breadth search first (BSF) algorithm (shortest path)

60 counties have at least one node point within the county boundary, nearest node points were identified for the rest of the 21 counties

Conceptual Foundation

Few well established, validated quantitative assessment methodologies for resilience

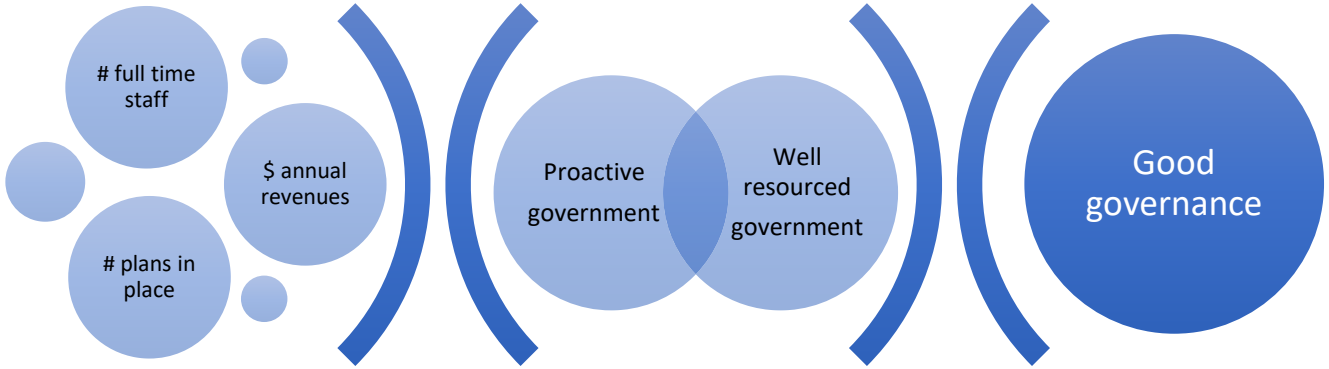
- Yet many resilience assessment frameworks and methodologies exist

Importance of both leading and lagging indicators

- Recovery indicators measure the post-event response of the community (lagging)
- Resilience indicators can assess the likely response of the community pre-event (leading)

Eye to the end goal

- Enabling smart decisions through our measurement choices
- **Ultimate goal of decision support**



Measures:

How can we measure the critical elements?

Indicators:

What are critical elements of this concept?

Composite indicator:

What is the big concept?

Composite Indicators

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Thank You

Jennifer Helgeson

Jennifer.Helgeson@nist.gov

Planning Guide: https://www.nist.gov/topics/community-resilience/planning-guide

EDGe$ Online Tool: https://edges.nist.gov

Website: https://www.nist.gov/topics/community-resilience

https://www.nist.gov/people/jennifer-f-helgeson

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Image Source (L-R): (1) Getty Images, Oct 23, 2017; (2) Sonoma Magazine, Oct 23, 2017. (3) NPR, Getting Back What You Lost — Rebuilding In A Wildfire Zone, Oct 16 2018; (3)

EXTRA SLIDES

Table 3-3. Example Building Cluster Table: Desired Performance Goals and Anticipated Performance (Action 3-4)

Building Clusters	Design Hazard Performance								
	Phase 1: Short-Term			Phase 2: Intermediate			Phase 3: Long-Term		
	Days			Weeks			Months		
	0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Critical Facilities									
Emergency Operation Centers	90%							X	
First Responder Facilities	90%							X	
Memorial Hospital	90%							X	
Non-ambulatory Occupants (prisons, nursing homes, etc.)	90%							X	
Critical Factory	90%							X	
Emergency Housing									
Temporary Emergency Shelters	30%	90%							X
Single and Multi-family Housing (shelter in place)	60%			90%					X
Housing/Neighborhoods									
Critical Retail		30%	60%	90%					X
Religious and Spiritual Centers			30%	60%	90%				X
Single and Multi-family Housing (full Function)			30%		60%		90%		X
Schools			30%	60%	90%				X
Hotels & Motels			30%		60%	90%			X
Community Recovery									
Businesses – Non-critical Factories				30%	60%	90%			X
Businesses - Commodity Services				30%	60%		90%		X
Businesses - Professional Services				30%		60%		90%	X
Conference & Event Venues				30%		60%		90%	X

Disturbance	
Hazard Type	Flood
Hazard Level	Design
Affected Area	Community
Disruption Level	Moderate

