

Risk vs. Resilience: Similarities and Differences

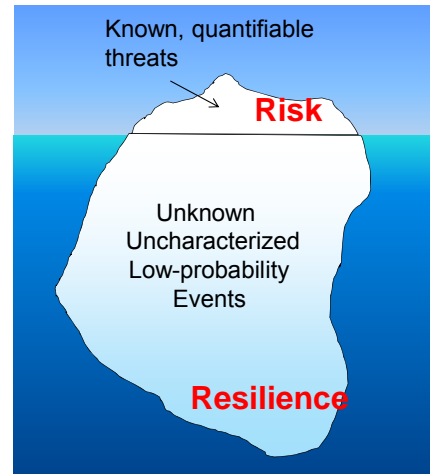
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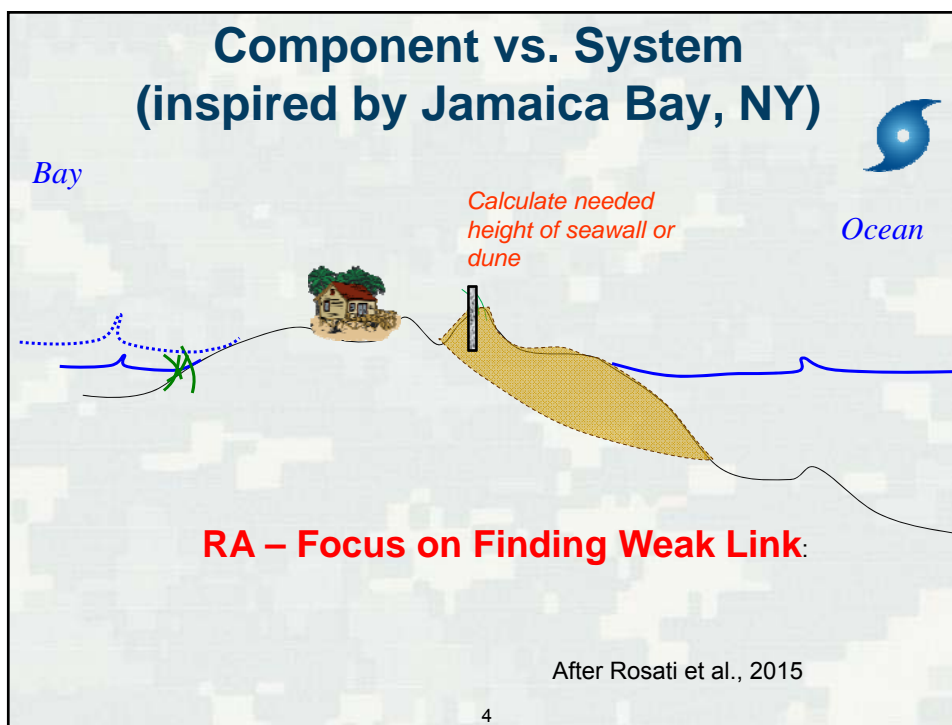
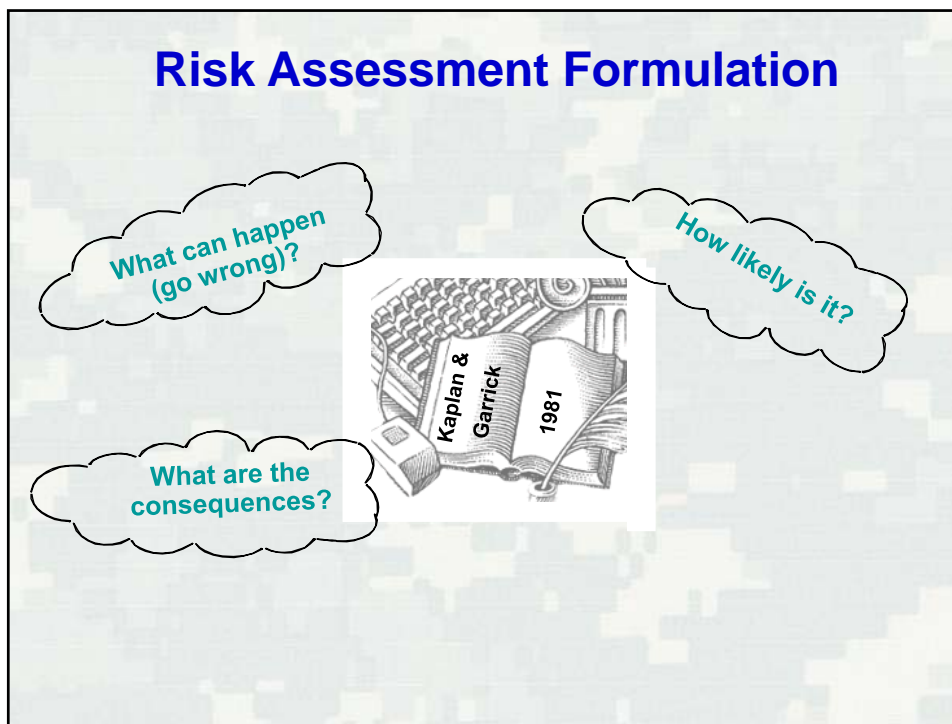
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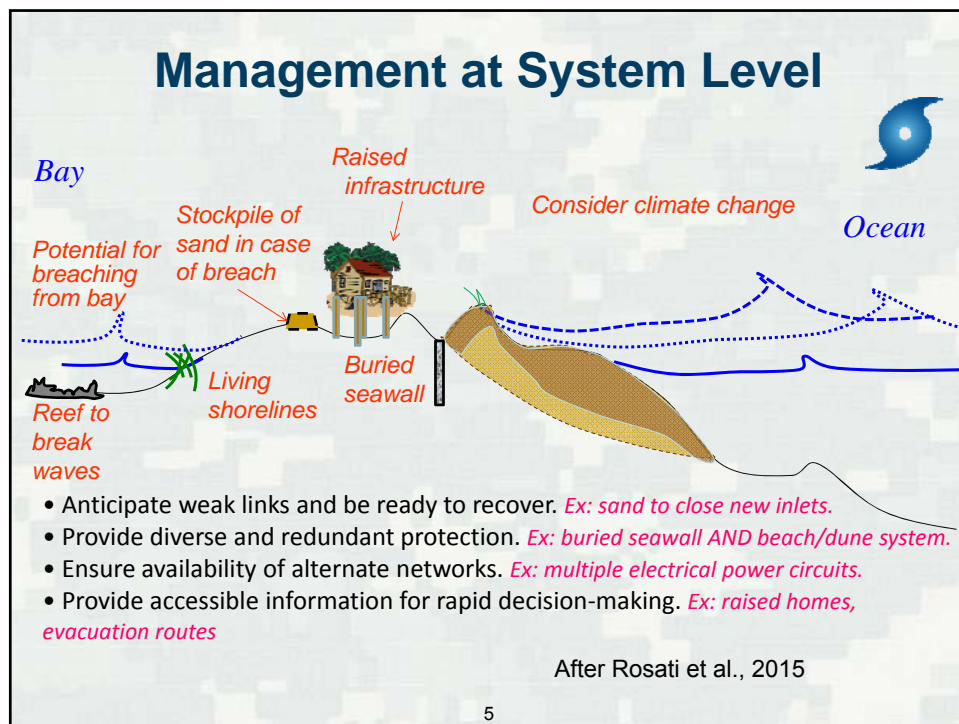
Aspen Global Change Institute,
December 2015



