Community Resilience and the Role of Federal Support

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

Outline

- Development of Resilience Concepts and Federal Policies
- Federal Programs for Community Resilience
- Considerations for Physical, Social, and Economic Systems
- NIST Resilience Research and Activities

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)

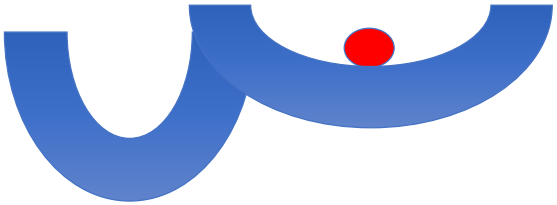
New Orleans Flooding in 2005 (FEMA)

Resilience goes beyond mitigating risk.

It includes planning for changing conditions (economic, land use, hazards, etc.) and implementing measures for recovery of community services and function in a specified timeframe.

Resilience Concepts have Evolved

- Ecology
  - Capacity of biosystem to continue to exist in a domain in the face of change
- Psychology
  - Individual's ability to successfully adapt to life tasks in the face of social disadvantage or other adverse conditions
- Organizational
  - Responding to changes in business environment
- Physical and Social Systems
  - Ability to prepare for and adapt to changing conditions and to withstand and recover rapidly from disruptions



U.S. Events That Influenced Community Resilience Concepts and Federal Policies

Many disruptive events have shaped community resilience concepts. Some of the key events include:

- 1992 Hurricane Andrew
- 2001 World Trade Center (WTC)
- 2005 Hurricane Katrina
- 2012 Superstorm Sandy
- 2018 Hurricanes Harvey, Irma, Maria, Alaska EQ, and Camp Fire

2018 Glenn Hwy, Alaska DOT&PF

2017 Hurricane Katia (left), Hurricane Irma (middle), and Hurricane Jose (right) NOAA.gov

2011 Joplin, MO F5 tornado
Credit: Jace Anderson/FEMA

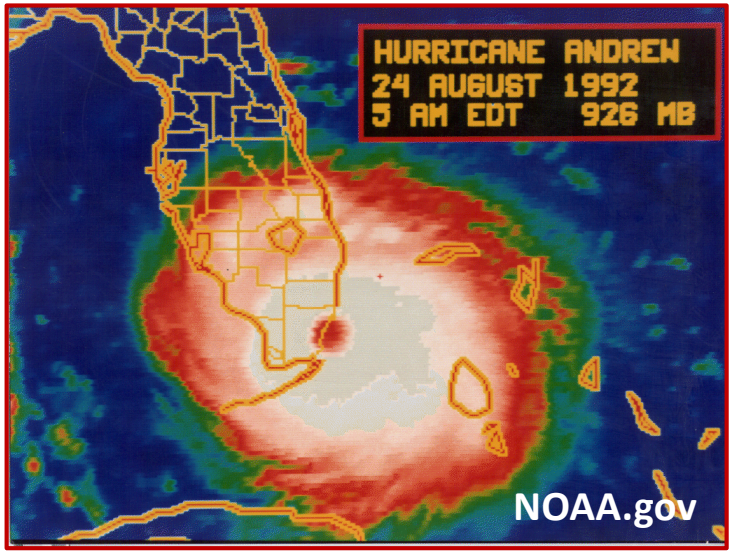
Federal Resilience Policies (1 of 3)

1979 FEMA Established as Federal Agency

- Consolidated ***emergency preparedness, mitigation, and response*** activities into one federal emergency management organization
- Prior to FEMA, 100 federal agencies were involved in some aspect of risk and disasters
- Other Federal Agencies still play key roles, such as
  - **US Housing and Urban Development (HUD)** – Funding for vulnerable population housing in communities
  - **US Army Corps of Engineers (USACE)** – waterway management and flood control systems, including dams, levees, coastal projects
  - **US Economic Development Administration (EDA)** – economic recovery strategic planning and implementation of projects, including infrastructure

1992 Hurricane Andrew

- $50B damages
- 150K homes destroyed or damaged.
- Led to South Florida Building Codes and improved standards and enforcement.
- FEMA was reorganized, with an emphasis on **emergency preparedness, mitigation and response** for natural hazards.



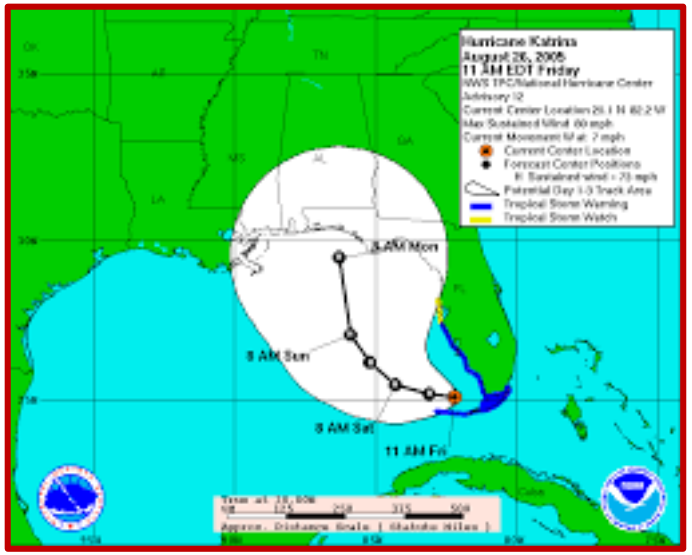
Roof failure from pressurization when the windward window failed. (FEMA 488)

2001 World Trade Center Attacks

- WTC 1, 2, and 7 collapsed and damaged surrounding buildings and power, transit, communication, and water systems in the lower Manhattan ***community*** and interrupted ***financial markets***.
- Systems were rebuilt to improve redundancy and minimize system failure across the community.
- Department of Homeland Security (DHS) established in 2002 and shifted focus to security of ***critical infrastructure*** against terrorism

2005 Hurricane Katrina

- Storm surge up to 8.5 m (28 ft) and max sustained winds of 56 m/s (125 mph).
- Approximately 75% of New Orleans flooded.
- Bridges, seaports, petrochemical facilities, electrical service, and transmission towers were damaged.



- Extent of damage pointed to social, economic, and physical ***vulnerability*** that resulted in permanent out-migration, and the important role of the built environment in community recovery
- Need for ***risk informed strategies*** for resilience, and standardized tools and metrics identified in the following reports
  - Grand Challenges for Disaster Reduction Report (OSTP 2008)
  - The National Infrastructure Protection Plan (DHS 2009)
  - Disaster Resilience, A National Imperative Report (NAP 2012)

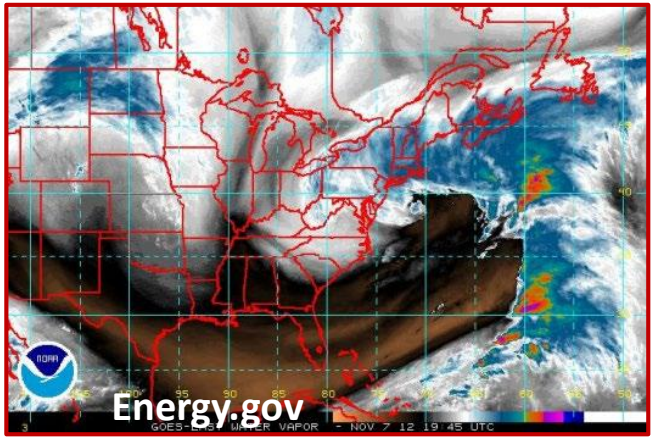
Federal Resilience Policies (2 of 3)