Cluster Recovery Levels	
30%	Minimal
60%	Functional
90%	Operational
X	Anticipated Performance

Action 3-5: Summarize the results

Table 3-4: Example Summary of Goals and Anticipated Performance (Action 3-5)

Summary Resilience Table	Design Hazard Performance								
	Phase 1: Short-Term			Phase 2: Intermediate			Phase 3: Long-Term		
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Critical Facilities									
Buildings	90%							X	
Transportation		90%	X						
Energy		90%	X						
Water			90%		X				
Wastewater				90%				X	
Communication	90%			X					
Emergency Housing									
Buildings				90%					X
Transportation			90%	X					
Energy				X					
Water			90%		X				
Wastewater				90%				X	
Communication				90%	X				
Housing/Neighborhoods									
Buildings						90%			X
Transportation			90%	X					
Energy			90%	X					
Water				90%				X	
Wastewater					90%			X	
Communication				90%			X		
Community Recovery									
Buildings								90%	X
Transportation				90%	X				
Energy			90%	X					
Water				90%				X	
Wastewater							90%	X	
Communication				90%			X		

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Step 4: Plan Development

Objective

Evaluate the gaps in desired and anticipated performance of the built environment, identify administrative and construction solutions, and set priorities for addressing critical gaps based on the community's resilience goals.

Actions to Accomplish

- ☐ 4-1: Evaluate the gaps between the desired and anticipated performance of the built environment and summarize the gap evaluation.
- ☐ 4-2: Identify solutions to address gaps including both administrative and construction options.
- ☐ 4-3: Prioritize solutions and develop an implementation strategy.

Action 4-1 and 4-2: Gap Evaluation & Solution Identification

Action 4-1: Evaluate gaps

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Action 4-2: Identify administration and construction solutions (Examples)

Administration Solutions

- Organize and maintain a resilience office with designated leadership.
- Align and integrate the resilience plan with other community plans
- Utilize land use planning tools

Construction Solutions

- Identify opportunities for natural resource protection and preservation
- Retrofit public buildings
- Adopt and enforce the latest national model building codes, standards, and regulations (new construction)

Community Focus

- National Disaster Recovery Framework (2016)
  - Community Focused Recovery: “The responsibility of preparing for disaster recovery begins with the individual and builds to the larger responsibility of the community and local government. The **local government has the primary role of planning and managing all aspects of the community’s recovery.**”
  - “…community assumes leadership in **developing recovery priorities** and activities that are realistic, well-planned, and clearly communicated.”
- Fulfilling this vision can be a technically complex, organizationally complex, and resource-intensive process.
- Resilient communities can:
  - Rapidly recover after disruptions
  - Specify & implement actions to meet recovery, reopening, restoration goals
  - Determine the phasing & sequence of recovery


Joplin 2011 Tornado


2017 Tubbs Wildfire

Guide Outcomes

- Representative, inclusive planning process reflecting the community's characteristics and residents
- Describe how a community's social functions connect to built environment (buildings & infrastructure)
- Specify recovery goals of elements of built environment
- Assessment of built environment's current ability to meet specified goals
- **Basis for future project planning & prioritization**

Examples of NIST Guide Use

Nashua, New Hampshire

- Resilience for Flood and Earthquake
- https://www.nist.gov/blogs/taking-measure/toward-resilient-nashua-new-hampshire

Boulder County, Colorado

- Developed a **resilience design performance standard** for evaluating community projects
- http://www.bccollaborative.org/

Fort Collins, Colorado

- Resilience for Floods, Fires, and Heat
- https://citiesspeak.org/2016/07/18/how-the-city-of-fort-collins-is-making-community-resiliency-a-reality/

Bozeman, Montana

- Resilience and Climate Adaptation
- https://www.bozeman.net/government/sustainability/initiatives

Clemson University

- Teaching courses in Community Resilience using the Guide

How NIST Defines Resilience

Resilience is the ability to ***prepare for*** and ***adapt to*** changing conditions and to ***withstand*** and ***recover rapidly*** from disruptions.

Community resilience goes beyond mitigating risk and includes implementing measures to ensure that the community recovers its functions in a specified timeframe.

Tulsa, OK Bishop Tract Detention Facility

Image: http://www.100resilientcities.org/learning-from-disaster-tulsas-resilient-floodplain-design/

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