Outline

- Resilience vs Risk
 - Known Threats vs Unknown Threats and Critical Functions
 - System vs. Component
 - Temporality
- Science of Resilience?
 - Qualitative/Process
 - Resilience Abilities
 - Resilience Properties
 - Quantitative
 - Metrics
 - Indices
 - Matrix/Integration
 - Network Science
- Resilience and Risk – Ways to Integrate
- USACE Approach





Critical Function – Stakeholder Engagement

- System has multiple functions, but not all of them are equally important
 - ▶ Stakeholder elicitation is required
 - ▶ Prioritization of project alternatives
 - ▶ Values, preferences
 - ▶ Public education

“We want to include you in this discussion without letting you affect it”

0

Resilience: Political Importance and Challenge

The White House
Office of the Press Secretary
For Immediate Release

Presidential Proclamation -- Critical Infrastructure Security and Resilience Month, 2013

CRITICAL INFRASTRUCTURE SECURITY AND RESILIENCE MONTH, 2013

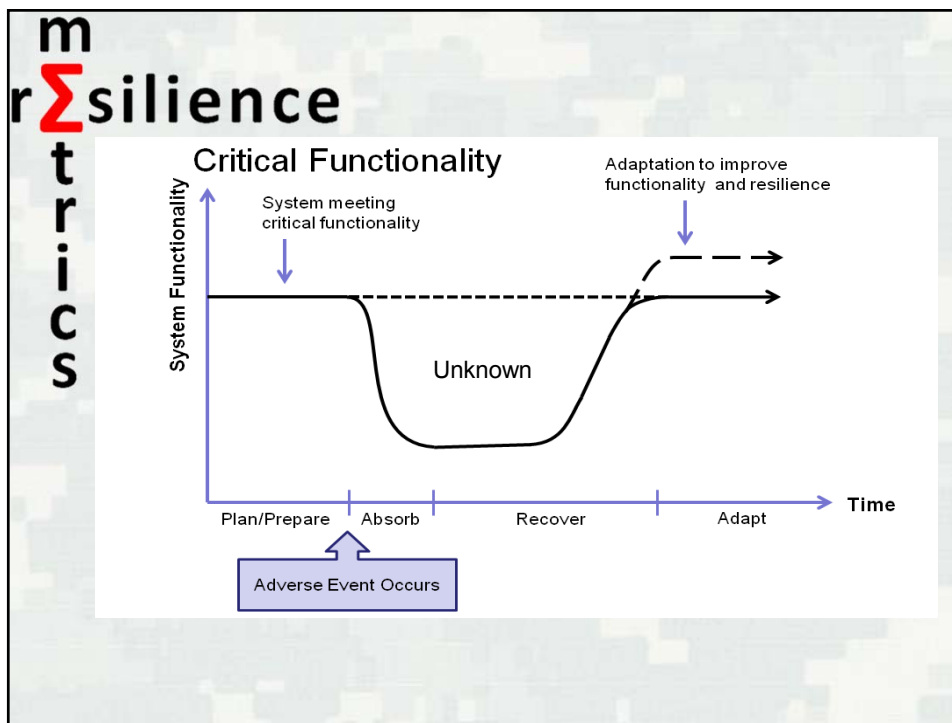
