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

The Decadal Influence of CoE and NIST Resilience Research

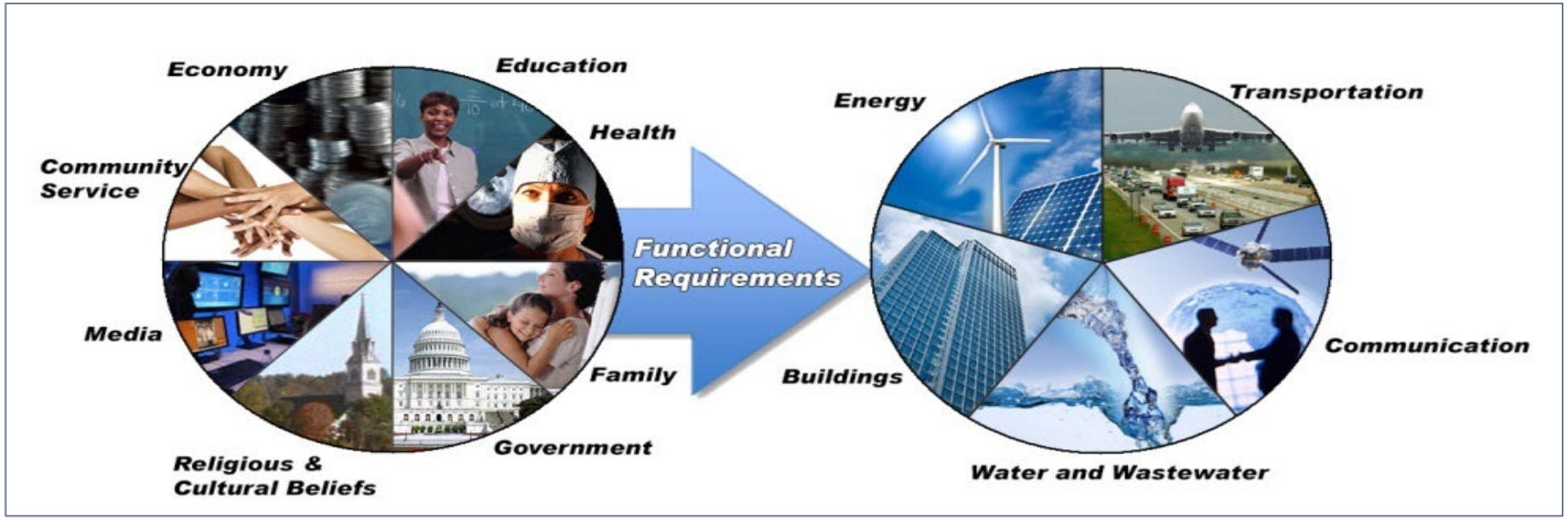
Presented by Jennifer Helgeson, Ph.D.
National Institute of Standards and Technology

Community 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.

- Communities bear primary responsibility to respond to the damage and impacts.
- The built environment exists to serve social functions (e.g., a hospital provides healthcare).
- **Social functions should drive the performance goals** of buildings and physical infrastructure.



Community Resilience Projects

	Project	Description
7316001	Community Resilience Guides	Guidance documents for community resilience planning; data from guides and tool use to inform future versions.
7316003	Systems Methods and Models	Software ARC tool to identify optimized sets of alternative solutions for informing community resilience planning.
7316004	Community Resilience Assessment Methodology	Metrics and indicators that quantitatively assess community resilience over time for physical, social, and economic systems.
7316008	Design Methods for Resilient Systems	Design methods and assessment criteria for buildings and infrastructure to support community resilience. Resilience, adaptation, and sustainability (RAS) planning methods and how they are implemented in the built environment.
7301026	Economic Methodology to Support Decision Making	EDGe$ web-based software tool to evaluate alternative resilience projects, including uncertainties and co-benefits.
7316011	Resilient Infrastructure and Future Hazard Impacts	Codes and Standards for future climate conditions.

Community Resilience Research NOW (10 years later)

Broader Definition of Resilience	• Beyond Disasters (compound events) • Holistic Approach
Emphasis on Equity and Social Justice	• Vulnerable Populations recognized • Inclusive Planning
Integration of Climate Change Considerations	• Climate-informed Planning • Nature-Based Solutions
Technological Advancements	• Data-driven Decision making • Digital Tools and Platforms
Partnerships and Collaborations	• Cross-Sector Partnerships • Regional and International Cooperation

NIST Collaboration with the CoE

Research Topics

Integrated Open-Source Modeling Environment (IN-CORE)

- Buildings, infrastructure, dependencies, uncertainty
- Population dislocation, housing, organizational functions
- Economic tax base and income
- Decision Support
- Social Institutions

Data Architecture

- Resilience data needs, standard formats
- Building fragilities and recovery curves

Testbeds and Field Studies

- Testbeds - Seaside, OR; Galveston, TX; Memphis, TN (MMSA); Mobile, AL; Lumberton, NC
- Hindcast - Joplin, MO
- Field Study – Lumberton, NC recovery
  - Interdisciplinary, longitudinal study of community recovery
  - School Function Focus - Housing, Businesses, Water treatment plant

CR Program Collaboration and Benefits

Modeling and Data

- Interdisciplinary data flows with varying spatial and temporal scales
- Recovery modeling
- Optimized modeling methods for community scale
- Decision support
- Community Engagement

Field Study Data Collection

- Longitudinal surveys and sampling plans that represent physical damage, socio-demographics, housing types, and business sectors
- Structured social science surveys and engineering damage assessments that integrate impacts and recovery
- Community function impacts and recovery models: housing/households, businesses, schools, government
- Institutional Review Board Protocols

External Collaboration

Communities

- Boulder, CO; Fort Collins, CO; Nashua, NH; Bozeman, MT; Salt Lake County, UT; 3 MD Counties; Charleston, SC; Cedar Rapids, IA; Biloxi, MS

Professional Organizations

- American Planning Association
- International City/County Management Association
- National Association of Counties
- National League of Cities
- National Association of Regional Councils
- Society of Risk Analysis

Academia (outside CoE and PREP)

- University of South Carolina
- East Carolina University

Standards

- ASTM
- ASCE
- API

Federal Engagement

- Mitigation Framework Leadership Group (MitFLG)
- Federal Adaptation and Resilience Working Group of the US Global Change Research Program (USGCRP)
- DHS Coastal Resilience Center, Flood Apex Research Review Board
- FEMA Building Science Branch, Mitigation Office, Building Resilient Infrastructure and Communities (BRIC), and Community Planning & Capacity Building (CPCB)
- HUD Residential Resiliency Advisory Group
- NASEM Action Collaborative on Disaster Research
- NSTC Subcommittee on Resilience Science and Technology (SRST)
- NOAA Climate Program Office
- USACE
- Census Bureau
- CDC
- IPC / Sub-IPC Engagement

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Communication of Research

Community Resilience Economic Decision Guide and Online Tool

The Community Resilience Economic Decision Guide for Buildings and Infrastructure Systems (EDG) provides a standard economic methodology for evaluating investment decisions aimed at improving the ability of communities to adapt to, withstand, and quickly recover from disruptive events. NIST has also produced the EDGe$ tool Version 1.0, a powerful, platform-independent online technique for selecting cost-effective, infrastructure-based community resilience projects based on the EDG.

This handout offers an overview of the Economic Decision Guide as well as details of the EDGe$ tool to support communities in using the recommendations from the Economic Decision Guide.

Webpage: https://www.nist.gov/community-resilience/edge-and-economic-decision-guide

Economic Decision Guide process assesses and compares alternative infrastructure projects for community resilience by analyzing the benefits and costs associated with competing capital improvements to support selecting investment strategies.

Case Studies can be found at https://tinyurl.com/y3h4dury

Figure 1: Economic Decision Guide's integration into the Community Resilience Planning Guide

HOW THE ECONOMIC DECISION GUIDE FITS INTO THE RESILIENCE PLANNING SIX-STEP PROCESS

EDG
1. SELECT CANDIDATE STRATEGIES
2. DEFINE INVESTMENT OBJECTIVE & SCOPE
3. IDENTIFY BENEFITS & COSTS
4. IDENTIFY NON-MARKET (NON-ECONOMIC) CONSIDERATIONS
5. DEFINE ANALYSIS PARAMETERS
6. PERFORM ECONOMIC EVALUATION
7. RANK STRATEGIES

CRPG
1) Form a Collaborative Planning Team
2) Understand the Situation
3) Determine Goals & Objectives
4) Plan Development
5) Plan Preparation, Review & Approval
6) Plan Implementation & Maintenance

EDGe$ (Economic Decision Guide Software) Online Tool helps the user 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. 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.

EDGe$ with Loss Amplification and Risk Aversion demonstrates an example of loss amplification and risk aversion in benefit-cost analysis. This work extends the EDG framework to include loss amplification and risk aversion and presents a case study example of how they can be incorporated into planning decisions.

Community Resilience Program

NIST manages the multi-faceted Community Resilience P... and stakeholders on issues related to buildings... infrastructure systems. The Community R... esilience work, complements efforts ... on research, community plan...

...bpage: https://www...

...es ...elves ...al ...ments ...nity ...ning Guide ...d Physical Systems ...anying 6-step

See associated publi... reports, and journal ... https://www.nist.gov/... resilience/publica...

...ernatives for Resilient Communities (ARC) is ...g tool that is designed to assist communities in re... ...g. NIST ARC is designed to assist a *collaborative* ... ...entification of solutions. Alternatives found with NIST ... ...erve as effective starting points for further analysis and ... ...uding with other tools.

The **Community Resilience Indicator Inve...** Assessment Methodology team supports ide... resilience indicators for testing and evaluation
- Based on 56 existing quantitative resilienc...
- 3,298 indicators and 7,165 measures

NIST's Community Resilience Program has on-going efforts ... collaboration with the National Oceanic and Atmospheric Administ... (NOAA), and American Society of Civil Engineers (ASCE) to adva... infrastructure planning in the face of future climate conditions. The... efforts will inform codes and standards to address community resilie... under future climate conditions.