- **2003 Homeland Security Policy Directive-8: National Preparedness**
  - Established the National Preparedness Goal and System
- **2005 National Preparedness Goal**
  - A secure and resilient Nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk.
- **2006 National Infrastructure Protection Plan**
  - Coordinated approach between the private sector and Federal, State, local, and tribal governments to protect critical infrastructure and key resources (CI/KR) from security threats.
    - National Response Plan
    - National Incident Management Plan
    - National Strategy for Physical Protection of Critical Infrastructure and Key Assets

FEMA

2012 Superstorm Sandy

- Surge of 12.6 ft (3.8 m) at Long Island Sound.
- Homes, hospitals, water and wastewater plants, transit facilities, and data centers were significantly damaged with long ***recovery times***.
- Recognized infrastructure ***dependencies***, cascading consequences, and need for ***rapid recovery*** to improve community resilience.
  - Hurricane Sandy Rebuilding Strategy (HUD 2012)
  - Sandy Recovery Improvement Act (FEMA 2013)
  - NYC Special Initiative for Rebuilding and Resiliency (2013)
  - Hoboken Community Resilience Plan (2013)



Federal Resilience Policies (3 of 3)

FEMA

- **2011 Presidential Policy Directive-8 (PPD-8): National Preparedness**
  - Defined resilience, protection, mitigation, response, and recovery.
- **2012 Sandy Recovery Reform Act**
  - Streamline assistance for the recovery of public infrastructure.
- **2013 Presidential Policy Directive-21 (PPD-21): Critical Infrastructure Security and Resilience**
  - Brought critical infrastructure under the National Preparedness System.
- ***2018 Disaster Recovery Reform Act (DRRA)***
  - Enable resilient infrastructure and communities through increased funding, stronger building codes, and streamlined administrative procedures.
  - Many provisions were retroactive to August 1, 2017, to bolster recovery efforts for Hurricanes Harvey, Irma, and Maria.
- ***2018 Building Resilient Infrastructure & Communities (BRIC)*** A New National Infrastructure Pre-Disaster Hazard Mitigation Grant Program established under DRRA.
  - Funded through 6% set aside from the Disaster Relief Fund.
  - Increased investment towards hazard mitigation is now allocated by a statute eliminating the need for separate legislative appropriation.

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Federal Community Resilience Programs

Part I: Federal Agencies/Offices with Community Resilience Support

Resources for community resilience, including:

- Preparing for future events
- New or improved infrastructure
- Strengthening community social networks
- Conserving ecosystems
- Performance of critical facilities and services

US Agency	Office
Dept of Agriculture (USDA)	• Natural Resources Conservation Service (NRCS) • Farm Service Agency (FSA) • Forest Service (FS)
Dept of Commerce (DOC)	• Economic Development Agency (EDA) • National Oceanic and Atmospheric Admin. (NOAA) Office for Coastal Management
Dept of Energy (DoE)	• State Energy Program
Dept of Homeland Security (DHS)	• Federal Emergency Management Agency (FEMA) Mitigation • FEMA Recovery • FEMA Federal Insurance & Mitigation Administration • FEMA Preparedness • Infrastructure Security Division
Dept of Housing and Urban Development (HUD)	• Office of Block Grant Assistance
Dept of the Interior (DOI)	• Bureau of Indian Affairs (BIA) Tribal Resilience
Environmental Protection Agency (EPA)	• Office of Wastewater Management
Dept of Transportation (DOT)	• Federal Transit Administration (FTA) • Federal Highway Administration (FHWA)
U.S. Army Corps of Engineers (USACE)	• Civil Works

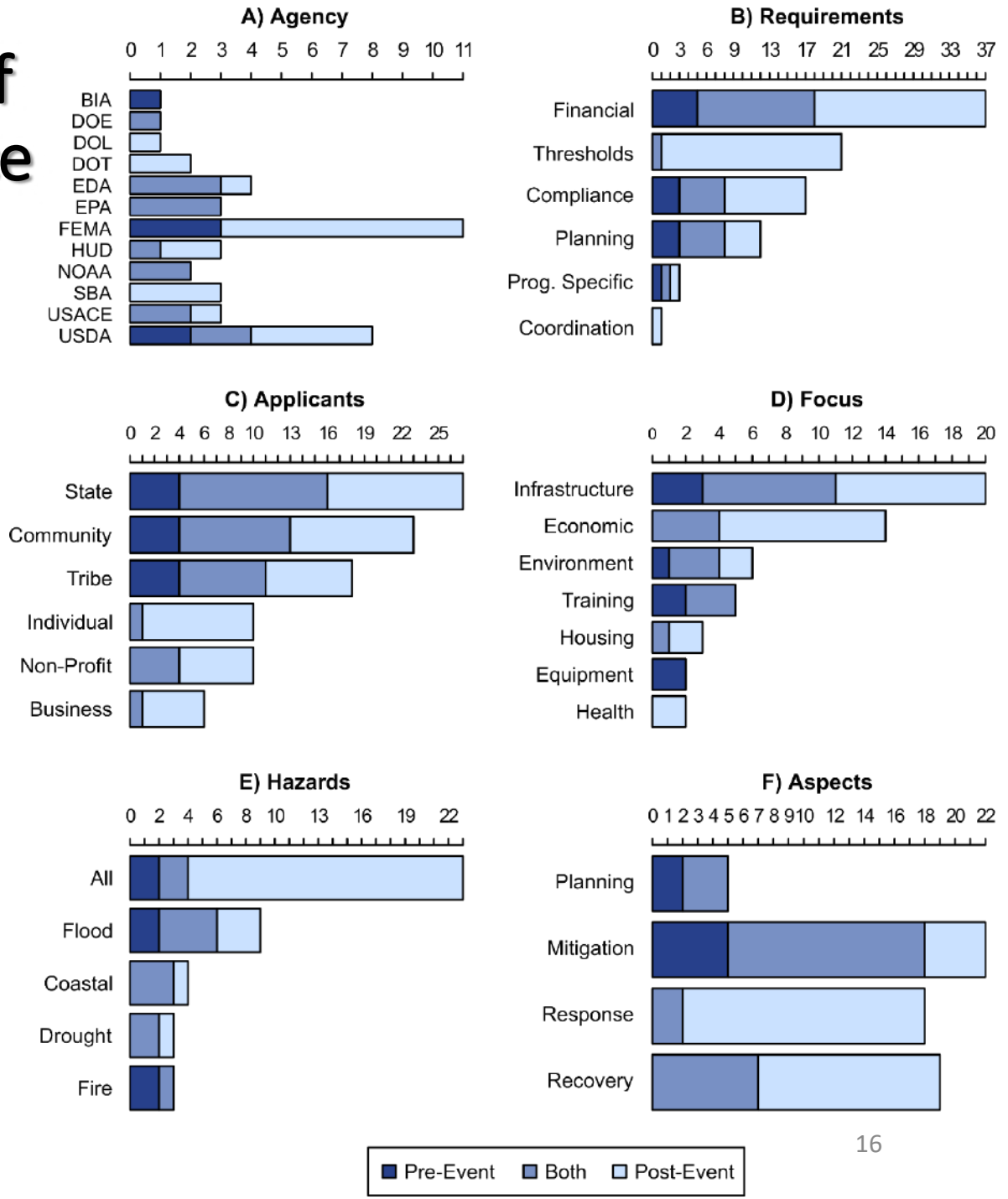
Community Resilience Categories

42 programs were evaluated for 6 categories:

- **Aspect** (planning, mitigation, response, recovery)
- **Hazard** (flood, earthquake, coastal, drought, wildfire, all)
- **Focus** (economic, health, infrastructure, housing, environment, training, equipment)
- **Timing** (pre-event, post-event, both)
- **Applicants** (state, community, tribe, individual, business, nonprofit)
- **Requirements** to qualify for program resources

Characteristics of Federal Resilience Programs

- Most agencies offer one to three programs, except for FEMA (11) and USDA (8).
- Most agencies provide pre- and post-event support.
- Infrastructure, economy, and environment are the primary focus areas.
- About half of the programs address all or multiple hazards.
- Only 5 programs support planning.



