

New Economic and Modeling Frameworks to Inform More Sustainable and Resilient Futures

Interagency Collaborative on Environmental Modeling and Monitoring

Annual Public Meeting: March 17-18, 2020

U.S. Geological Survey (USGS) Headquarters, Reston, VA

Theme: Integrated Modeling, Monitoring, and Working with Nature

Jennifer Helgeson, Ph.D.

Applied Economics Office, Engineering Lab

National Institute of Standards and Technology

Outline

- NIST Community Resilience Tools and Research
- Economic Decision Guide Software (EDGe\$) Online
- Business Surveys
- Valuing Net Co-Benefits of Resilience

How NIST Defines Resilience

Resilience is the ability to prepare for and adapt to changing conditions and to withstand and recover rapidly from disruptions. (PPD-8, PPD-21)



Tulsa, OK Bishop Tract Detention Facility

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

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

NIST Community Resilience Program: Overview

<https://www.nist.gov/topics/community-resilience>

Community Engagement: Outreach, Collaboration, and Input

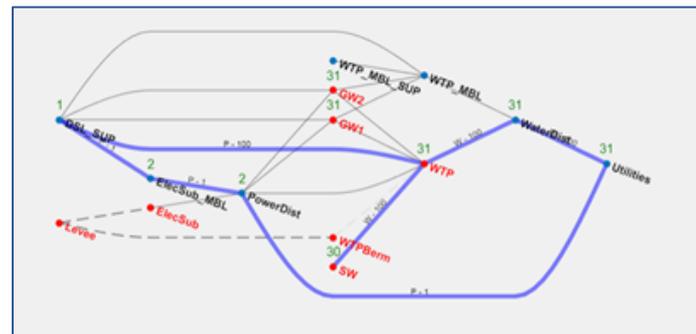
- **Resilience needs** of communities – planning, data, tools, guidance
- **Data and decision ‘levers’** – being used or needed

Science-Based Tools: Assess resilience and support informed decision making

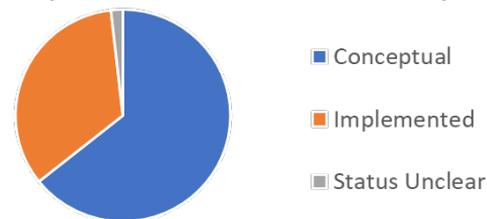
- **Guidance and best practices** – social, economic, built systems
- **Modeling** – pre- and post-event performance assessment, generation of alternative actions
- **Metrics** – quantitative and qualitative resilience and recovery indicators
- **Economics** – Small business continuity, quantifying net co-benefits, improved BCA guidance
- **Codes and standards** – Improved design and assessment methods

Disaster and Failure Studies: Metrology for field studies and data collection

- Improved field **tools and methods**
- Integrated and longitudinal **data collection**
- Focus on damage and loss of **function/service**



Inventory of 56 Frameworks
(3900 indicators, 7100 measures)



NIST-funded CoE: Center for Risk-Based Community Resilience Planning

- Led by Colorado State University with 13 institutions
- Renewed for 5 more years of collaboration with NIST
- Objectives
 - **Community modeling (IN-CORE)**
 - Modular systems analysis environment
 - Physical: Buildings, infrastructure, interdependencies
 - Social: Population dislocation, housing, social institutions
 - Economic: Tax base, revenue/income
 - Decision support: Metrics, optimized resilience planning options
 - First release with 2 case studies – December 2019
 - <https://www.nist.gov/news-events/news/core-v100-released>
 - **Data Science and Field Studies**
 - Multi-disciplinary, multi-scale data integration
 - Standard formats
 - Testbeds – Centerville (virtual); Seaside, OR; Galveston, TX; Shelby County, TN; Mobile, AL
 - Validate models and tools
 - Hindcast - Joplin, MO
 - Field Study – Lumberton, NC
 - **Decision Support and User Engagement**
 - Risk-informed decision support algorithms, decision levers
 - Community engagement program, user consortium



<http://resilience.colostate.edu/>



<https://incore.ncsa.illinois.edu>

<https://github.com/IN-CORE/>

NIST Community Resilience Planning Guide

6-Steps to Community Resilience Planning



NIST Community Resilience Planning Guide – Upcoming Products

- Increasing accessibility of CR planning concepts and methods with CR Playbook
 - Expected Spring 2020
- Developing standard for practice based on CR Planning Guide
- Engagement with communities and community associations with Community Resilience Planning Guide
 - Dissemination of approach
 - Input for updating guidance



Coming Soon!