BY THE PRESIDENT OF THE UNITED STATES OF AMERICA

A PROCLAMATION

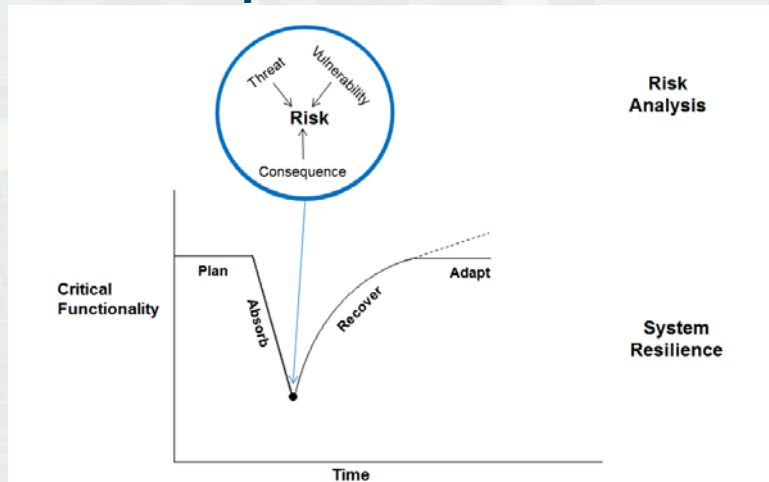
Over the last few decades, our Nation has grown increasingly dependent on critical infrastructure, the backbone of our national and economic security. America's critical infrastructure is complex and diverse, combining systems in both cyberspace and the physical world -- from power plants, bridges, and interstates to Federal buildings and the massive electrical grids that power our Nation. During Critical Infrastructure Security and Resilience Month, we resolve to remain vigilant against foreign and domestic threats, and work together to further secure our vital assets, systems, and networks.

Executive Order:

"resilience" means the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.

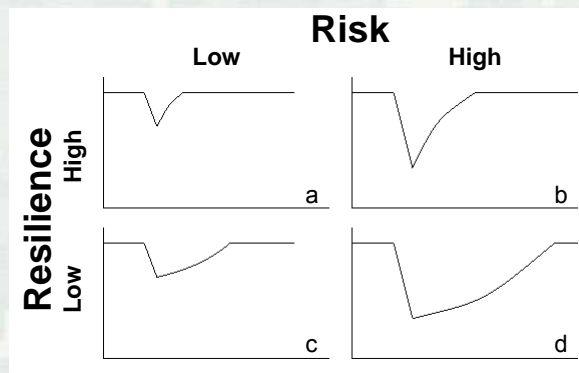


Risk Assessment is one part of Resilience



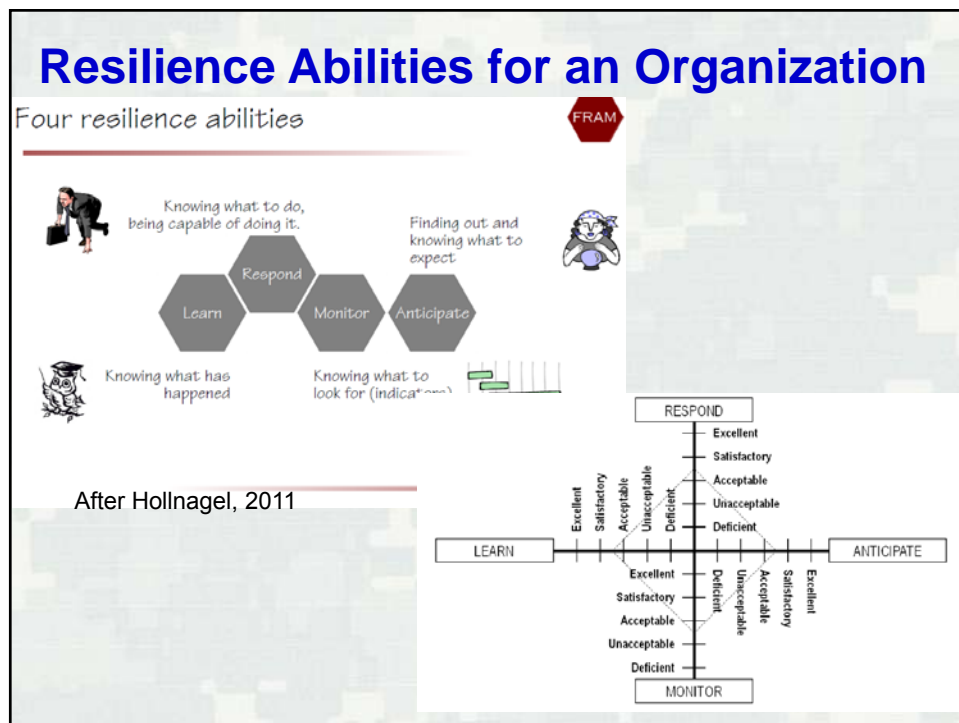
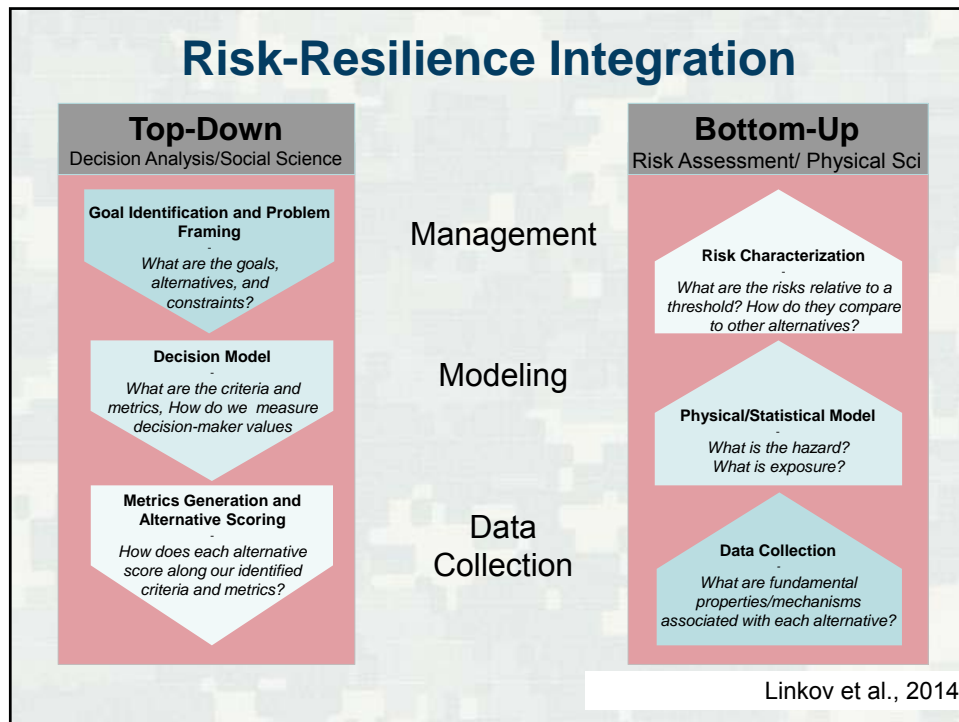
After Linkov et al, Nature Climate Change 2014