Updated May 2024

Community Resilience Assessment Methodology Products

The National Institute of Standards and Technology (NIST) Community Resilience Assessment Methodology team helps communities and researchers to assess resilience at the community-scale based on community functions, supported by buildings and infrastructure systems, and the recovery of those functions following a disruptive hazard event.

This handout offers an overview of the foundational products, which provides tools, metrics, and guidance for the measurement of baseline resilience and changes in resilience over time.

Webpage: https://www.nist.gov/community-resilience/assessment-products

Community Resilience Indicator Inventory to support the identification and consensus of indicators for testing and evaluation.
- Based on 56 existing quantitative resilience frameworks
- 3,298 indicators and 7,165 measures

TraCR Database is expected to be released to the public in 2025

TraCR Database *and* ***TraCR Interactive*** to house the measures data needed to produce the priority indicator values used in the community resilience assessment tool.

Related Publications

An Annotated Bibliography that outlines each selected framework

A Data Article which presents summary descriptive statistics for the inventory

Commonly Used Indicator Validation to investigate overall performance

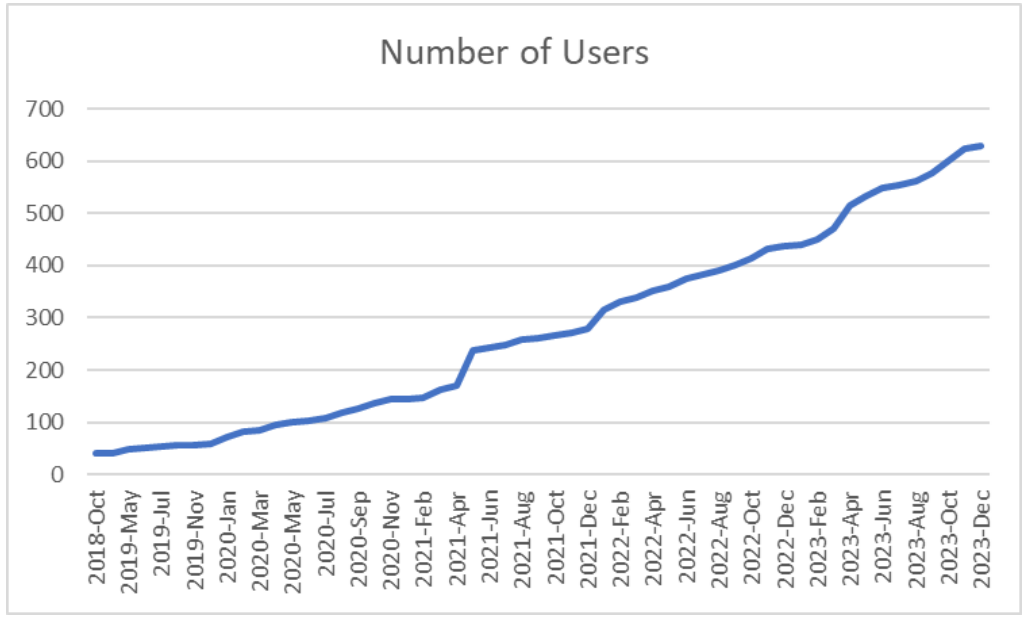
NIST National Institute of Standards and Technology U.S. Department of Commerce

borat...ory

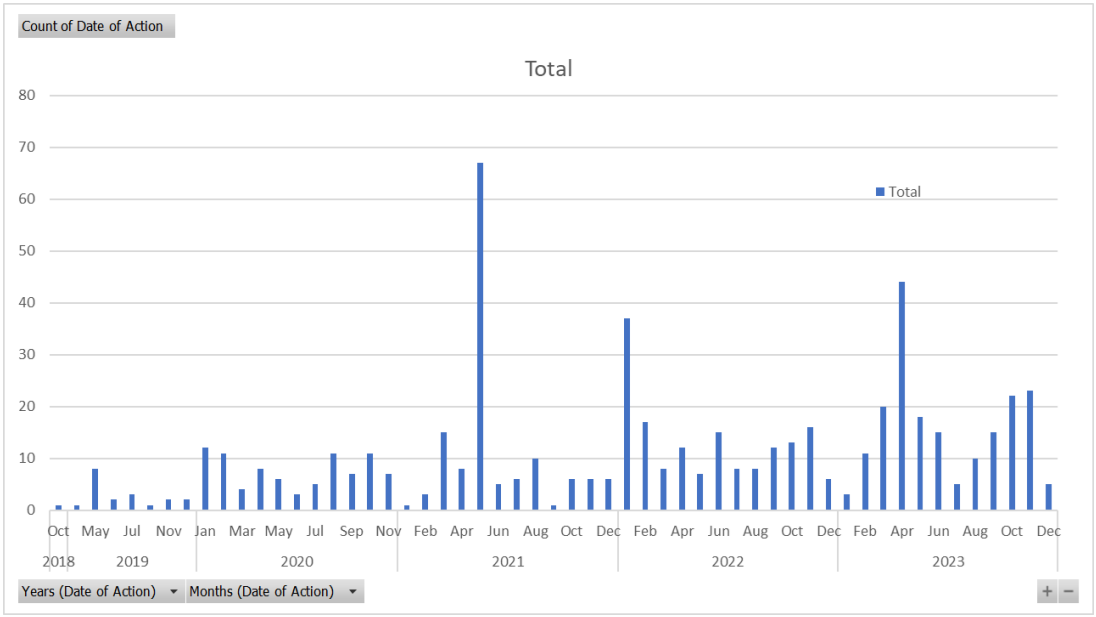
Slide credit: Dr. Jong Lee

IN-CORE User Stats as of December 1, 2023

- Total number of users: **628**
  - CoE users: 60
  - Non-CoE users: 568



Total Number of Users by Month



Number of New Users by Month

The Science Behind IN-CORE (in numbers)

1
Longitudinal Field Study

17
Ph.D. Dissertations

27
Postdoctoral Scholars

222
Peer-reviewed Journal Articles

14
Book Chapters

8
Data Collection Instruments Published

Data provided by: Dr. John van de Lindt

Corpus of Community Resilience Journal Publications

WEB OF SCIENCE SEARCH

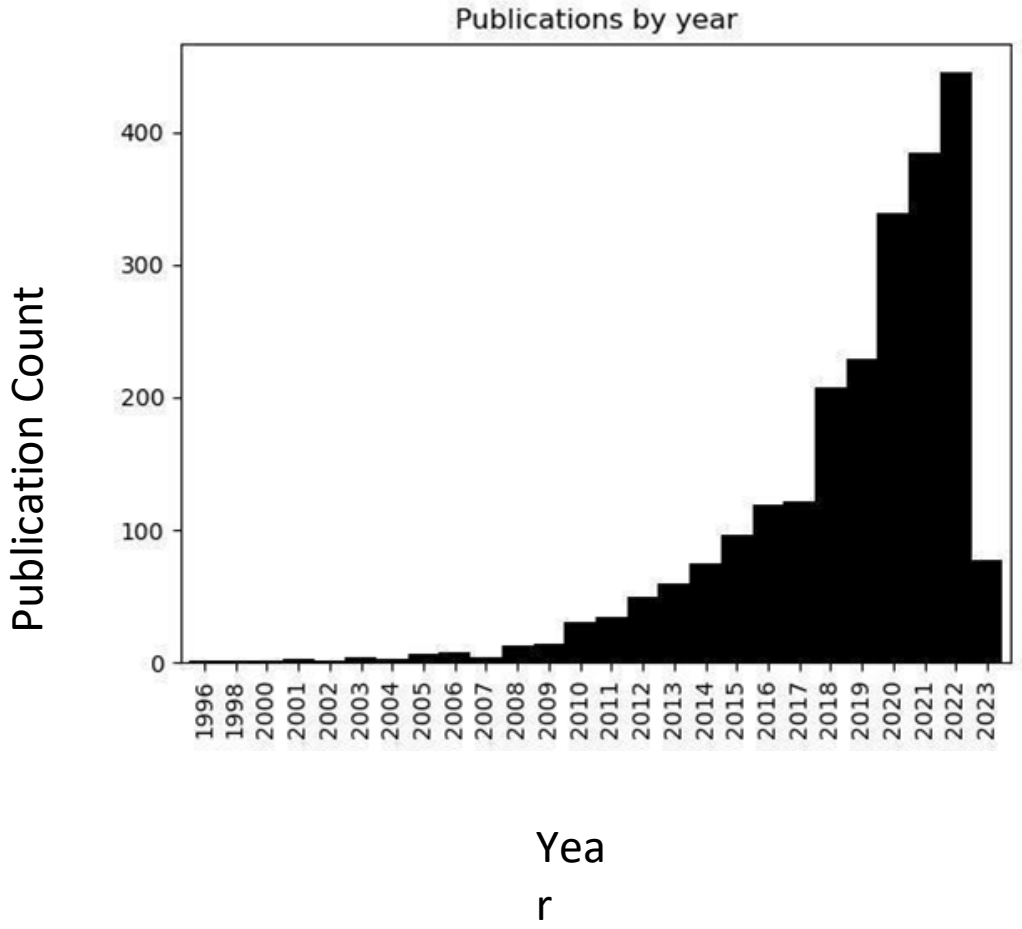
- 2,331 research documents
  - Consists of 92% research articles
  - Commentaries, reviews, proceedings

Clarivate Web of Science™

SEARCH STRING

```
ALL=(communit*) AND ALL=(resilien*) AND ALL=(planning) AND
(ALL=(vulnerab*) OR ALL=(hazard*))
```

Corpus of Community Resilience Journal Publications

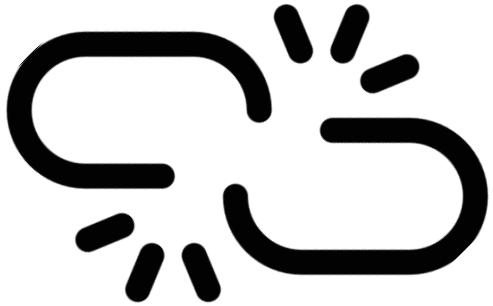


- 644 different journals
- 58% contribute just one article
- Three core journals account for 16% of the corpus:
  - *International Journal of Disaster Risk Reduction* (est. 2012)
  - *Sustainability* (est. 2009)
  - *Natural Hazards* (est. 1988)