A PLAYBOOK FOR COMMUNITY RESILIENCE PLANNING

Communities want to prepare for risks to natural and other hazards. The **Community Resilience Planning Guide for Buildings and Infrastructure Systems** provides a flexible, practical, and goal-driven process for communities to come together and take the necessary steps to increase their resilience.

The *National Institute of Standards and Technology (NIST)* produced the Guide based on the experience and expertise of community officials and technical experts who have gone through hazard events. The Guide's six-step process encourages community leaders to think holistically and systematically about connecting a community's values to the role buildings and physical infrastructure systems play in meeting their resilience goals.

In early 2020, NIST plans to release a new **playbook** that provides an accessible and action-oriented aid to help communities to get the most out of the Guide. The playbook is designed to be useful to varied stakeholders for all communities facing any type of hazard:

- Elected or career officials in the public sector including Planning, Emergency Management, and Public Works
- Private sector businesses including manufacturers and service providers
- Non-profits and volunteer organizations

More Information

To be notified when the (free) **playbook** is available contact: resilience@nist.gov

More about NIST
Community Resilience Program:
<https://www.nist.gov/topics/community-resilience>

Economic Decision Guide & EDGe\$ Online Tool

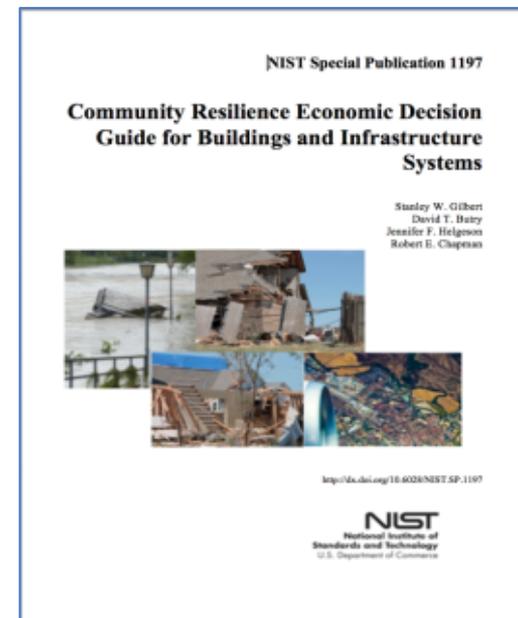
Economic Decision Guide (EDG) (1)

- Designed for use with NIST's *Planning Guide* to evaluate and prioritize resilience actions or as a standalone process
- Standard methodology for evaluating investment decisions for community resilience

ASTM Standard E3130-18:

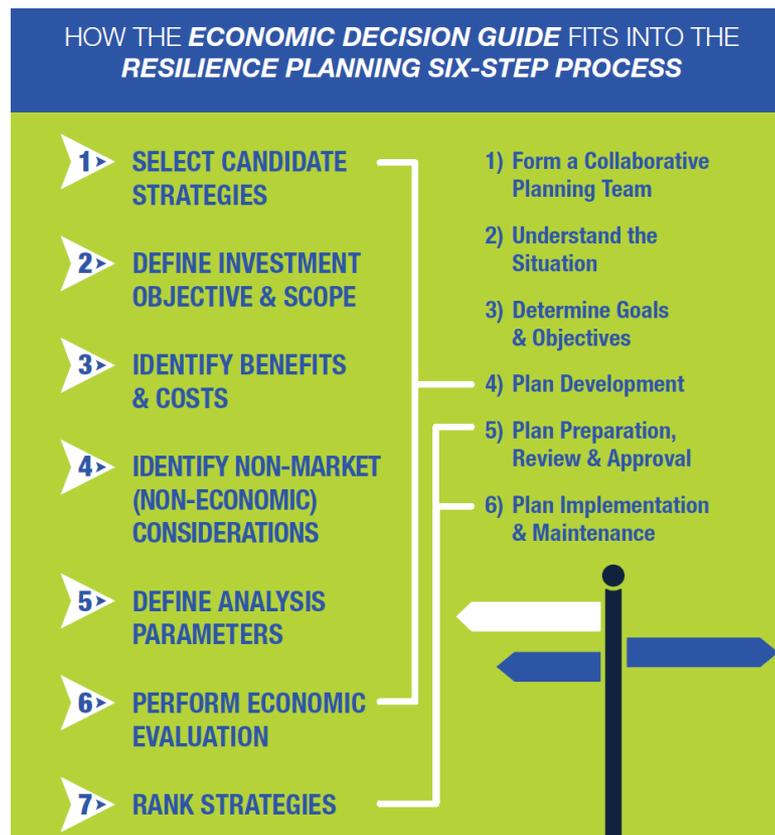
Standard Guide for Developing Cost-Effective Community Resilience Strategies