Importance of Recovery

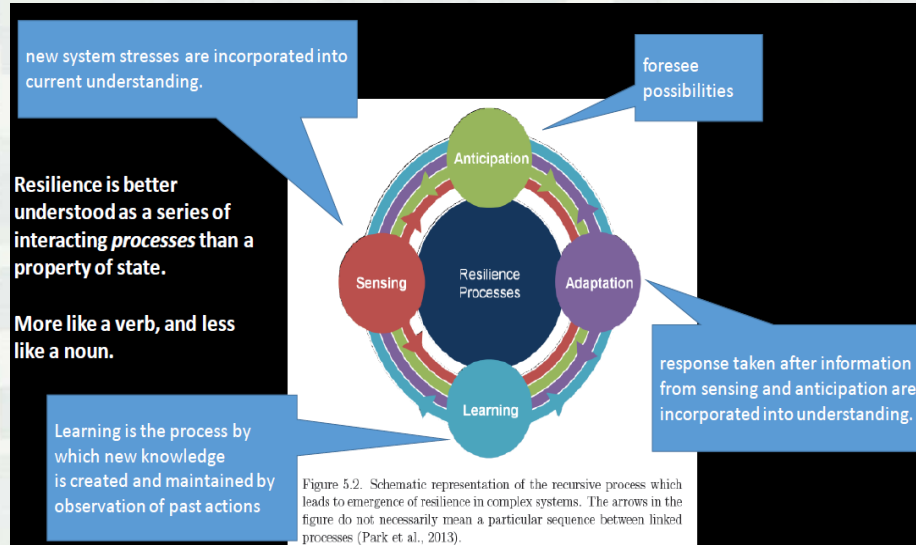


Traditional risk management focuses on planning and reducing vulnerabilities. Resilience management puts additional emphasis on speeding recovery and facilitating adaptation.

After Linkov et al, Nature Climate Change 2014



Resilience as a Process



Process for Social-Ecological Resilience

- Meant for resource management and planning stakeholders
- Workbooks guide stakeholders through 5 steps of resilience assessment:
 - ▶ Defining your system
 - ▶ Identifying alternate states and thresholds
 - ▶ Evaluating dynamics based on system cycles
 - ▶ Probing the system's adaptability
 - ▶ Planning interventions
- Qualitative resilience assessment helps to frame current state of system, identify desirability of possible changes in system states and functions, and determine disturbances of concern.

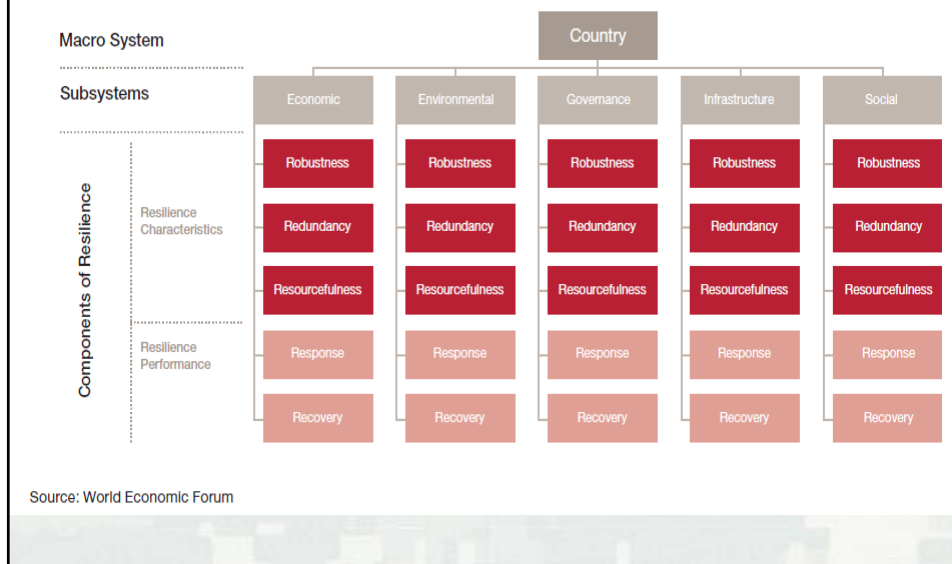
Table 1.4.1 Summary table of focal system disturbances