Domain Topic Model

THEMATIC CONTENT ANALYSIS

- One-dimensional
- Limited tools to formally analyze document-level clusters



No formal link between thematic and citation-based analyses

CITATION ANALYSIS

- One-dimensional
- May reify disciplinary boundaries

Domain Topic Model

DOMAIN-TOPIC ANALYSIS

- Multidimensional
- Documents are clustered at multiple levels of abstraction

LINKED CITATION ANALYSIS

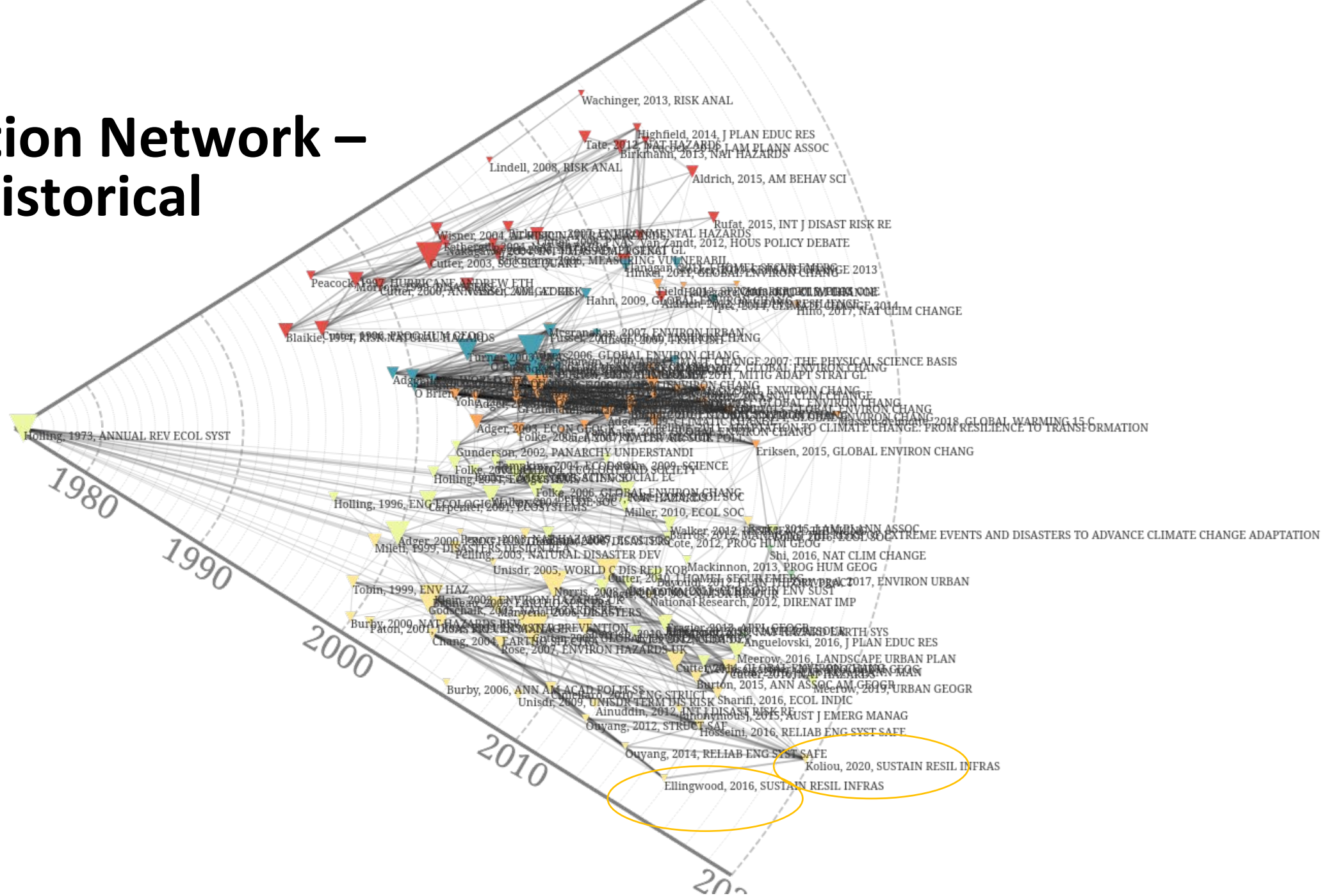
- Multidimensional
- Encompasses broad divisions and granular connectivity

Network analysis allows for a formal link between thematic and citation-based structures

LISIS
Laboratoire Interdisciplinaire Sciences Innovations Sociétés

CORTEXT

Co-citation Network – historical



Co-citation Network (2019-2023)

SEARCH:

"community AND resilience AND planning"

(2019-2023)

2,976 articles -- Four broad clusters are identified

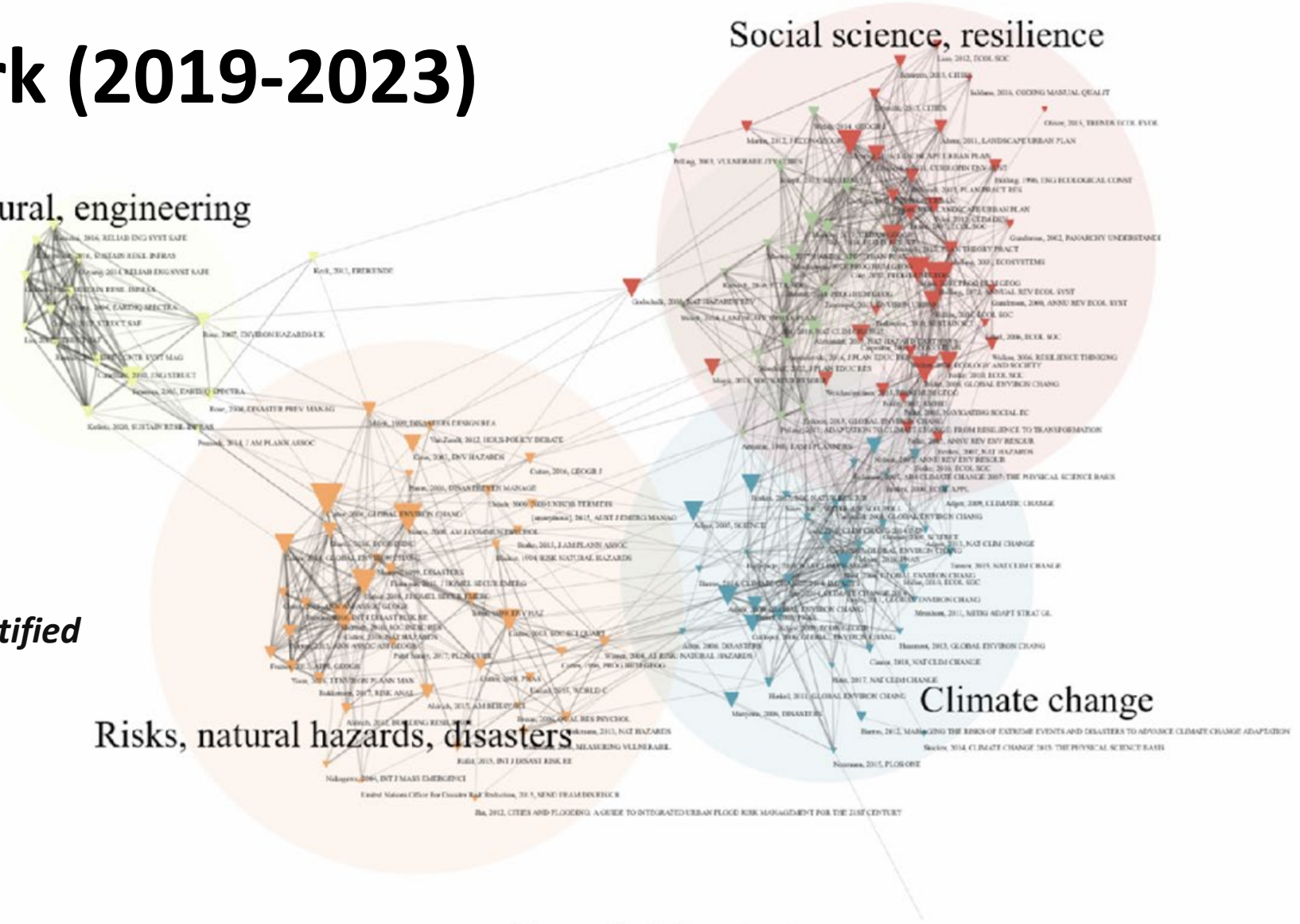
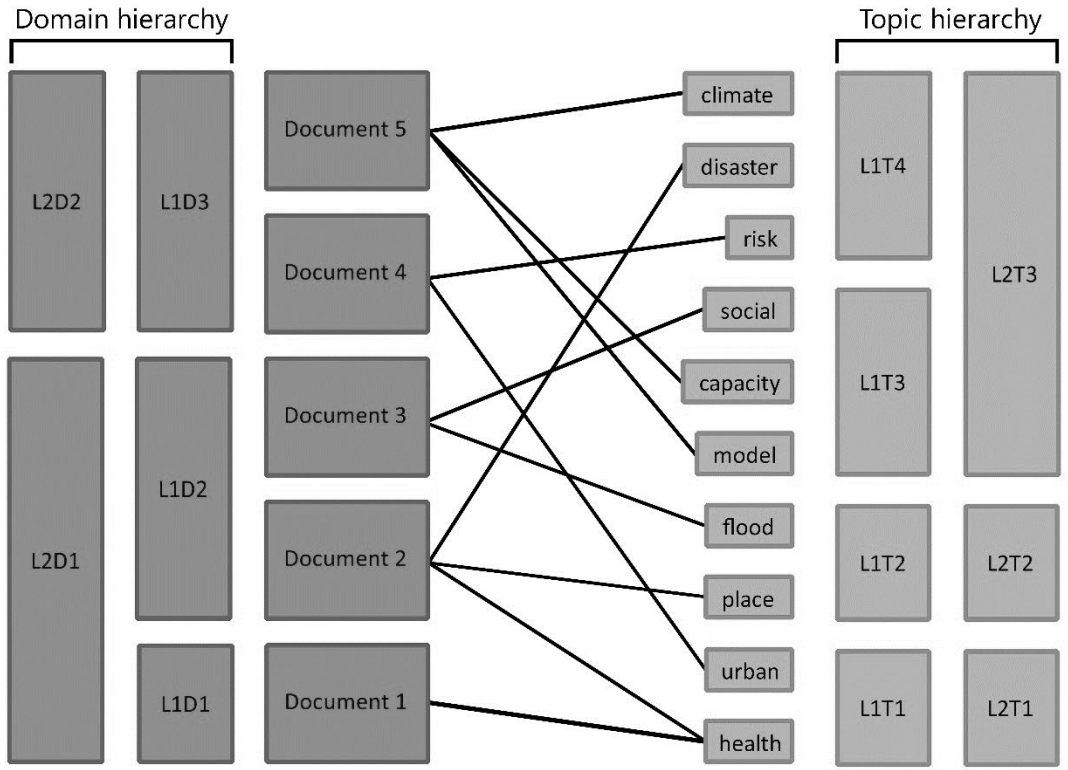


Figure 2: Co-citation network.