Community Resilience Tools

Part II: Types of Tool Providers

Tools that communities can access to:

- Fulfill Federal resilience program requirements
- Leverage available opportunities for fostering and strengthening their resilience

Agency	Office
Federal Agency	Provider is a Federal agency or office. These tools are freely available.
Private Sector	Provider is a private-sector entity; can be for-profit or non-profit. Tools provided by non-profit entities are generally free, but some for-profit entities may require purchase.
Local Government	Provider is a public agency or office serving a specific community or region.
Academic Institution	Provider is based at an academic institution.
International Organization	Provider is an international entity, possibly with support from more than one government.

Community Resilience Tools Categories

~120 Tools were evaluated for 4 categories:

Type

- Assessment, Guide, Data & Modeling

Hazard

- Flood, Earthquake, Coastal, Drought, Wildfire, All

Provider

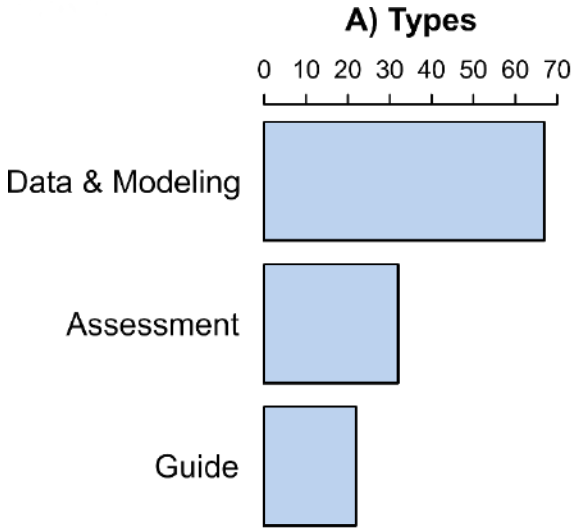
- Federal Agency, Academic Institution, International Organization, Local Government, Private Sector

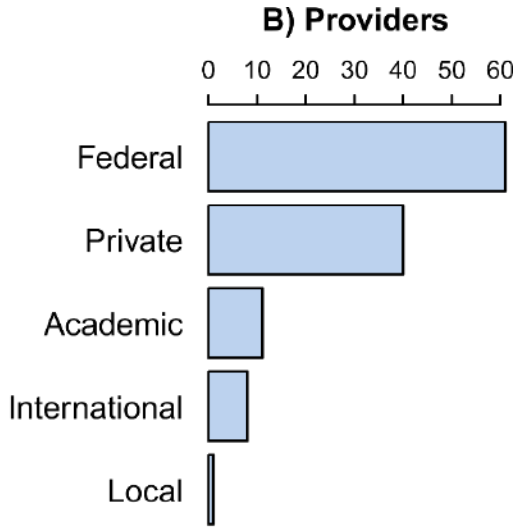
Focus

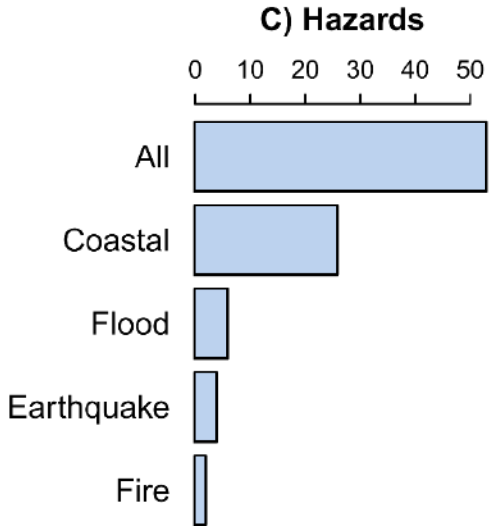
- General, Economic, Health, Infrastructure, Environment, Climate, Water Quality, Chemical

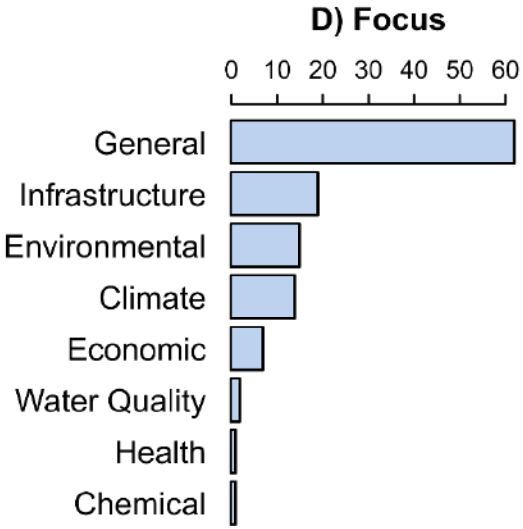
Characteristics of Resilience Tools

- Most resilience tools do not target specific Federal programs or requirements.
- Approximately half of the tools have a general resilience focus.









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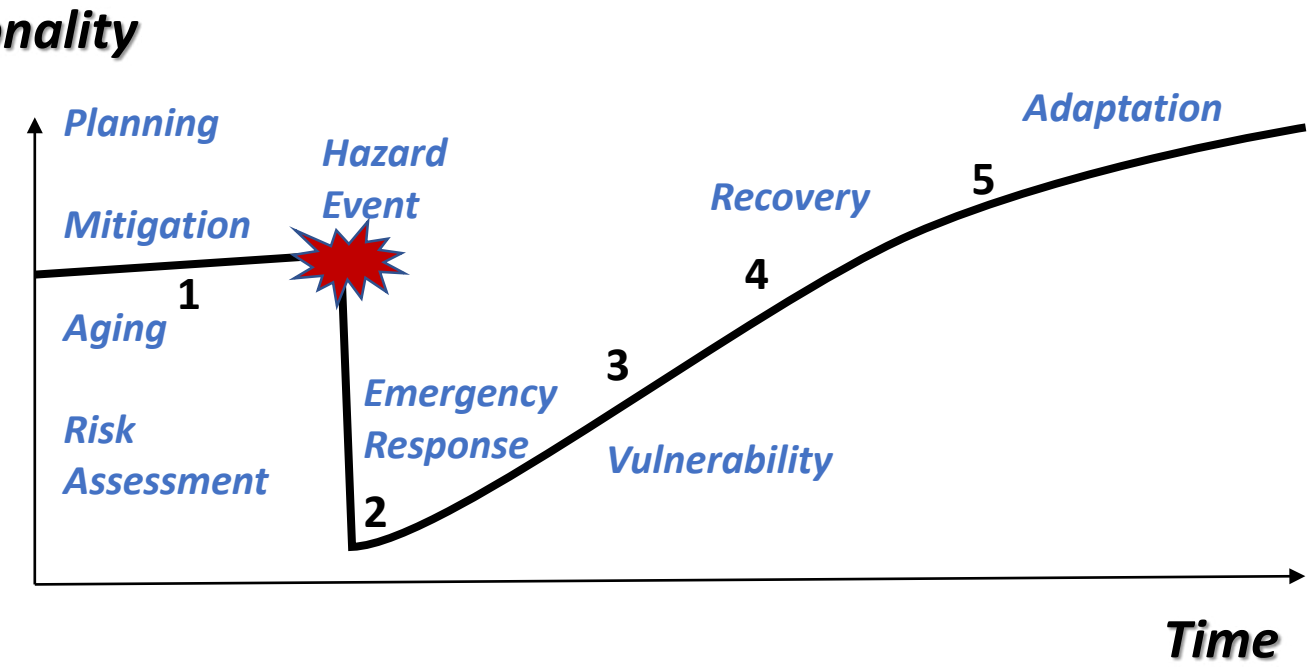
Resilience for Hazard Events

- Resilience incorporates many familiar concepts into an integrated perspective.