- Frames the economic decision process
 - Identifies and compares resilience-related benefits & costs, resilience dividends
 - EDGe\$ Online Tool



Economic Decision Guide (EDG) (2)

- Data Sources
 - Community plans (e.g., comprehensive plan, etc.)
 - Engineers/planners – cost estimates
 - Socio-economic – cost estimates and goals
 - Tools for optimum decision sets
 - Tools/estimates for (non-market) considerations
- Decision makers
 - Collaborative planning team with engagement of stakeholders
 - Budget Office/Board
- **Supports decisions on:**
 - **Resilience baselines**
 - **Viable project options aligned with community goals**

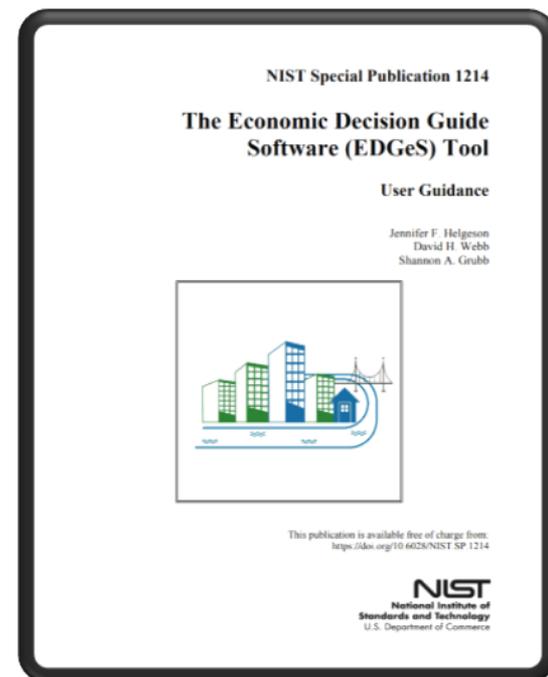


EDG Process Overview



Economic Decision Guide Software (EDGe\$) Online Tool (1)

- 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
 - Based on ASTM Standard E3130: *Standard Guide for Developing Cost-Effective Community Resilience Strategies*
- 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



EDGE\$ Online Tool (2)

- Easy-to-use web-based, platform-independent app
- Mechanism to increase return-on-investment from community resilience planning
- Easy-to-use software tool to assist decision makers in making resilience planning choices
- Designed for economists and non-economists working on community resilience planning
- Step-by-Step User Guide with example community resilience planning scenarios

Brand NEW EDGE\$ Online Tool, Version 1.0
JUST RELEASED: <https://edges.nist.gov>

Now seeking First Users



EDGE\$ User Capabilities

- Collect and input information on alternative resilience projects the community is considering
- Uncertainty (user defined):
 - hazard probability,
 - benefits, costs,
 - co-benefits, co-costs
- Collect information on alternative resilience projects under consideration
- Externalities: Bearers of costs/benefits
- Users can input (dollar) values and descriptions for all costs and benefits for each project
- **Net co-benefits/resilience dividend (i.e., “non-disaster related benefits”)**