DOMAIN-TOPIC MODELING: EPISTEMIC STRUCTURE

DOMAINS

- Mutually exclusive groups of **documents** defined by the distribution of their constitutive **topics**
- Linked to **topics** with a measure of network-based connectivity
- Organized in a nested hierarchy according to the distribution of constitutive **topics**



TOPICS

- Mutually exclusive groups of **terms** defined by their co-occurrence across **documents**
- Linked to **documents** with a measure of network-based connectivity
- Organized in a nested hierarchy according to the co-occurrence of **topics** within **documents**

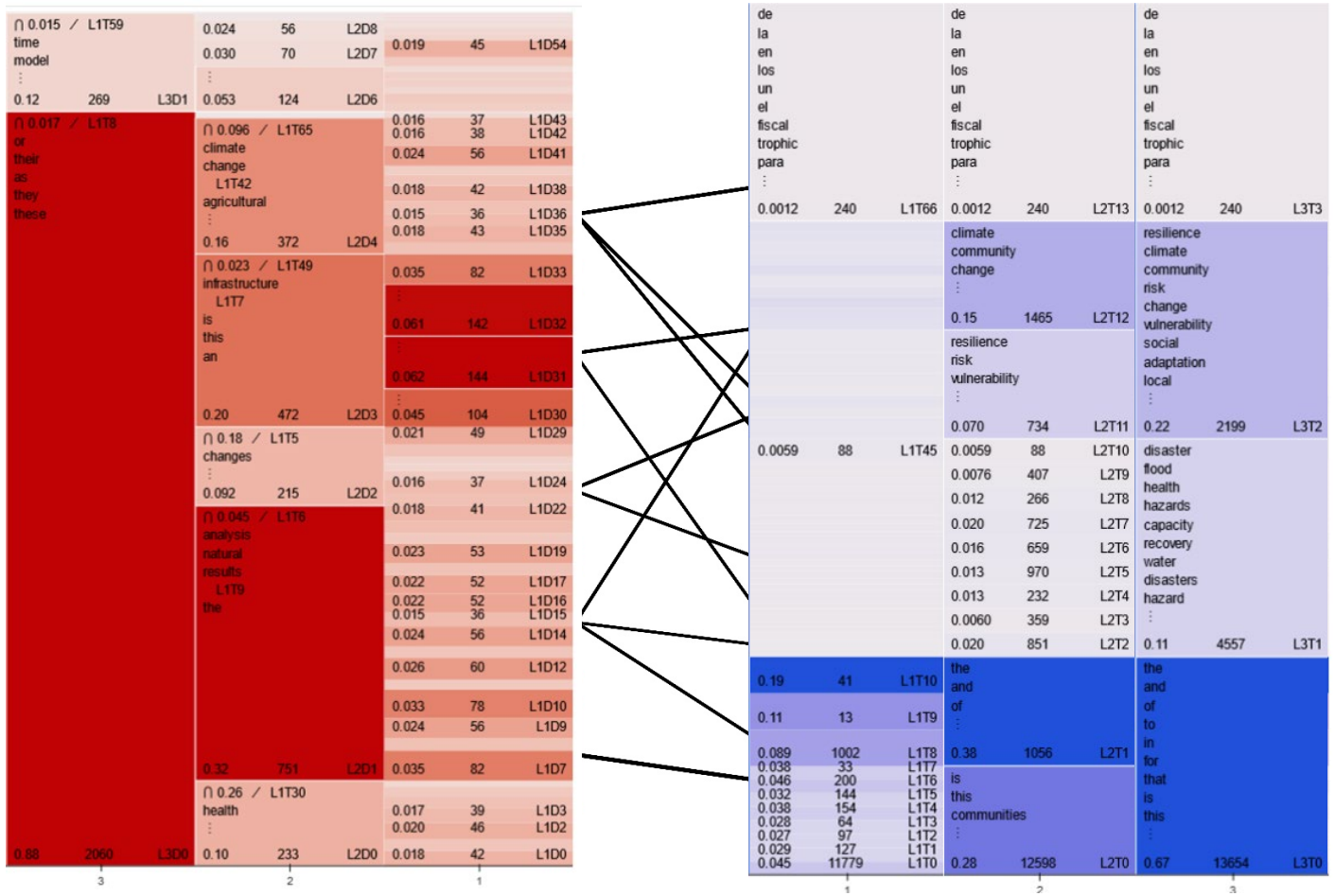
From: J. Toffelson, C. Gore, J. Helgeson, and S. Frickel. "Community resilience planning: What new methods reveal about the formation and transformation of a field" (under review).

See also: Hannud Abdo, Alexandre, Jean-Philippe Cointet, Pascale Bourret, and Alberto Cambrosio. 2022. "Domain-Topic Models with Chained Dimensions: Charting an Emergent Domain of a Major Oncology Conference." *Journal of the Association for Information Science and Technology* 73(7):992–1011.