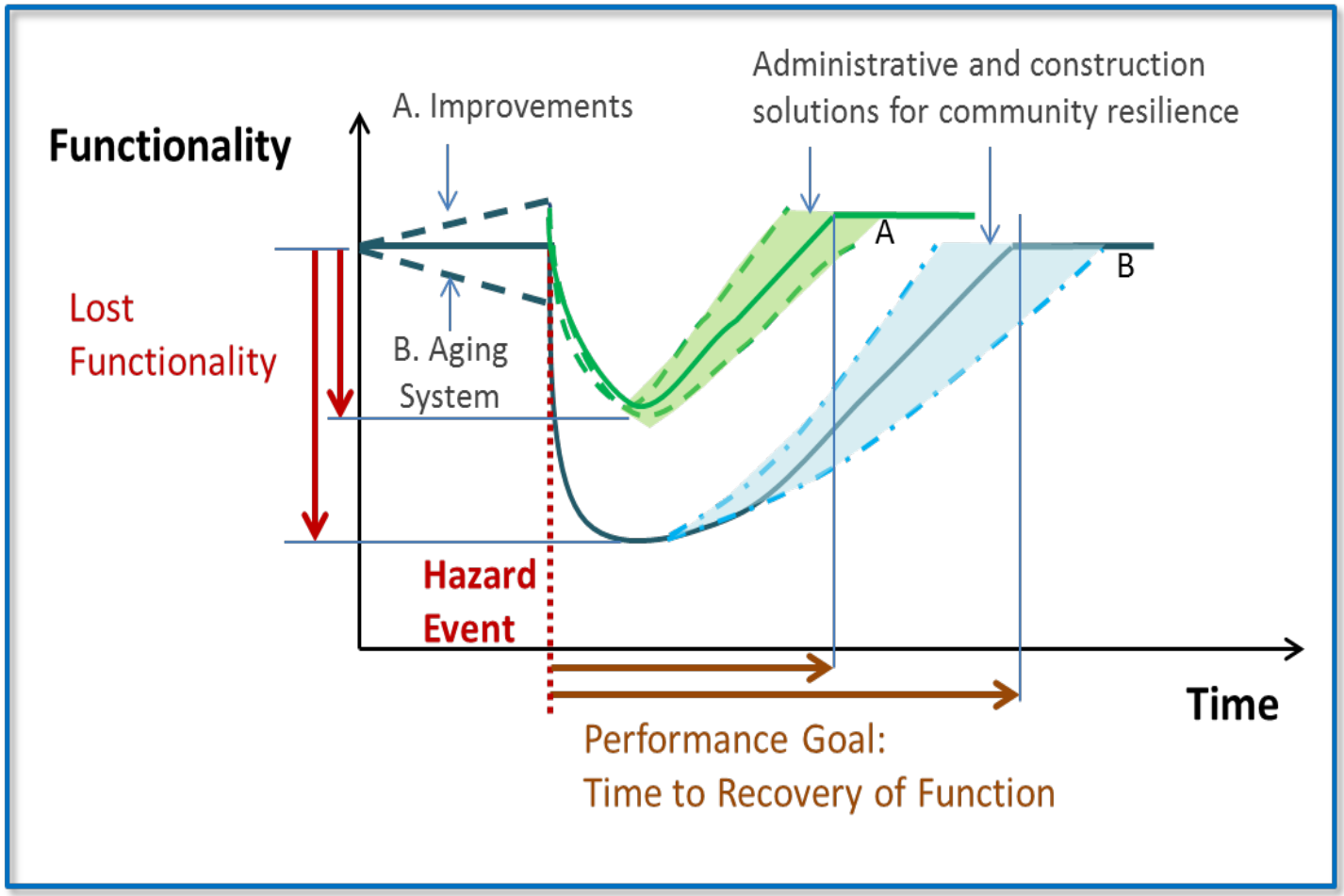


1. Current State (pre-event)
- Existing vs. Desired Performance
- Dependencies

2. Immediate Damage (post-event)
- Loss of Life/Injury
- Physical Damage
- Loss of Function
- Decision Support

3-5. Recovery Stages (post-event)
- Social and Economic
- Repaired Damage
- Recovered Functions
- Decision Support

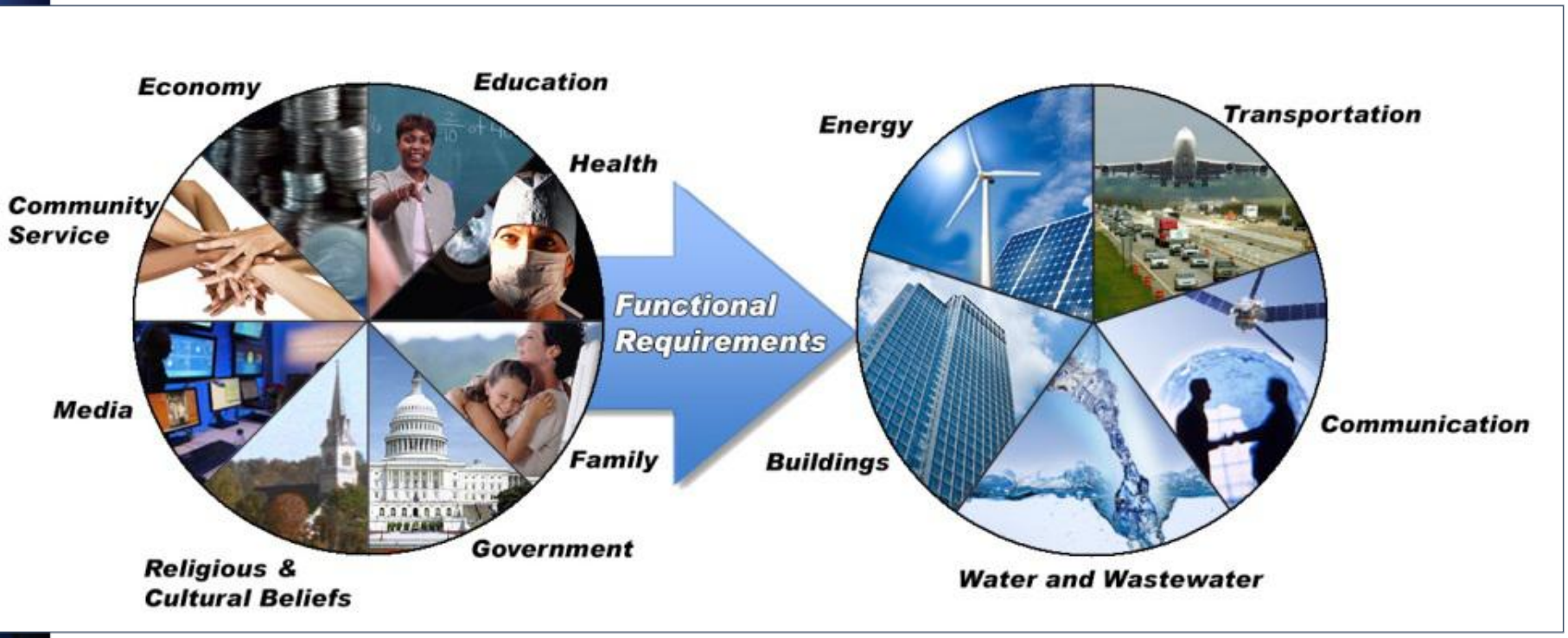
Recovery of Functionality



Resilience can be expressed as the ***time to recover functionality*** following a disruption.