[illegible]

http://www.sustentabilidad.uai.edu.ar/pdf/cs/practitioner_workbook_1.pdf

Resilience as 3R, 4R, 5R...?

Figure 1 What is resilience?



The Disaster Resilience Scorecard for Cities

Engage, Share Understanding and Coordinate

Essential 1: Put in place organization and coordination to understand and reduce disaster risk in civil society. Build local alliances. Ensure that all departments understand their role in disaster risk reduction.

This section of the scorecard will help you assess the structure and governance of the various actors involved in disaster risk reduction, prediction, mitigation, response, restoration and recovery. It looks "top-down", on the coordination that may be involved; "bottom up", on the management of and engagement with grass roots disaster risk reduction initiatives that may have a disaster resilience impact.

Data you will need to answer this section of the scorecard will include: organization charts; lists of organizations; applicable, MOUs and other role descriptions for each organization concerned; names of key individuals from the organizations concerned.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement
1.1 Organization and coordination	1.1.1 Co-ordination of all relevant organizations and agencies	Presence of organizational chart	5 - Single point of contact with all relevant agencies

Table 1. Recommended core performance metrics by coastal feature for Department of the Interior Resilience projects funded through the Disaster Relief Recovery Act of 2013.

Natural and Artificial Coastal Features	Primary Objectives and Ecosystem Services	Recommended Core Performance Metrics
Beach System: Beach/Barrier Island/Dune	<p>Beaches and Dunes:</p> <ul style="list-style-type: none"> 1) Restore or improve beach habitat to enhance resilience of fish, wildlife, and plants, and their habitats (e.g., spawning, migration stopovers, critical habitats) 2) Restore/improve dune habitat to enhance resilience of coastal infrastructure by reducing flooding extent and attenuating wave energy 3) Improve/sustain beach/barrier island ecosystem and community resilience to storm surge events 4) Enhance understanding of natural system dynamics including immediate storm responses, natural recovery from disturbance events, and natural adaptation capacities and tendencies. 5) Improve recreation/aesthetics <p>Breaches:</p> <ul style="list-style-type: none"> 1) Manage breach occurrences to maximize habitat and hazard mitigation benefits at least cost 	<p>Beaches and Dunes:</p> <p>Biotic:</p> <ul style="list-style-type: none"> • Vegetation cover of dunes pre and post event • Fish and wildlife population/ recruitment/ overwintering/stopover weight/health relative to other mitigating factors (e.g. other threats throughout range: site and species specific) <p>Abiotic:</p> <ul style="list-style-type: none"> • Post-storm volume of sand in the active shoreface • Recovery rates of beach and dunes <p>Structural/Engineering:</p> <ul style="list-style-type: none"> • Beach width, elevation, volume, shoreline position (post-event) • Dune characterization (height, width, length, texture, substrate) <p>Breaches:</p> <p>Biotic:</p> <ul style="list-style-type: none"> • Fish and wildlife population/ recruitment/ overwintering/ stopover weight/health changes relative to other mitigating factors (e.g. other threats throughout its range: site and species specific)

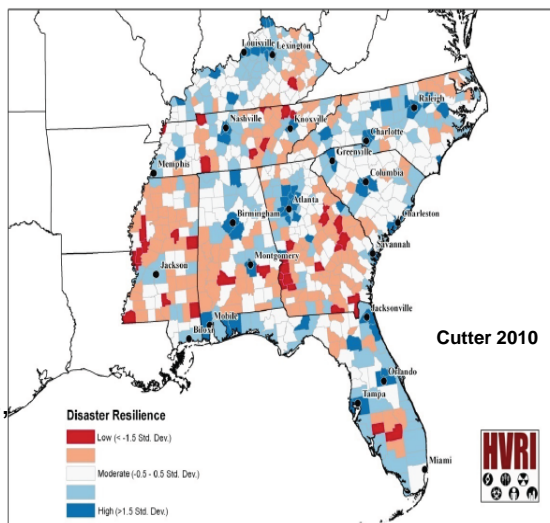
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Resilience Metrics

DHS Disaster Resilience Index

- Demographic data as indicators of scale of vulnerability and resilience/ ability to recover quickly.
- Metrics in categories of : social, economic, institutional, infrastructure, and community.
- All categories equally weighted.
- Regional assessment, county level resolution.
- Spatially reported results comparative.
- All hazards assessment