DOMAIN-TOPIC MODELING: EPISTEMIC STRUCTURE

DOMAINS

- 61 Level-1 **domains** clustered into 10 Level-2 **domain groups**

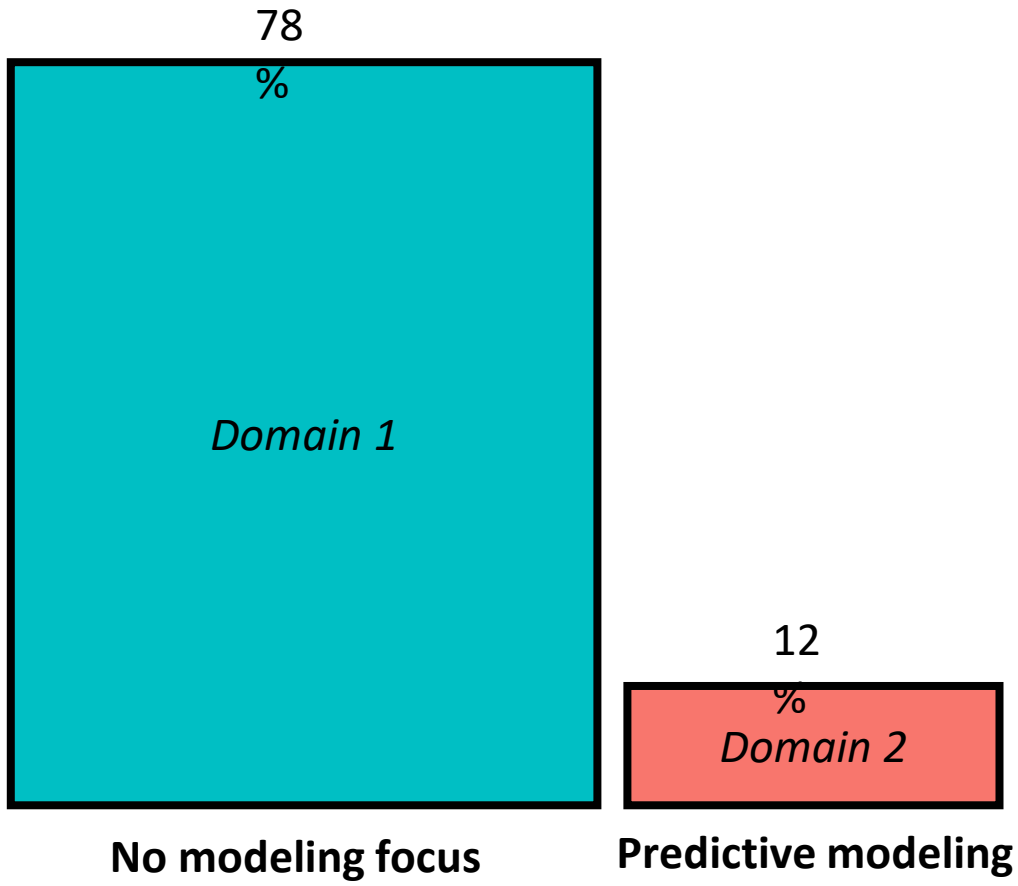


TOPICS

- 67 Level-1 **topics** clustered with 14 Level-2 **topic groups**

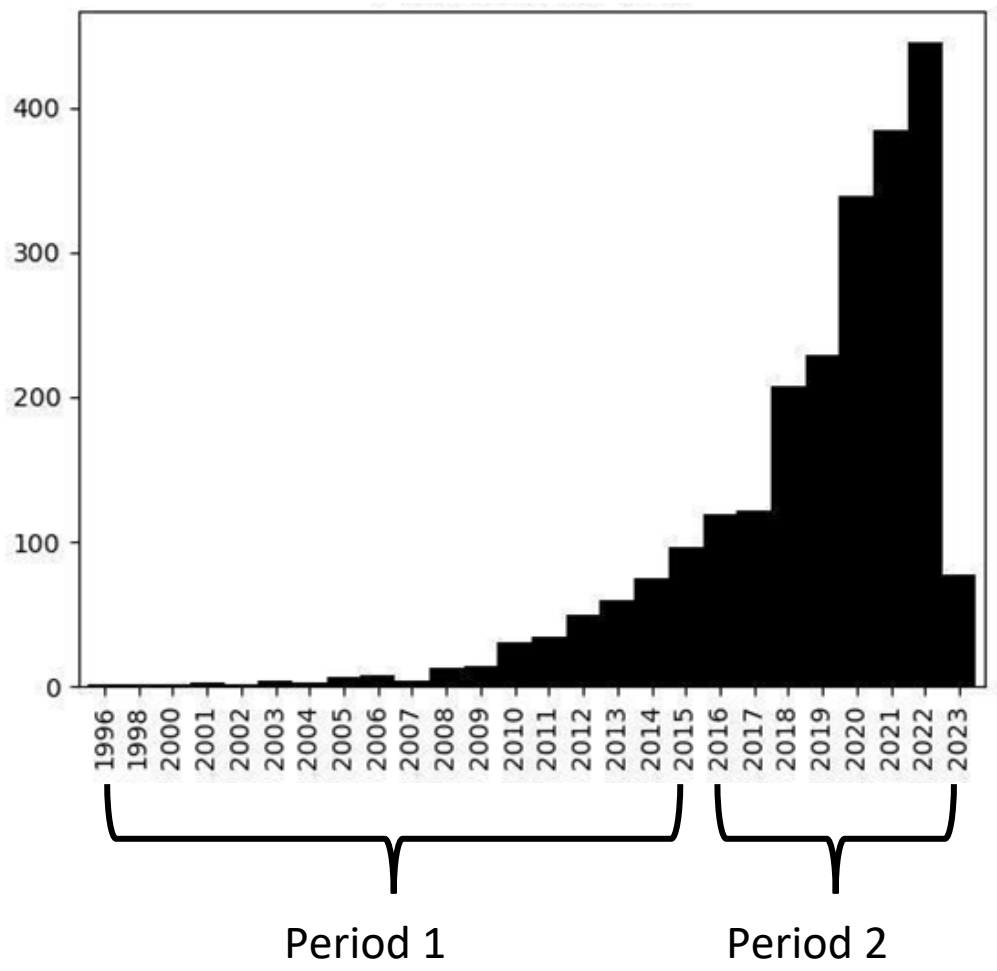
See also: Hannud Abdo, Alexandre, Jean-Philippe Cointet, Pascale Bourret, and Alberto Cambrosio. 2022. "Domain-Topic Models with Chained Dimensions: Charting an Emergent Domain of a Major Oncology Conference." *Journal of the Association for Information Science and Technology* 73(7):992–1011.

Higher Order Domain Clusters

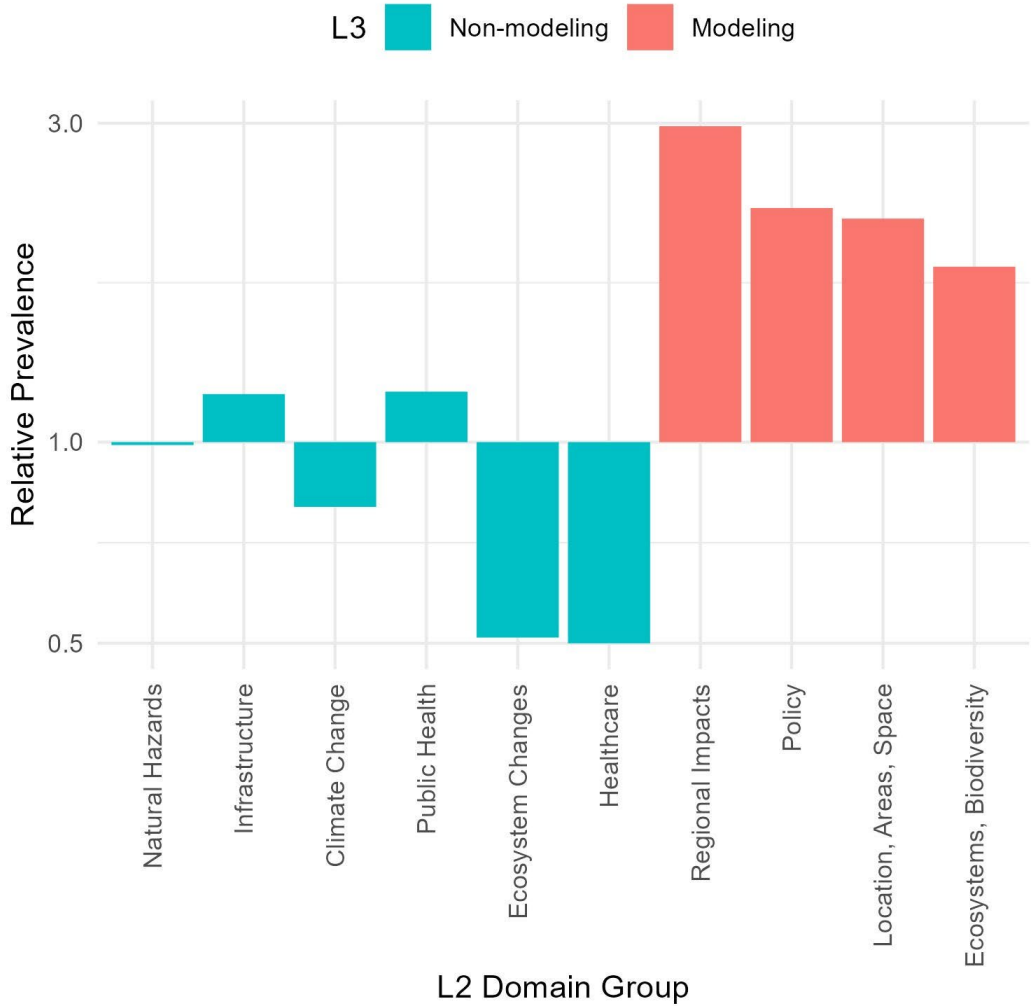


Temporal Change

Publication frequency



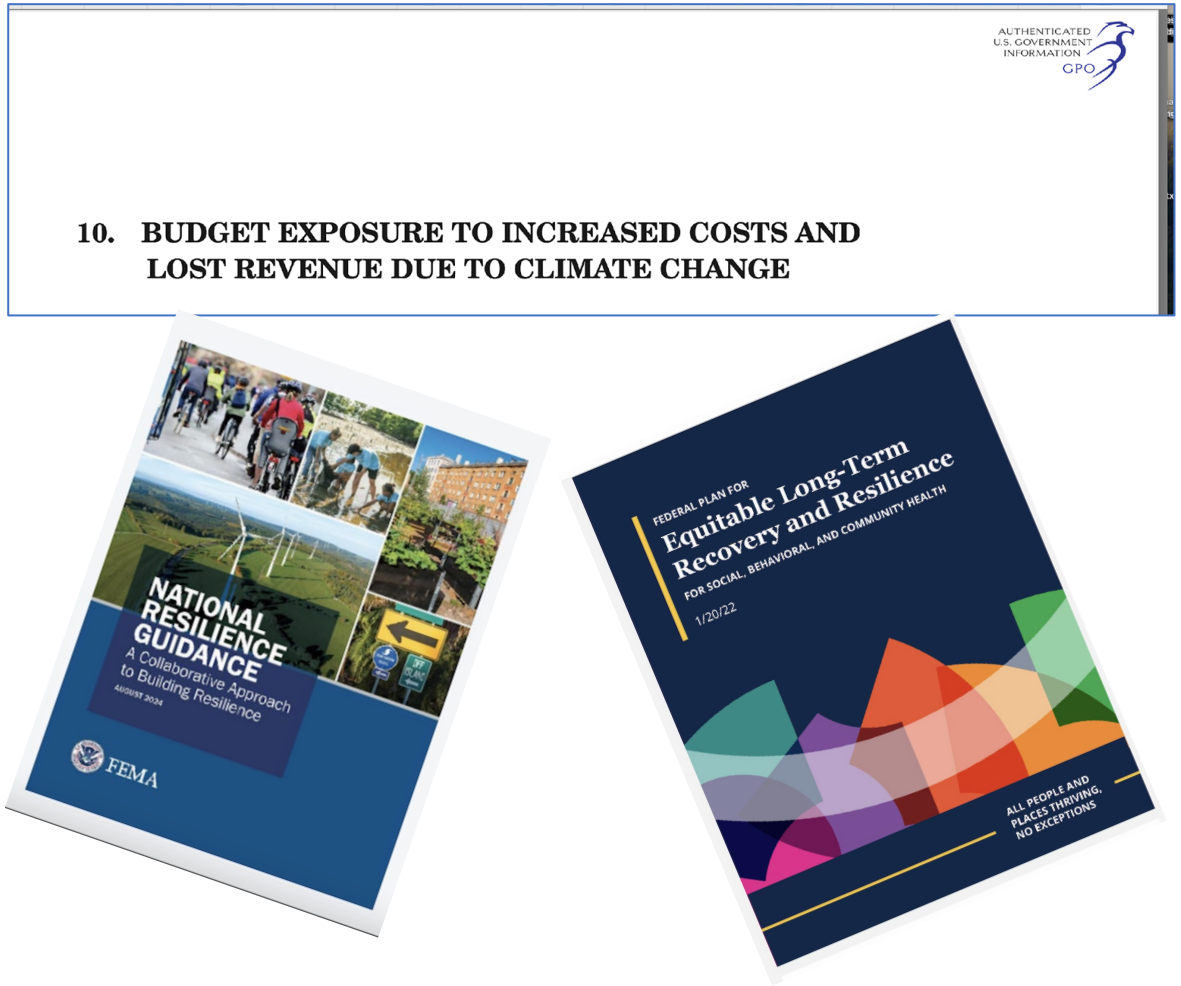
Relative frequency of thematic domains, 2016-2023 compared to pre-2016