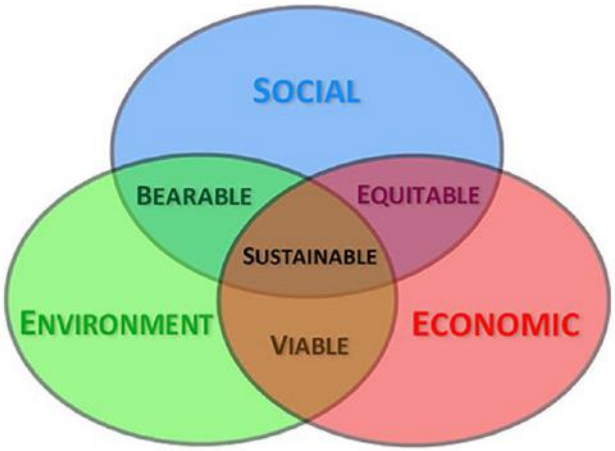
How Should Functional Requirements Be Determined for Resilience?

- Social and economic activities should inform the desired performance of community infrastructure, including the time for recovery of functions following a disruptive event.



Resilience, Sustainability, and Adaptation

- Concepts can be viewed through *time*
  - ***Resilience*** - improved performance and recovery over a long planning horizon
  - ***Sustainability*** – meeting current needs without impact on future generations
  - ***Adaptation*** – future conditions and events that diverge from historical patterns
- And their *goals*
  - ***Resilience*** – timely recovery of functions
  - ***Sustainability*** – solutions that minimize social, environmental, economic impacts
  - ***Adaptation*** – minimize future impacts on current investments



Triple Bottom Line (US DOT)

Charleston, SC Sea Level Rise (NOAA)

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NIST Community Resilience Program

<u>Community Engagement</u>: Outreach, Collaboration, and Input

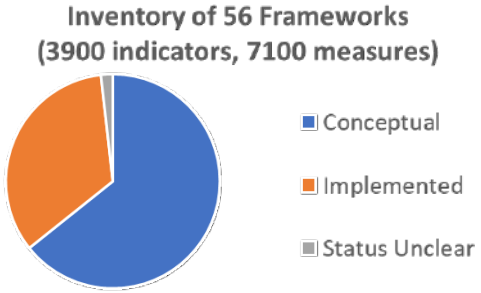
- ***Resilience needs*** of communities – planning, data, tools, guidance
- ***Data and decision 'levers'*** – being used or needed

<u>Science-Based Tools</u>: Assess resilience and support informed decision making

- ***Guidance and best practices*** – social, economic, built systems
- ***Modeling*** – pre- and post-event performance assessment, alternate outcomes
- ***Metrics*** – quantitative and qualitative measures
- ***Economics*** – Small business, supply chain, resilience dividend
- ***Codes and standards*** – Improved design and assessment methods

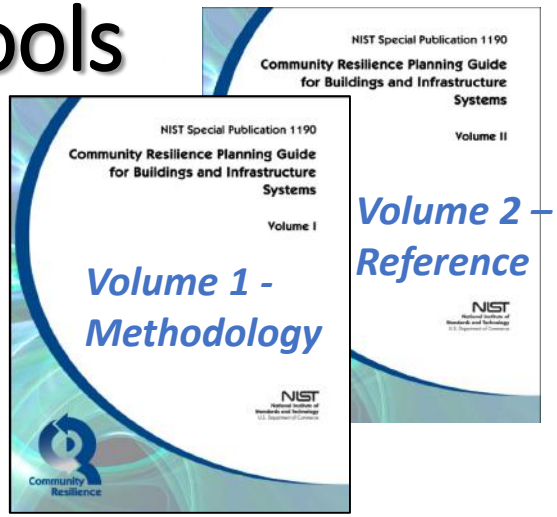
<u>Disaster and Failure Studies</u>: Metrology for field studies and data collection

- Improved field ***tools and methods***
- Integrated and longitudinal ***data collection***
- Loss of ***functions and services***



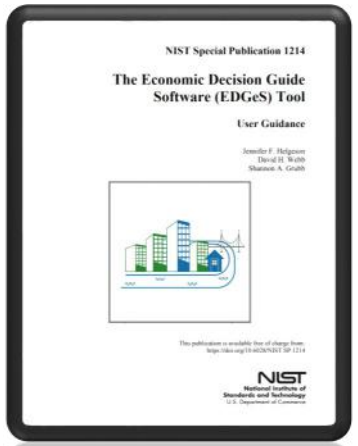
NIST Community Resilience Tools

http://www.nist.gov/el/resilience/



Community Resilience Planning Guide

- Planning at the community scale
- Links social needs and building and infrastructure performance
- Establish community resilience goals
- Local government is the logical convener for comprehensive resilience planning
- ASTM Standard under development



Economic Decision Guide

- Standard approach for consistently evaluating investment decisions
- ASTM Standard E3130

EDGe$ Software Tool

- Tool to assist decision-makers with resilience planning choices
- Beta version available at User Guide with example planning scenarios: NIST.SP.1214.pdf