FEMA Disaster Resilience Index

- Community member awareness and vulnerability survey
- Potential hazard severity identification
- Strength of social systems
- Relative importance of community structures
- Rate general mitigation measures on level of effectiveness or feasibility to improve each community component
- Guidance on developing specific mitigation actions.
- Supplements: specific hazard probability, functional loss, and cost calculator; local all-hazards risk assessment

Mitigation Action	Cost	Priority	Technical	Political	Legal	Environmental	Social	Health/Safety	Other	Notes
Local Plans and Regulations										
Disaster and Mitigation Programs										
Technical Systems Protection										
Education and Awareness Programs										

<http://www.dhss.ny.gov/oem/mitigation/documents/fema-local-mitigation-handbook.pdf>

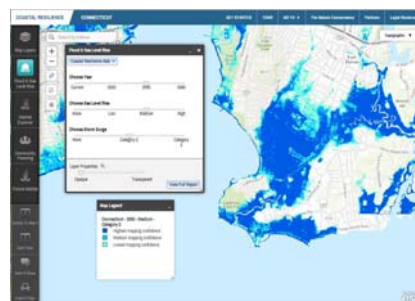
NOAA Community Resilience Index

- Identify past and expected storm strength for benchmark scenarios.
- Checklist of likely losses to critical infrastructure and facilities under each scenario.
- Expected level of recover in 1 week.
- Business recovery,
- Strength of social systems
- Existing plans and agreements
- Rank resilience in each category as High, Medium, Low.
- No relative weights
- Local Government Use
- Specific to coastal storms

	Special Flood Hazard Area (SFHA)	Bad Storm Scenario 1	Future Storm Scenario 2	Infrastructure or facility functions after disaster
<i>Example Power grid</i>		✓		✓
Section A: Critical Infrastructure				
Wastewater treatment system				
Power grid				
Water purification system				
Transportation/evacuation routes				
Total check marks for Section A:				
Section B: Critical Facilities*				
City Hall or other local government building(s)				
Police station or other law enforcement building(s)				
Fire station(s)				
Communications main office or substations				
Emergency operation center				
Evacuation shelter(s)				
Hospital(s)				
Critical record storage				
Total check marks for Section B:				

Nature Conservancy Coastal Resilience Mapping Tool

- ESRI powered geospatial analysis tool
- Pre-loaded map layers of relevant demographic and ecological data
- 4 apps available for decision making purposes
 - Flood and Sea Level Rise (future projections)
 - Habitat Explorer (weighing habitat importance)
 - Community Planning (current data map layers)
 - Future Habitat (projected marsh advancement)
- Local decision-makers and planners in coastal communities
- Used for land management and wetland preservation prioritization



<http://maps.coastalresilience.org/ct/>

Weaknesses of Existing Methods

- Assessments built in ad-hoc manner based on specific expertise of agency.
- Most agencies efforts are not framed in context of larger system. These efforts are each components of the necessary changes.
- Assessments do not explicitly consider uncertainty
- Assume future impacts will reflect past impacts and that locations of past events will be equally important in future events.
- Tools largely assess vulnerability through risk metrics rather than assess resilience through capabilities to absorb, recover, and adapt.

Resilience Matrix Approach

Resilience Matrix:

Analyze the functionality of each **domain** of the system across each **stage** of the event timeline

	Prepare	Absorb	Recover	Adapt
Physical				
Information				
Cognitive				
Social				

- Uses general metrics for measuring relative system resilience
- Different from vulnerability assessment – threats unknown
- Useful for identifying weak areas and prioritizing investment to improve overall resilience

From Linkov et al, Env. Sci. & Tech 2013

Assessment using Decision Analysis

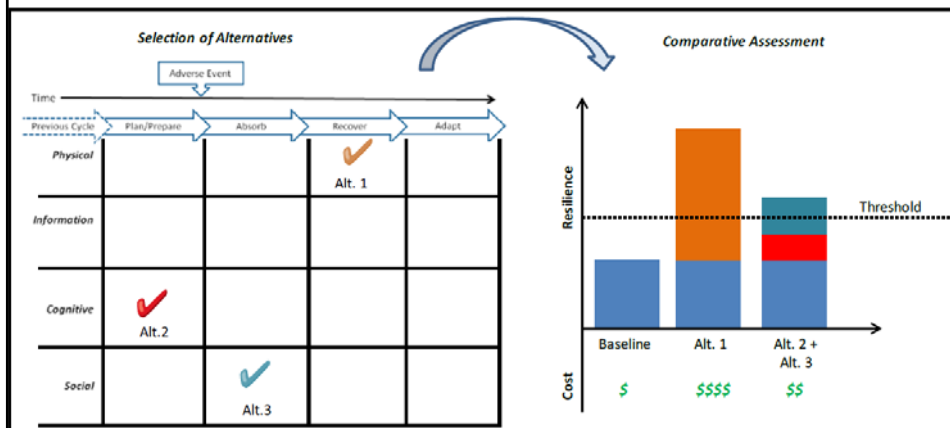


Figure 5: Comparative Assessment of Resilience-Enhancing Alternatives

Use developed resilience metrics to comparatively assess the costs and benefits of different courses of action

How it works: Project Evaluation

- Baseline assessment can be used to evaluate proposed projects

	Prepare	Absorb	Recover	Adapt
Physical	71	16	60	10
Information	63	45	21	18
Cognitive	90	49	38	27
Social	82	54	12	52