EDGe\$ Outputs

- *EDGe\$ includes, but exceeds, the required Federal Emergency Management Agency (FEMA) Benefit-Cost Analysis (BCA) elements.*
- Includes metrics with and without consideration for externalities:
 - Net Present Value
 - Benefit-to-Cost Ratio
 - Internal Rate of Return
 - Return on Investment (ROI)
 - Non-Disaster ROI



NIST Economic Decision Guide Software

The Economic Decision Guide Software (EDGE\$) Tool brings to your fingertips a powerful technique for selecting cost-effective community resilience projects. This decision support software is designed to support those engaged in community-level resilience planning, including community planners and resilience officers, as well as economic development, budget, and public works officials. It provides a standard economic methodology for evaluating investment decisions required to improve the ability of communities to adapt to, withstand, and quickly recover from natural, technology, and human-caused disruptive events. The tool helps to identify and compare the relevant present and future resilience costs and benefits associated with new capital investment versus maintaining a community's status-quo. The benefits include cost savings and damage loss avoidance because enhancing resilience on a community scale creates value, including co-benefits, even if a hazard event does not strike.

[Login](#)

[New User](#)

EDGE\$ Case Studies / Examples

1. Adoption of a Wildfire Urban Interface (WUI)-specific code

After a WUI fire sweeps through town, a community considers a WUI-specific building code.

2. Land reclamation

After a major flood, a town considers purchasing all (or a percentage) of private homes in the 100-year flood plain.

3. Hospital relocation

A town at risk of flooding is worried its hospital is too close to the flood source and may be inaccessible in a major event.

4. Levee and pump system construction

A town considers building a levee to prevent flooding due to a 50- or 100-year event

Survey Efforts

Small- and Medium-Sized Business Interruption & Recovery

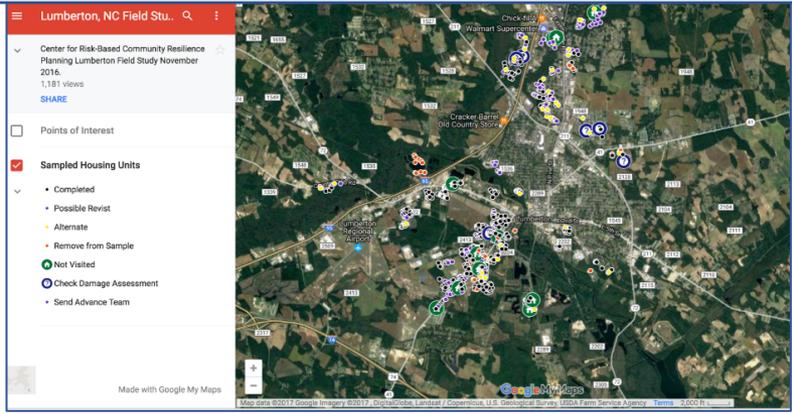
NIST and CoE Longitudinal Field Study

Impacts from Hurricanes Matthew and Florence in the Community of Lumberton, North Carolina

- Novel field study data collection methods:
 - Focus around social dimensions (*e.g., education*) critical to community resilience
 - Surveys and sampling plans ensure representation of physical damage, socio-demographics, housing types, and business sectors
 - Structured surveys that integrate physical and social impacts and track recovery over time



**NIST Special
Publication
(NIST SP 1230)**



Businesses – Importance of the Small- and Medium-Sized

- *Almost 50% of the US workforce is employed by a small business. (1)*
- “Small businesses are the lifeblood of the U.S. economy: they create two-thirds of net new jobs and drive U.S. innovation and competitiveness. [A new report](#) shows that they account for 44 percent of U.S. economic activity.” (2)
- “Ninety-seven percent of all exporters are small business owners, comprising 29% of total exports, and nationally, 75% of all new jobs come from small businesses.” (3)
- **40-60 % of small businesses close permanently after a disaster. Among businesses that are closed for at least five days, 90 % fail within a year. (FEMA) (4)**