EDGe$ Online Tool

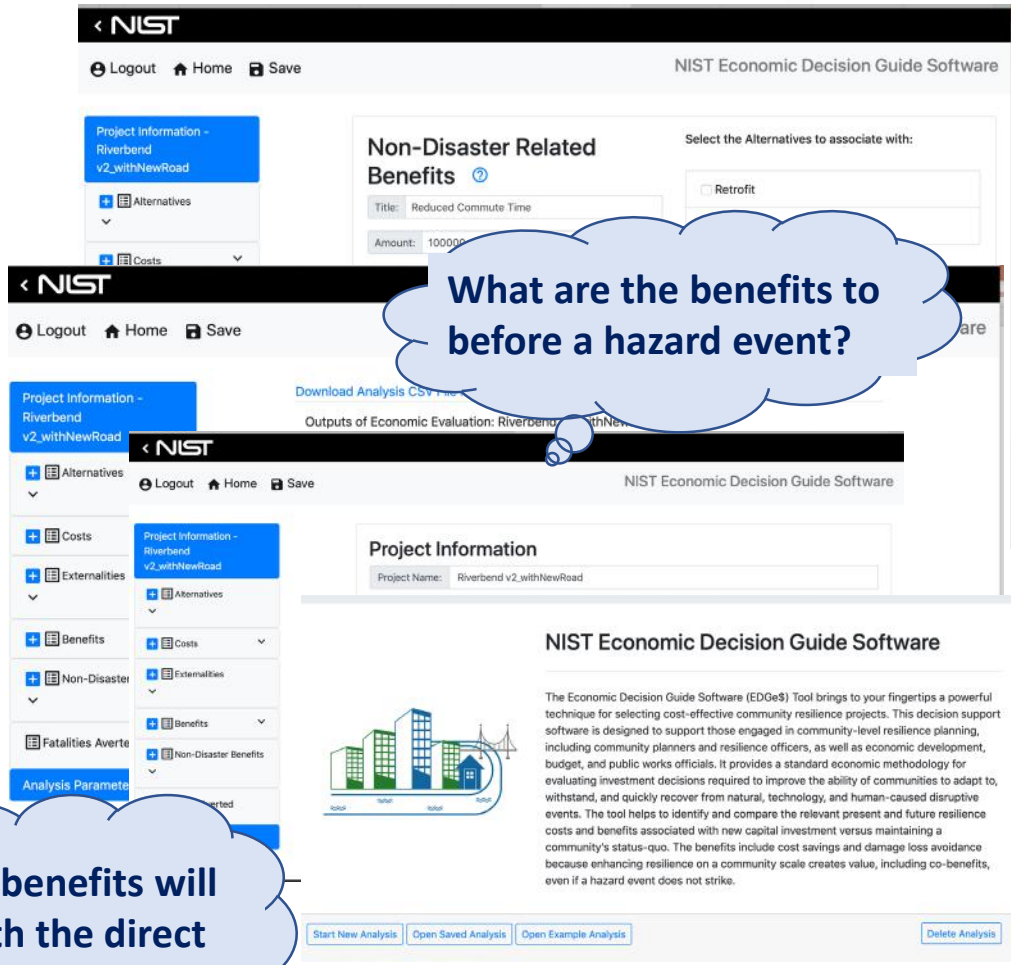
Economic Valuation of Resilience Projects and Strategies

EDGe$ Online Tool V1.0

Compares alternative solutions to select cost-effective projects that meet resilience goals.

- Platform-independent
- Captures net co-benefits and non-disaster return-on-investment
- Data uncertainty and risk profiles addressed

Improves short- and long-term valuation of infrastructure resilience investments by communities and stakeholders.



https://edges.nist.gov/

Systems Modeling: Optimization Tool for Planning

Alternatives for Resilient Communities (ARC) Tool:

Interactive tool for developing alternative sets of actions that meet community resilience and cost goals, given hazard and interdependency information, and socio-economic data.

Goal: Decrease the burden of developing viable alternatives for stakeholder consideration.

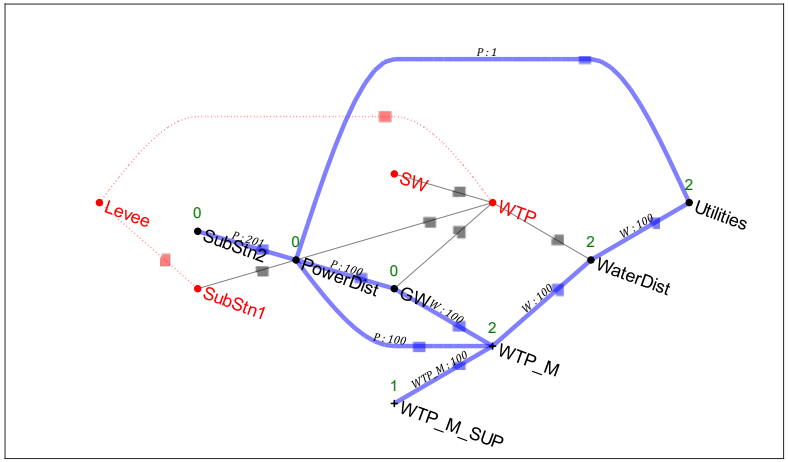
NIST ARC Features

Social
- Demographics

Hazards
- Flood
- Wind
- EQ

Buildings
- Housing
- Businesses
- Schools

Infrastructure
- Water
- Roads & bridges
- Electric power



ARC Simple Example of Water and Power Network Dependencies

Data, Information, and Tools Workshop

Community Resilience Planning and Decision-Making (NIST SP 1240)

Summary of Gaps and Needs

Community Resilience Goals and Metrics (Chapter 2)

- Core Set of Standard Community Resilience Indicators and Metrics
- Methodology for Aggregation or Dis-aggregation of Data from Multiple Sources

Data and Information (Chapter 3)

- Common Community Resilience Data Standards
- Best Practices to Aid Curation & Dissemination of Validated Data & Tools

Community Resilience Tools (Chapter 4)

- Visualization Tools for Communities
- Engagement between Community Users and Tool Developers

Community Resilience Planning (Chapter 5)

- Standard Approach for Community Resilience Planning
- Leadership Training and Certification

Funding Sources and Economic Decision Support (Chapter 6)

- Awareness & Coordination of Resilience Funding Resources
- Resilience Benefits in Financial Products
- Economic Decision Support Tools

Communi-cation with Stakeholders (Chapter 7)

- Stakeholder Communi-cation Best Practices
- Risk & Benefits Communi-cation Methods

Center for Risk-Based Community Resilience Planning

- Led by Colorado State University with ~14 institutions
- Renewed in 2020 for 5 more years of collaboration with NIST
- Objectives
  - **Community model (IN-CORE)**
    - Buildings, infrastructure, dependencies, uncertainty
    - Population dislocation, housing, organizational functions
    - Economic tax base and income
    - Decision Support – optimization, metrics, uncertainty
    - Social Institutions
    - First release with 2 case studies – December 2019
  - **Data management tools**
    - Multi-disciplinary, multi-scale data integration
    - Standard data formats
  - **Field studies**
    - Validate models and tools
    - Testbeds - Seaside, OR; Galveston, TX; Memphis/Shelby County, TN; Mobile, AL
    - Hindcast - Joplin, MO
    - Field Study – Lumberton, NC

Resilience

http://resilience.colostate.edu/

IN-CORE

https://incore.ncsa.illinois.edu
https://github.com/IN-CORE/

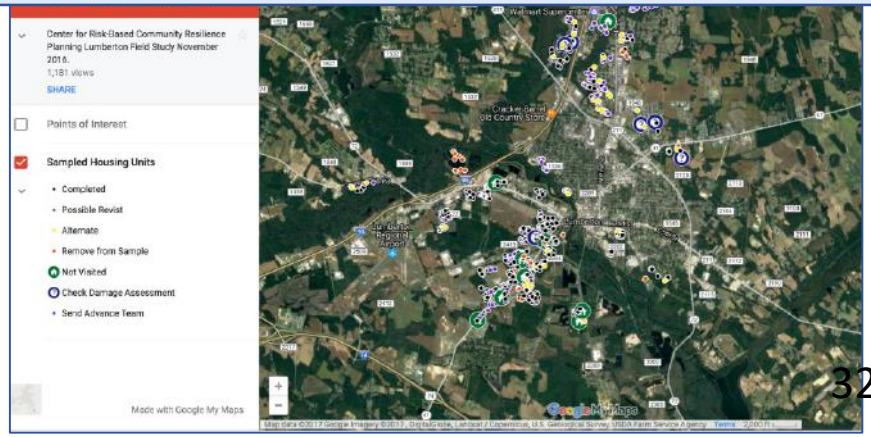
NIST and CoE Longitudinal Field Study

Lumberton, NC Impacts from 2016 Hurricane Matthew

- 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, and housing types
  - GIS-enabled structured surveys that integrate physical and social impacts