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Project 1

	Prepare	Absorb	Recover	Adapt
Physical	+10	+18	+9	+32
Information	+8		+17	
Cognitive				
Social				

	Prepare	Absorb	Recover	Adapt
Physical	81	34	69	42
Information	71	45	38	18
Cognitive	90	49	38	27
Social	82	54	12	52

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Project 2

	Prepare	Absorb	Recover	Adapt
Physical				
Information		+5	+15	+22
Cognitive				
Social	+3		+12	+21

	Prepare	Absorb	Recover	Adapt
Physical	71	6	60	10
Information	63	50	36	40
Cognitive	90	49	38	27
Social	85	54	24	73

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*Projects may have (+) or (-) in other matrices

Resilience Quantification through Network Science

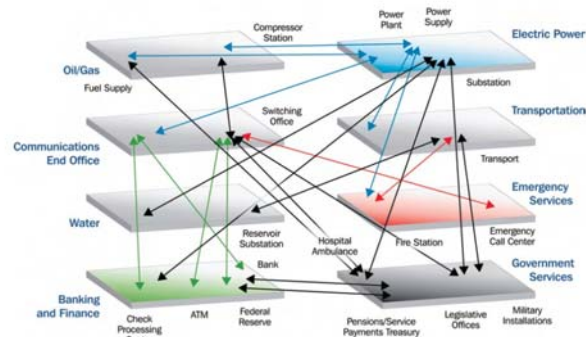
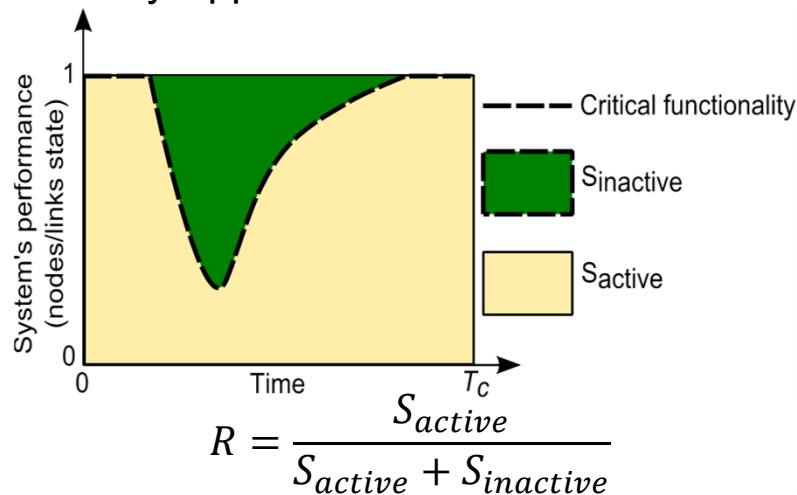


FIGURE 3.1 Connections and interdependencies across the economy. Schematic showing the interconnected infrastructures and their qualitative dependencies and interdependencies. SOURCE: Department of Homeland Security, National Infrastructure Protection Plan, available at http://www.dhs.gov/xpreprod/programs/editorial_0827.shtm.

Resilience Quantification

- Based on NAS Definition
- Widely Applicable



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After Ganin et al., Nature Scientific Reports, 2015

Generalized Form of Resilience

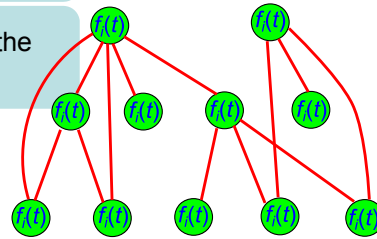
System's *critical functionality* (K)

Network topology: *nodes* (\mathcal{N}) and *links* (\mathcal{L})

Network *adaptive algorithms* (\mathcal{C}) defining how nodes' (links') properties and parameters change with time

A set of possible damages stakeholders want the network to be resilient against (E)

$$R = f(\mathcal{N}, \mathcal{L}, \mathcal{C}, E)$$

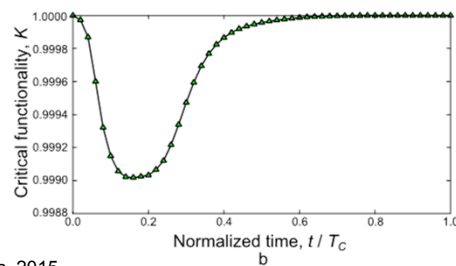
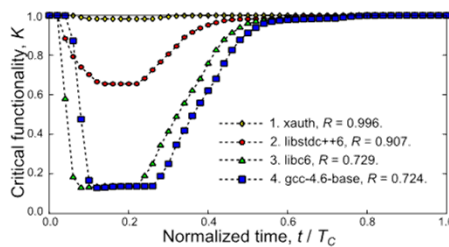
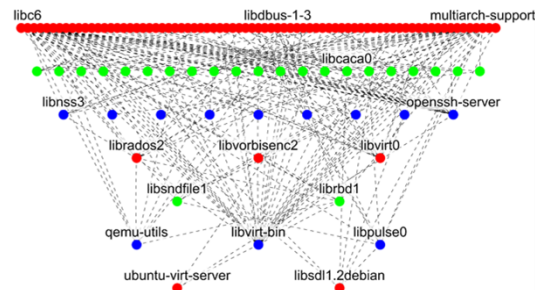


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After Ganin et al., Nature Scientific Reports, 2015