(1) US SBA <https://www.sba.gov/advocacy/small-business-facts-and-infographics>

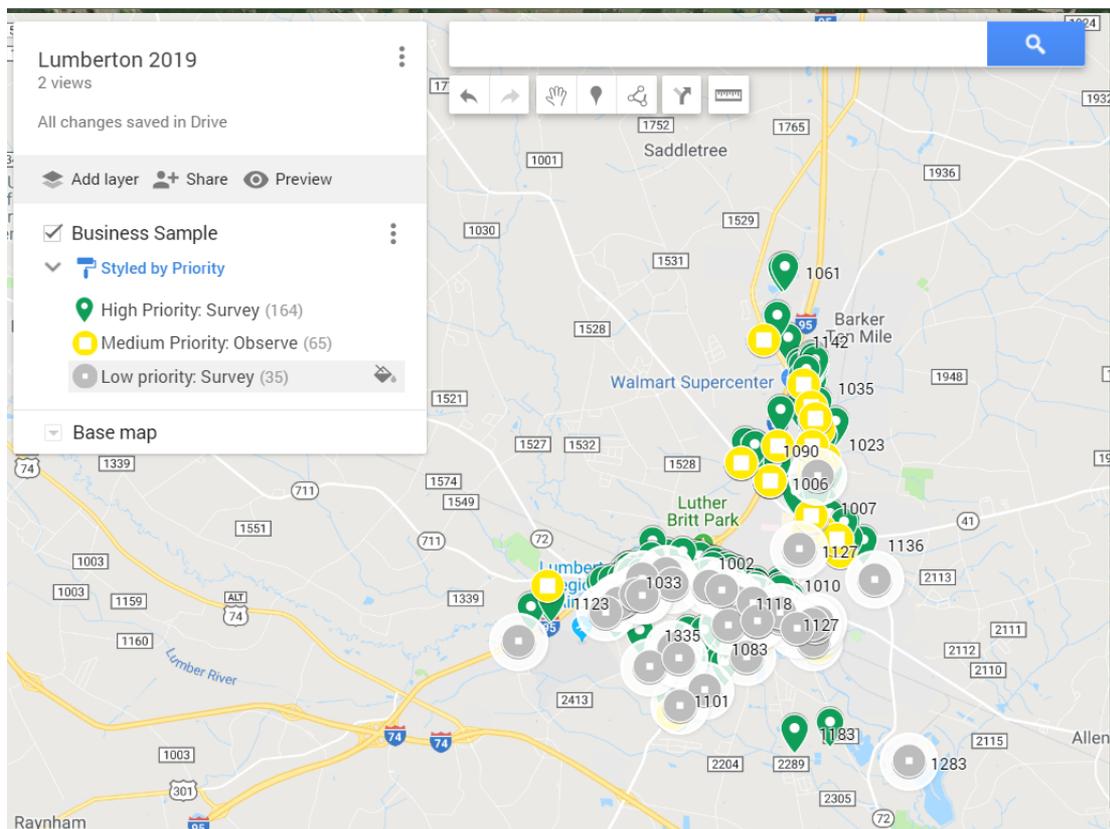
(2) <https://advocacy.sba.gov/2019/01/30/small-businesses-generate-44-percent-of-u-s-economic-activity/>

(3) http://www.sba.gov/sites/default/files/rs372tot_0.pdf

(4) <https://www.business.com/articles/business-disaster-prep/>

Longitudinal Study Business Sample

- 15 mo. Post-Hurricane Matthew
- 7 mo. Post-Hurricane Florence
- Database: ReferenceUSA
- Took all businesses in the simulated inundation area +100m buffer (n=218)
- Took a random sample (n=122) from Northern floodplain



Businesses – Challenges to Resilience and Coping Capacity

Multiple hazards (sometimes cascading) across timescales – e.g., Charleston

Changing nature of extreme events – hurricanes – e.g., outside Houston

Changing risks of fire, smoke leaving long-term recovery challenges and next sets of economic challenges

What are businesses facing in terms of a learning/behavior curve; where will resources come from to support a shift from waiting for "recovery" to planning for change; what is the nature of the shifting terrain for business risks and opportunities?