Hurr Matthew Oct 2016 → **Wave 1 Nov 2016** → **Wave 2 Jan 2018** → **Hurr Florence Sep 2018** → **Wave 3 Apr 2019** → **Wave 4 Apr 2020 (Delayed)**

NIST Special Publication, 2018 (NIST SP 1230)



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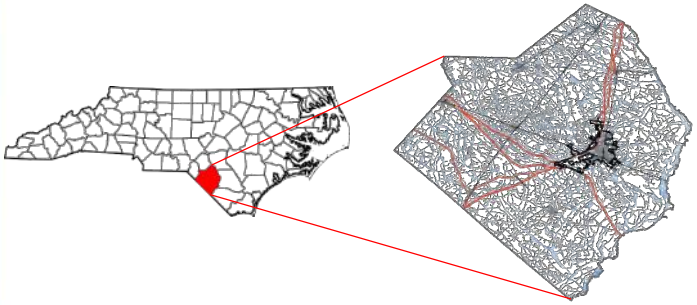
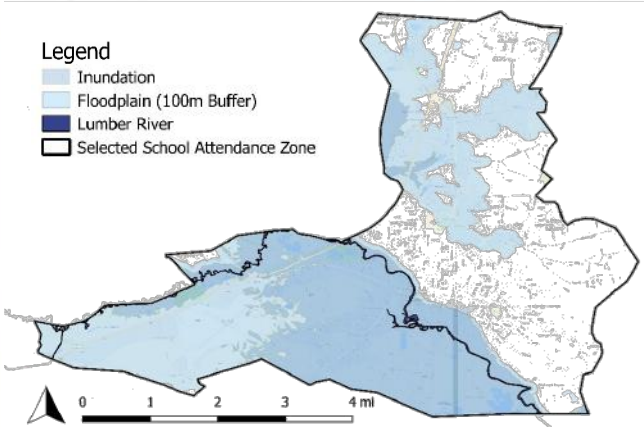
Hurricane Matthew Impacts

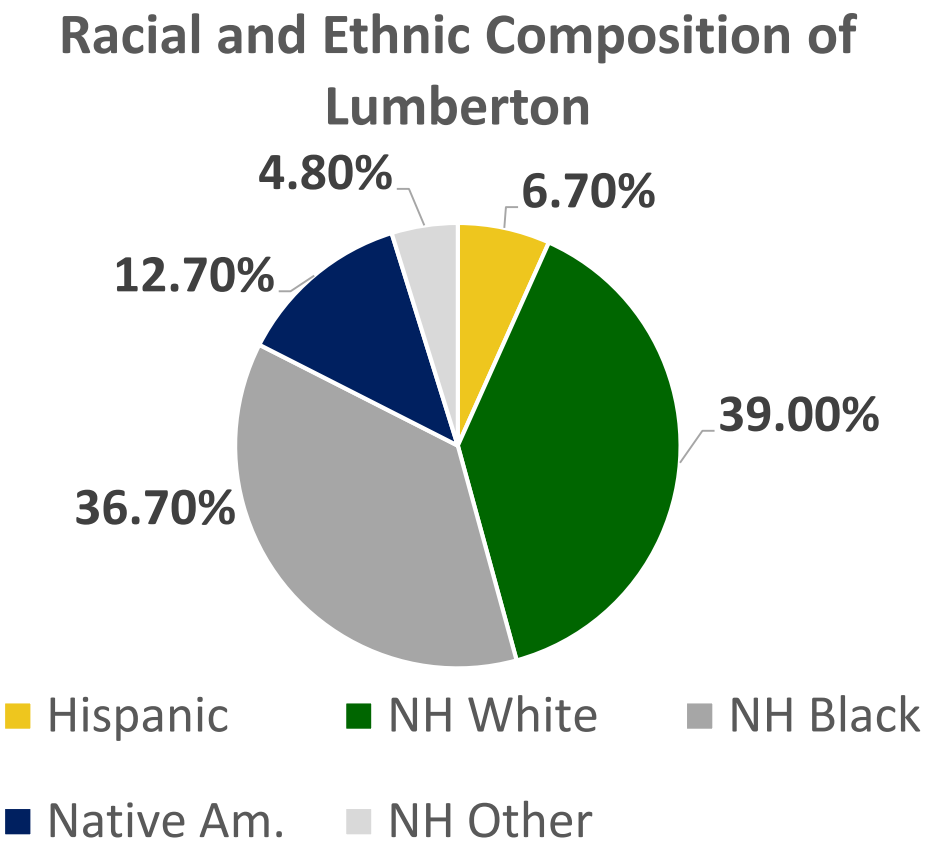
- > 15 in. rain fell in some areas of North Carolina
- Flooding was exacerbated by already saturated ground due to rains in September
- > 5,000 people in Robeson County were placed in shelters and temporary housing by FEMA
- ALL 42 schools, serving 24,000 children closed for 3 weeks in Robeson County