Our Resilience Measurement Science informing policy

Some examples

- COE-supported research on building fragility to flood hazard supported Federal real property climate financial risk assessments in the FY24 President's Budget, in response to the Climate-Related Financial Risk Executive Order.
- ASTM E3350-22 Standard Guide for Community Resilience Planning for Buildings and Infrastructure a recommended resource in Circular A-11's Federal Capital Programming Guide for conducting resilience assessments when screening major Federal acquisitions.
- NIST's Community Resilience input and contributions to FEMA's National Resilience Guidance
- On-going contributions to the Federal Equitable Long-Term Recovery and Resilience Plan



TECHNICAL NOTES

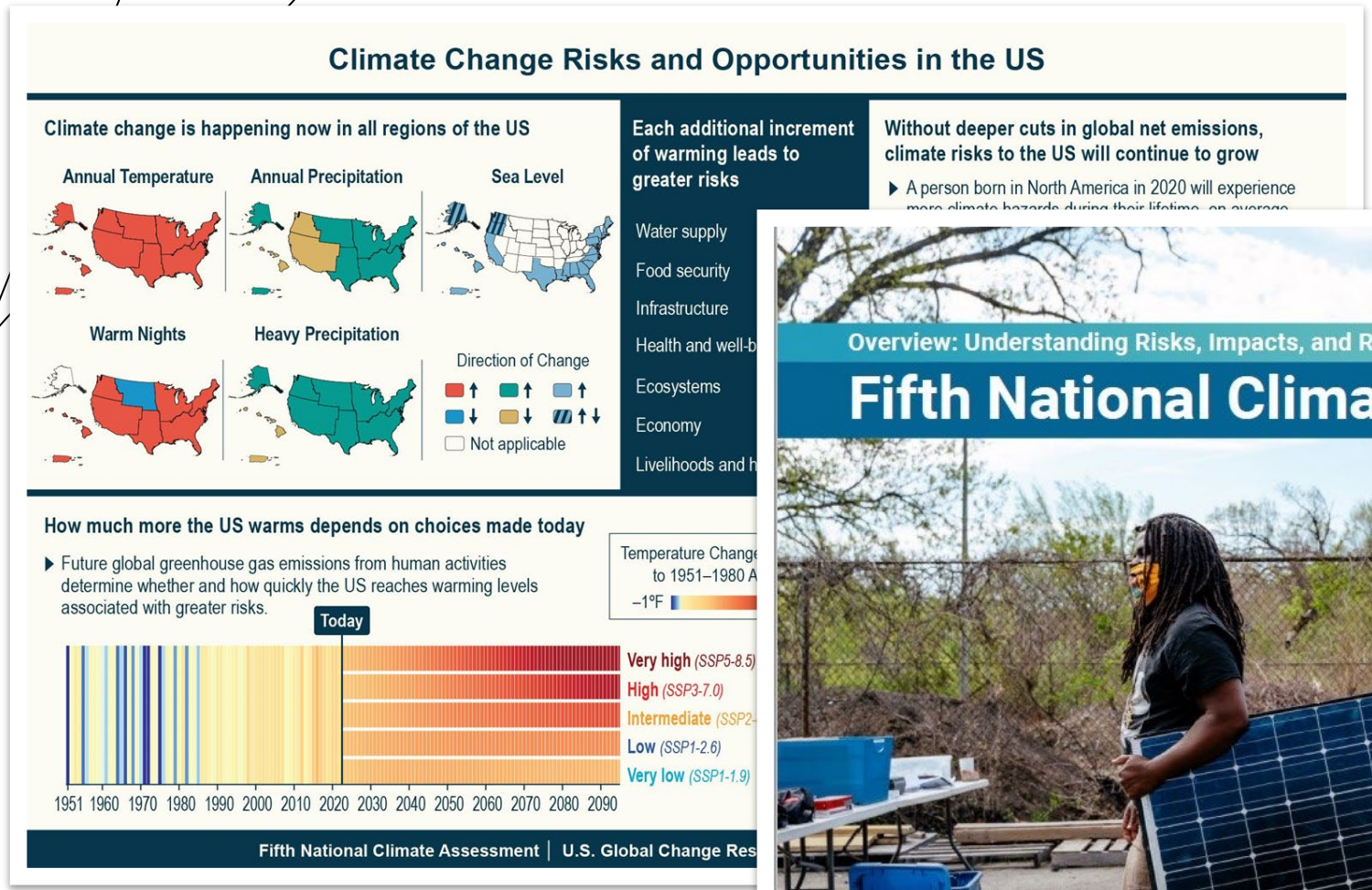
Massive, deadly Midwestern tornado storm offers lessons in housing resilience

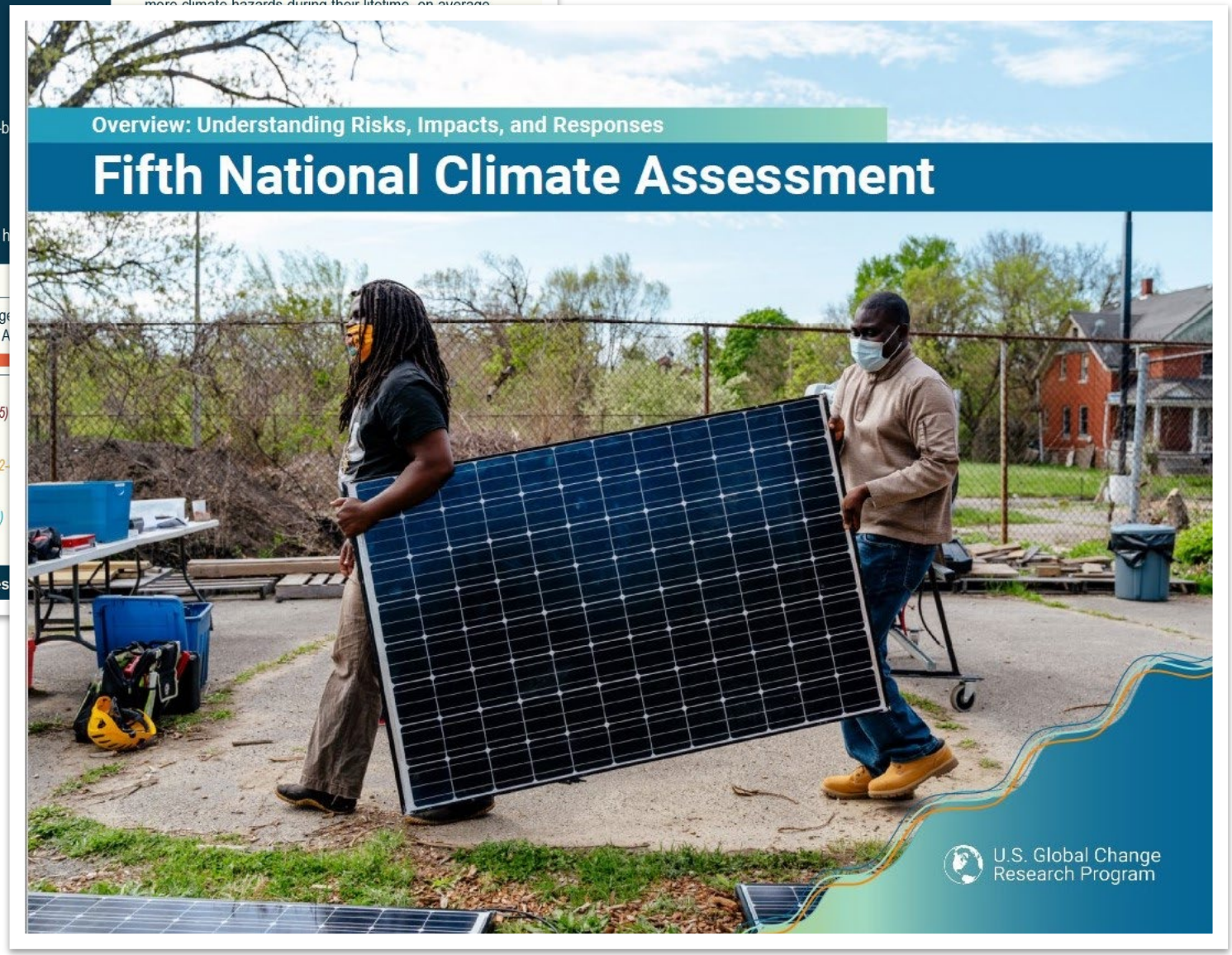
6/25/2024 | 0 | 2 MIN READ

The December 2021 "Quad-State Supercell" was a late season tornadic storm that tore t
Arkansas before moving through Missouri, Illinois, Tennessee, and Kentucky. It generated
EF4 tornadoes responsible for most damage, with 70 confirmed tornadoes during a 48-h
total of 90 people died, hundreds were injured, and property damage topped $3.9 billion.
hit Mayfield, Kentucky damaged or destroyed more than 3,700 residential buildings and l
churches, city hall, the fire station, and the police station. Around 1,200 families in the co

displaced, many relocating permanently; a year after the event, 190 families were still classified as homeless. What lessons can decision-makers draw from Mayfield to improve community resiliency moving forward?

Research funded by the National Institute of Standards and Technology through its Center for Risk-Based Community Resilience Planning examined damage in Mayfield to help in forecasting how different building designs or policies could affect housing damage and the potential for household dislocation at different tornado intensity levels. This work will help in developing design code changes for residential structures and improve their resiliency. Researchers Wanting Wang, John W. van de Lindt, Blythe Johnston, P. Shane Crawford, Guirong Yan, Thang Dao, Trung Do, Katie Skakel, Mojtaba Harati, Tu Nguyen, Robinson Umeike, Silvana Croope, and Andre R. Barbosa applied a multidisciplinary community resilience model to a real community and provided what-if scenarios for city planners and community stakeholders. Their study, "Application of Multidisciplinary Community Resilience Modeling to Reduce Disaster Risk: Building Back Better," appears in the *Journal of Performance of Constructed Facilities* at https://doi.org/10.1061/JPCFEV.CFENG-4650. Its abstract is below.