Business Survey Structure

Survey Sections:

- Introduction and operating status of the business
- Impact and Recovery from Hazard Event
- Recovery Finance
- Mitigation and Preparedness
- Business Information
- Owner/Manager Demographics

Multi-Dimensional Business Recovery

Business Recovery State (structure)

Business Recovery (firm's operating capacity)

RS1: Still in survival/response mode (but *will* recover)

Estimated Δ % capacity

RS2: Recovering

Revenue change

RS3: Mostly Recovered

Estimated Δ profitability

RS4: Fully Recovered

Estimate Δ # customer

Predictors of recovery outcome (P fully recovered [1|0]):

Damage (building, contents), accessibility, customer loss, owner demographics, financial resources, employee issues

- Customer loss, in particular, had a higher effect magnitude than initial damage, in terms of hindering recovery.
- Labor disruption caused by transportation issues and childcare issues had a smaller relative effect, but also significantly lowered a business' odds of full recovery.

Valuing the Resilience Dividend

Defining the “Resilience Dividend”

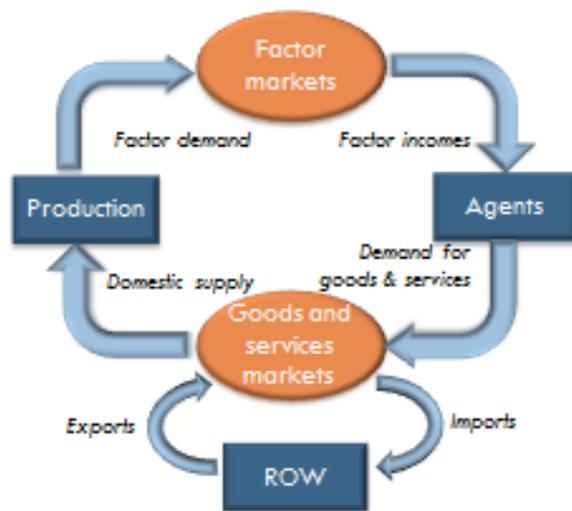
Premise: Even when a hazard event does not occur, the community can garner value on a day-to-day basis from the resilience planning that has taken place.

- Largely qualitative assessments to date (e.g., Rodin, 2014; Zolli and Healy, 2013)
 - Tulsa, Oklahoma: rapid urban development in a floodplain
 - Medellin, Colombia: emerged from a drug and murder capital to host int’l. conferences and is an emerging vacation destination

- Value in quantifying co-benefits of resilience planning and providing methodological approaches (see Fung & Helgeson, 2017; Helgeson et al., 2017; RAND, 2017)
 - Inherent resilience
 - Adaptive resilience

CGE Models & Co-benefits of Resilience Planning

- Computable General Equilibrium (CGE) Models can allow us to test net-benefits of enacting policies and/or implementing built environment changes that support chosen alternatives; medium- and long-term.
 - Look at CGE model based on data pre-hazard event
 - Look at the CGE model based on the data post-hazard
- In our case we are using spatial elements (S-CGE)
 - Ties economic activity and households to locations
 - Can include inter-regional resource flows, e.g., commuting



SCGE Snapshot: Simplified General Form

PRE-DISASTER EVENT DATA CGE MODEL

Labor data
from SAM

Enters SAM
through
supply
equation:

$$Q_s = AL^\alpha K^{(1-\alpha)}$$

Profit-Max
labor
derived:

$$L = \alpha \frac{p}{w} Q^S$$

Model
Calibrates
by
equilibrium
condition:

$$Q^S = Q^D$$

Run
simulation
on
calibrated
model

POST-DISASTER EVENT DATA CGE MODEL

Case study: Cedar Rapids, Iowa

- Flooding (severe): 2008, 2016
- Deliberate steps taken to enhance community resilience (post-2008)
- Data available to compare 2007 snapshot of the economy to the 2015 snapshot
- Co-benefits of resilience planning in Cedar Rapids (examples)
 - Increased revenue from build-up of downtown areas (able to differentiate downtown from other areas in the CGE model)
 - Buyouts of housing in the floodplain
 - Green space + McGrath Amphitheater





Thank You

Email: resilience@nist.gov / Jennifer.Helgeson@nist.gov

Data & Info for CR Planning Report: <https://tinyurl.com/resilience-data-info>

EDGE\$ Online Tool: <https://edges.nist.gov>

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

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)