Study Area: Lumberton, NC





Population ~21,000



Study Focus: Recovery of schools, housing, business, and infrastructure

Flooded school after Hurricane Matthew

Water Treatment Plant before and after the flood

Flooded homes a few days after the storm

Study Design: Integrated Methodology

Engineering

Damage assessments of housing units and businesses

Social Science

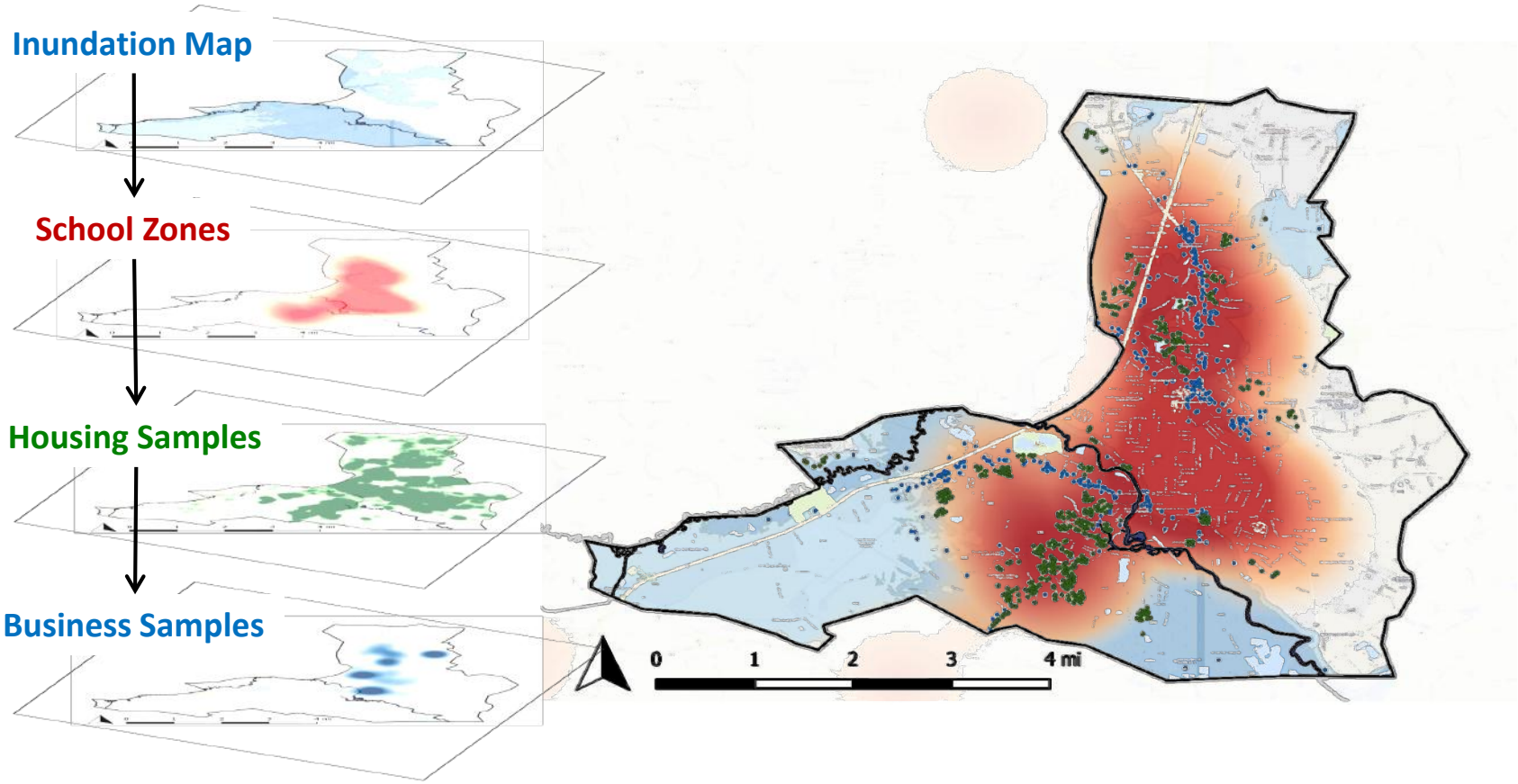
Surveys of households and businesses

Engineering + Social Science

Qualitative interviews with school representatives

Meetings with local/state government representatives, infrastructure managers

Interdependencies through Sampling



Measuring Recovery

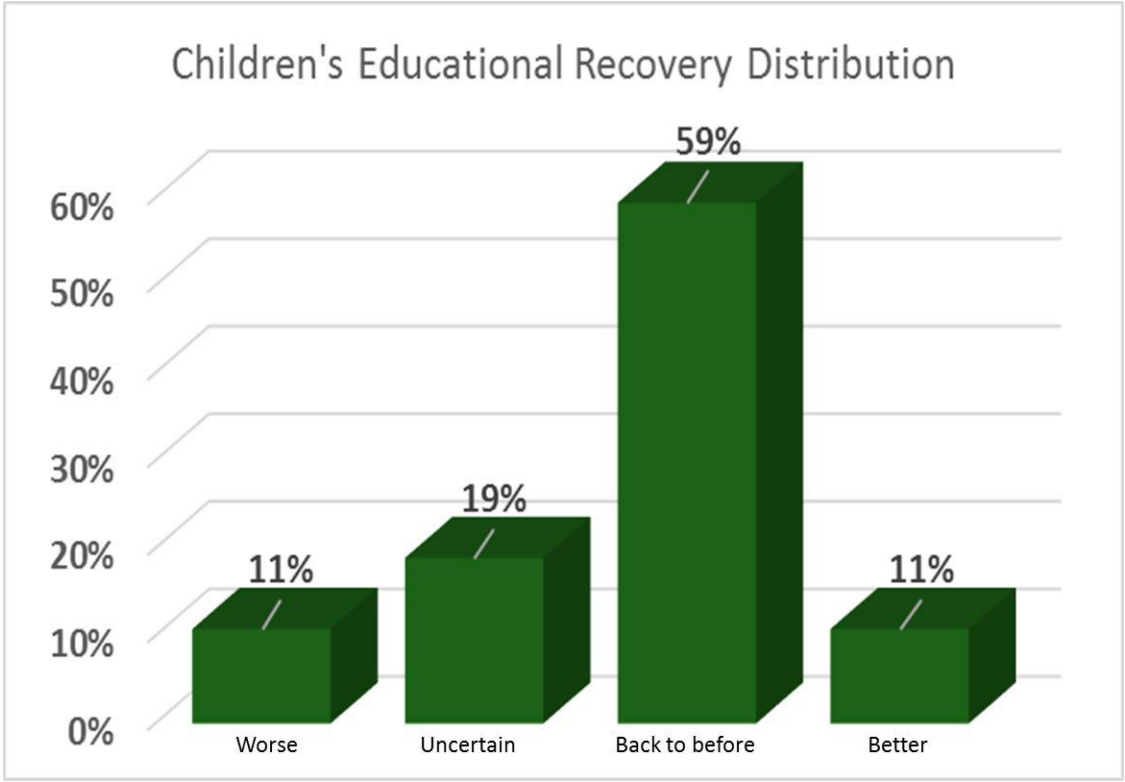
School Recovery

Indicators:

- Infrastructure repair and restoration
- Student return
- Perceived educational recovery

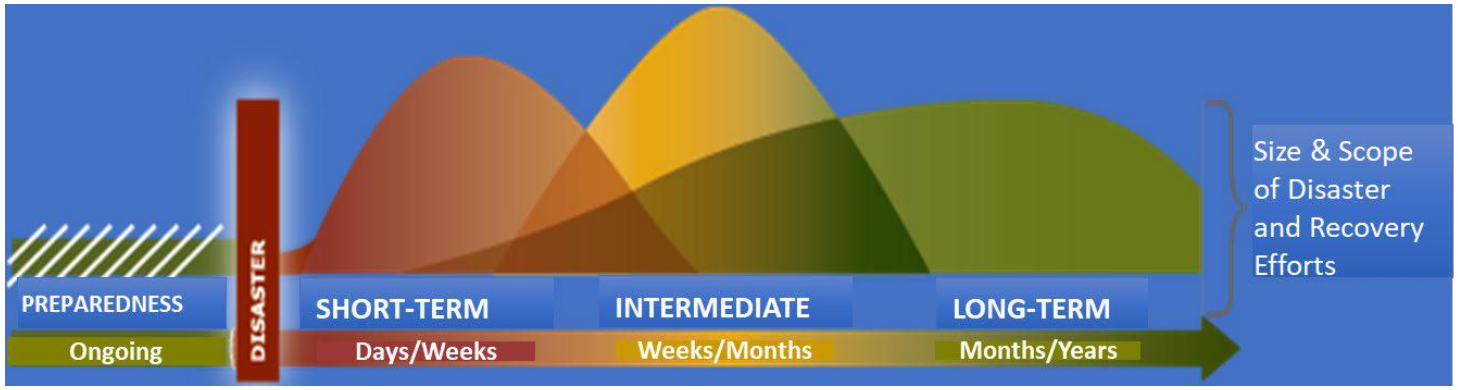
Impact on other indicators:

- Business recovery
- Tax base



Community Resilience Measurement Challenges

- **Metrics**
  - Minimum set of indicators and metrics for community resilience status over time
  - Is data available or obtainable?
- **Data**
  - Varying spatial and temporal scales of data
  - Lack of recovery data to inform models
- **Models**
  - Integrating physical, social, economic data and analyses to inform metrics
  - Validating interdisciplinary models at community scale
- **Decision Support**
  - Short and long-term decisions, before and after disruptive events
  - Uncertainty in model outputs and metrics



Thank You!

Questions?

NIST Community Resilience
https://www.nist.gov/topics/community-resilience

Center for Risk-Based Community Resilience
http://resilience.colostate.edu/