Climate Change Risks and Opportunities in the US
Climate change is happening now in all regions of the US
Annual Temperature
Annual Precipitation
Sea Level
Warm Nights
Heavy Precipitation
Direction of Change
Not applicable
Each additional increment of warming leads to greater risks
Water supply
Food security
Infrastructure
Health and well-b
Ecosystems
Economy
Livelihoods and h
Without deeper cuts in global net emissions, climate risks to the US will continue to grow
A person born in North America in 2020 will experience
How much more the US warms depends on choices made today
Future global greenhouse gas emissions from human activities determine whether and how quickly the US reaches warming levels associated with greater risks.
Temperature Change
to 1951–1980 A
–1°F
Today
Very high (SSP5-8.5)
High (SSP3-7.0)
Intermediate (SSP2-
Low (SSP1-2.6)
Very low (SSP1-1.9)
1951 1960 1970 1980 1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090
Fifth National Climate Assessment | U.S. Global Change Res


Overview: Understanding Risks, Impacts, and Responses
Fifth National Climate Assessment
U.S. Global Change
Research Program

Compounding Events

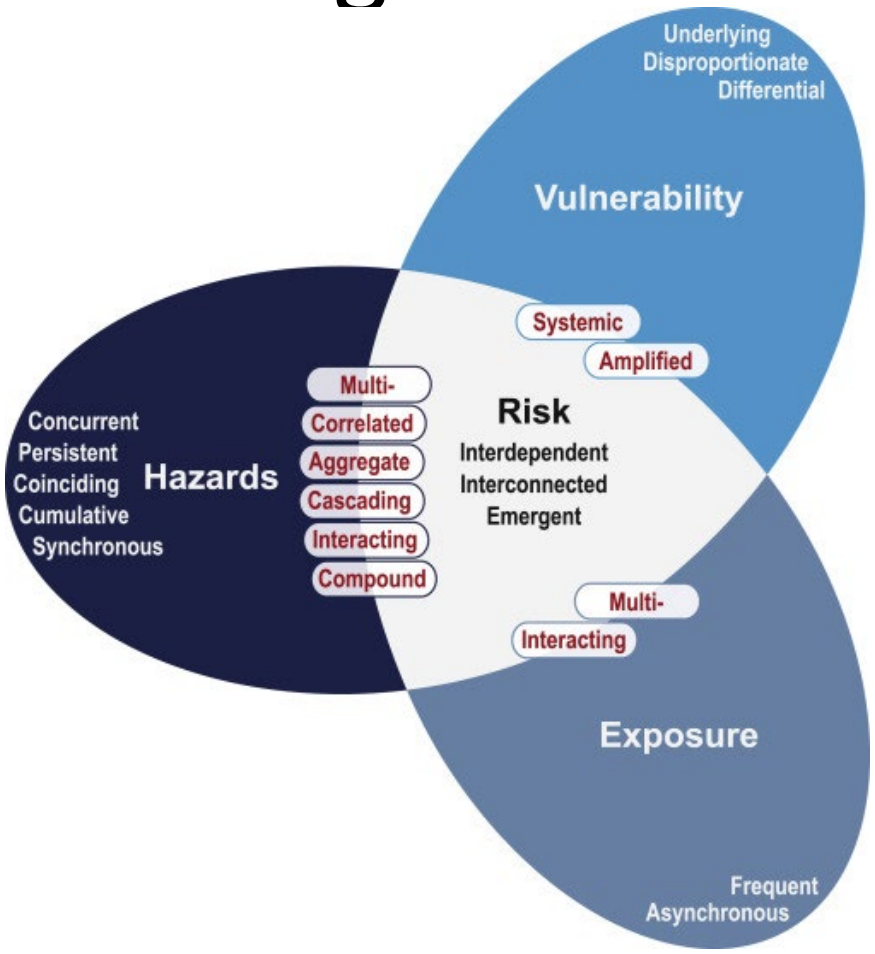
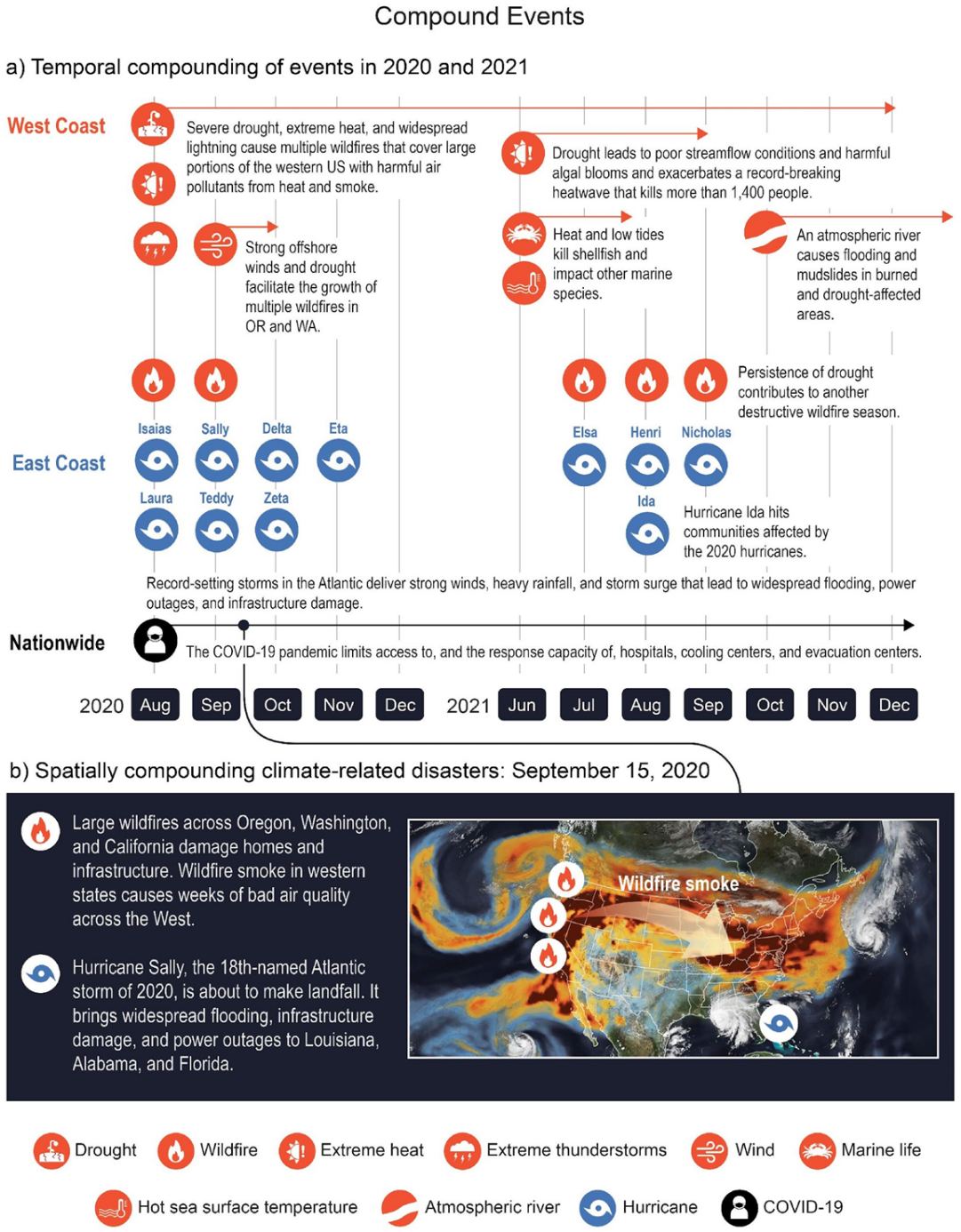
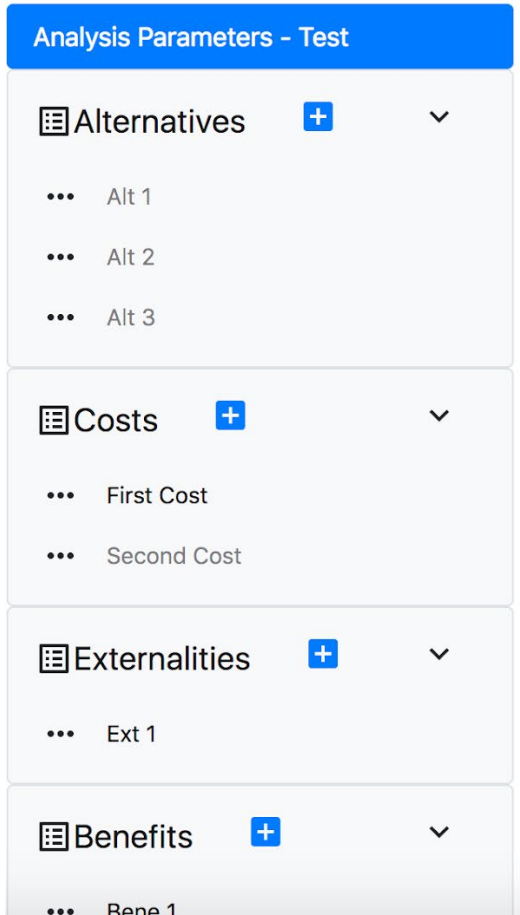


FIGURE F1.1 in Singh, D., A.R. Crimmins, J.M. Pflug, P.L. Barnard, J.F. Helgeson, A. Hoell, F.H. Jacobs, M.G. Jacox, A. Jerolleman, and M.F. Wehner, 2023: Focus on compound events. In: *Fifth National Climate Assessment*. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.F1



EDGe$ Online Tool V. 1.0

- 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
  - Five economic evaluation criteria are available in EDGe$' output analysis, once the user has input all relevant data:
    - Net Present Value (NPV)
    - Benefit-to-cost ratio (BCR),
    - Return-on-investment (ROI),
    - Non-disaster ROI, and
    - Internal rate of return (IRR)



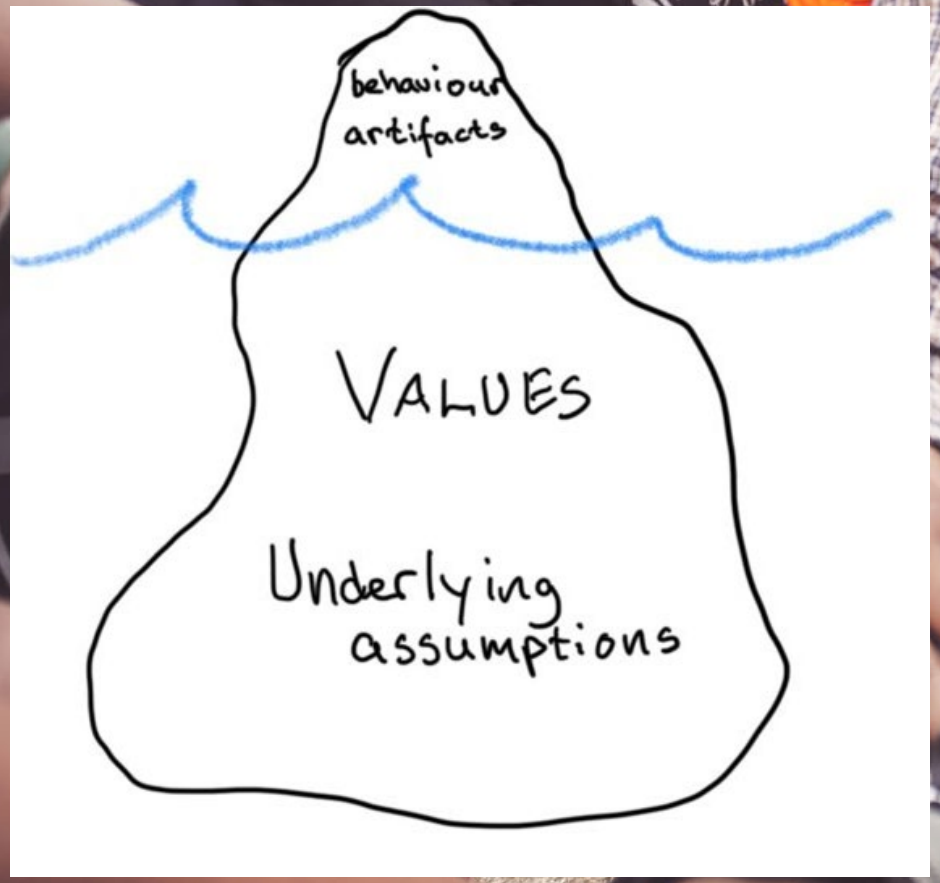
Why Benefit Cost Analysis (BCA) Falls Short in Resilience Planning?

- **Valuation Challenge**: Some impacts lack relevant data or are too expensive to collect, making it impractical to assign monetary values.
- **Non-Monetary Values**: BCA focuses on monetary value, but not all impacts can be readily quantified or valued in monetary terms.
- **Complex Interactions**: BCA often overlooks the complex interactions between different impacts, leading to an incomplete assessment.
- **Subjectivity:** Social consequences like social cohesion are subjective and may not fit neatly into a monetary scale.

Engaging Communities for Resilience Planning

- Local knowledge integration
- Stakeholder involvement
- Inclusive decision-making
- Building trust and partnerships
- **Understanding what the community members value**

Engaging Communities for Resilience Planning



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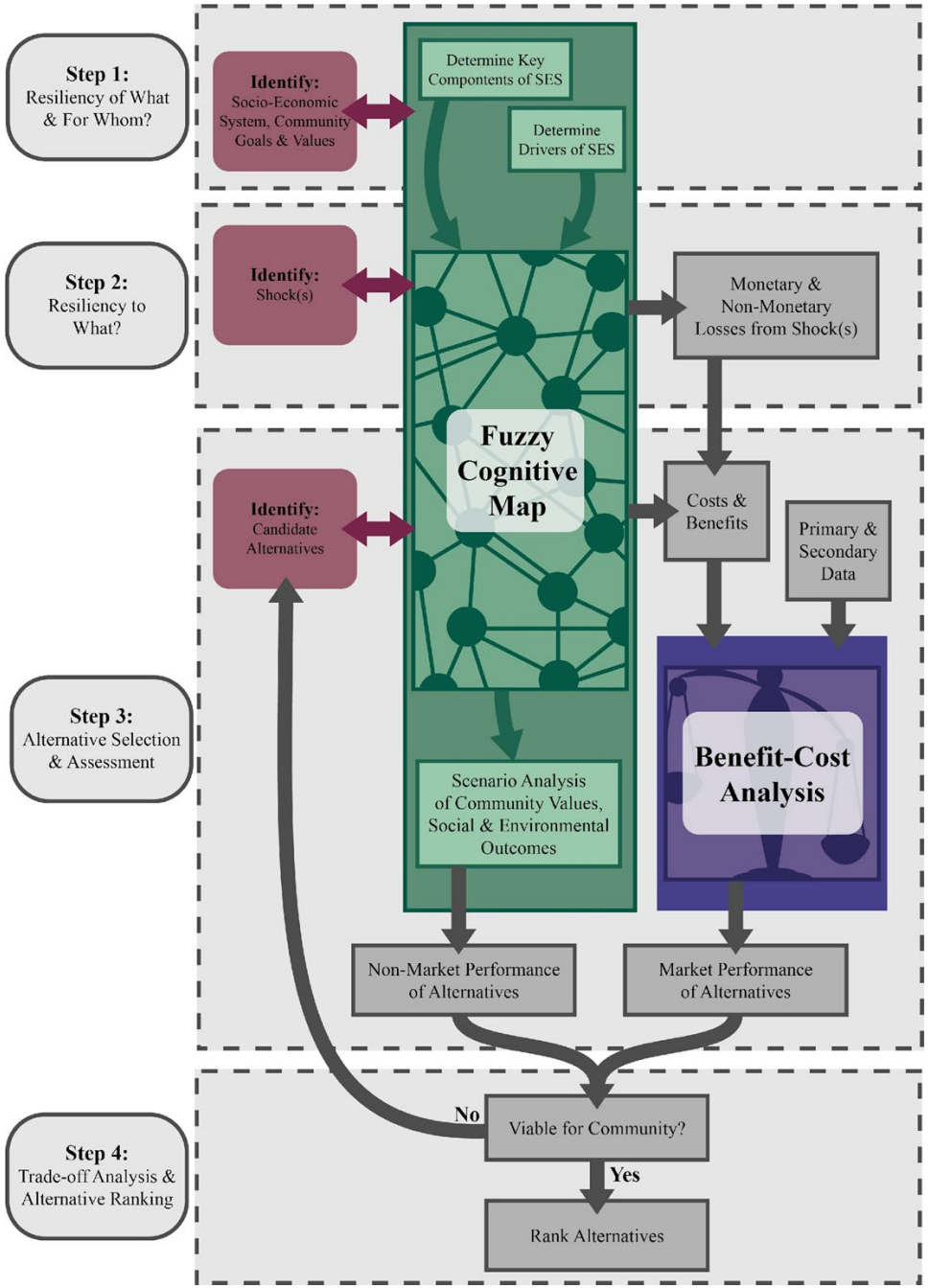
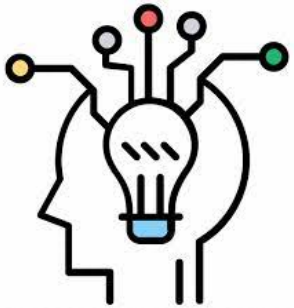


Community-informed **D**ecisions for **E**quitable, **C**ost-effective, and **I**nclusive **D**isaster **R**esilience Planning **CIDR**) Framework

EDGe$ (Economic Decision Guide Software)

https://edges.nist.gov



Mental Modeler

https://www.mentalmodeler.com

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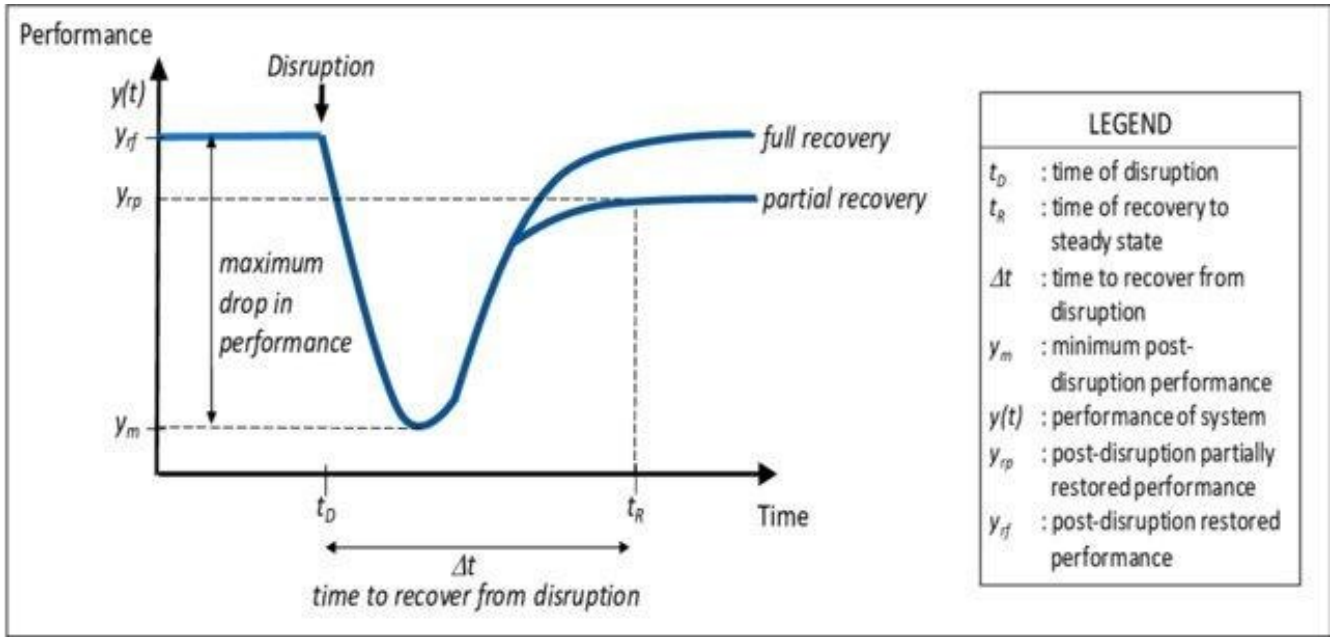

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