Case: Linux Packages Network

Subnetwork of Linux packages dependencies network (*right*) and resilience profiles (*bottom*) for guided and random attacks on nodes



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After Ganin et al., Nature Scientific Reports, 2015

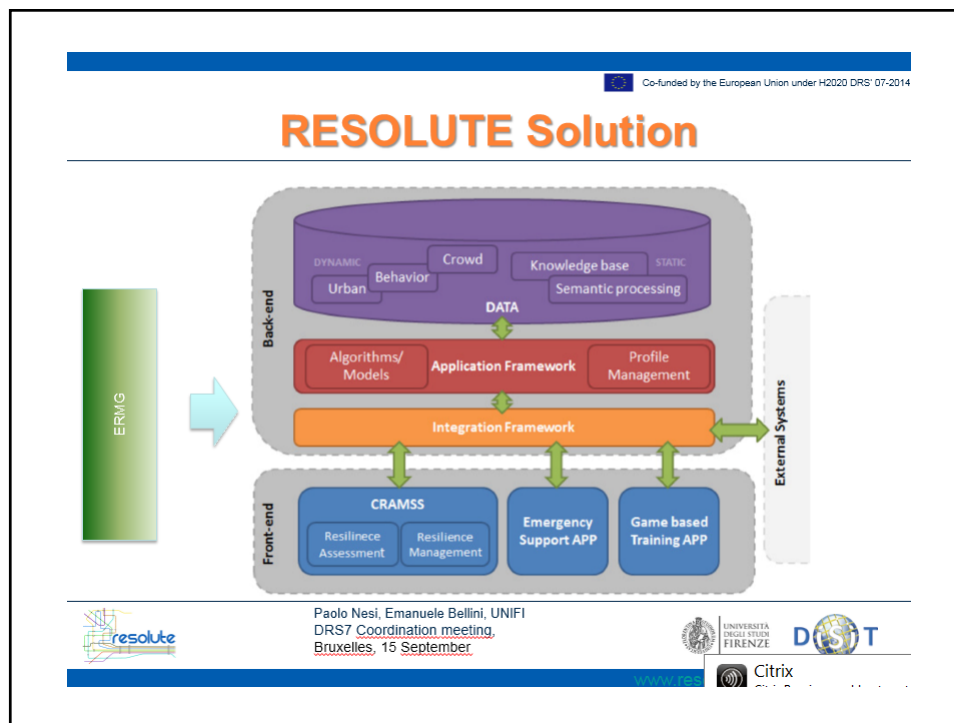
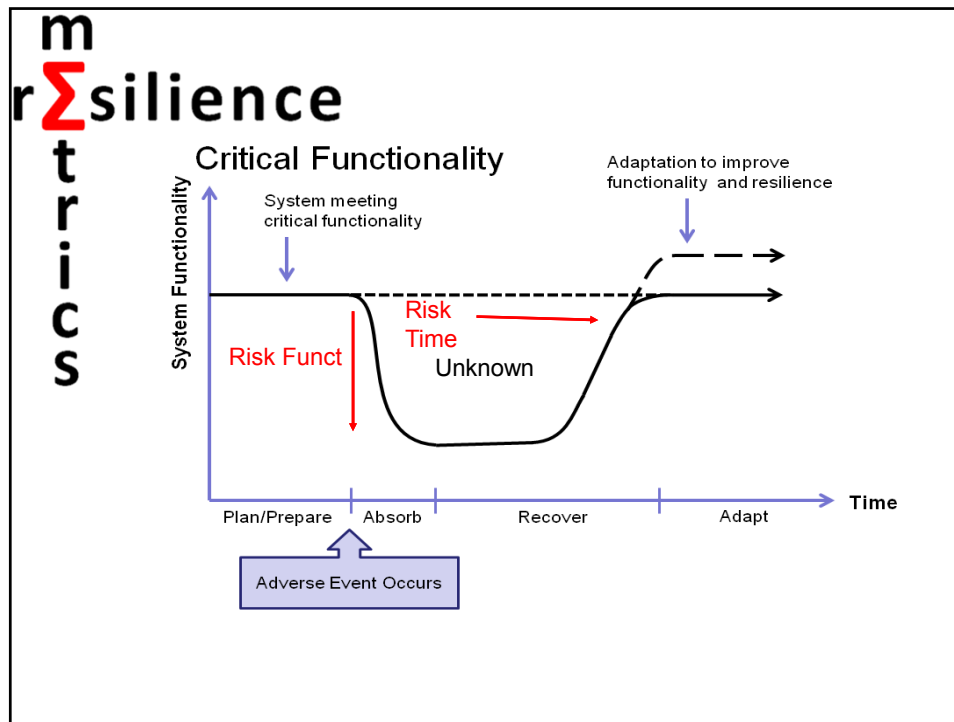
Risk/Resilience Integration?

Resilience as ...	<p>goal of risk management: Many documents describe resilience as the overarching goal of protection policies and risk management as the method to achieve this goal. <i>Resilience replaces or complements the concept of protection</i>, which was previously defined as the goal of risk management activities.</p> <p>part of risk management: <i>Resilience is understood as a part of risk management.</i> Activities to strengthen resilience are needed in order to deal with the so-called "remaining risks", i.e. risks that have not been identified or underestimated and are thus not covered by appropriate protection (preventive) measures.</p> <p>alternative to risk management: Challenges the traditional methods of risk management and promotes <i>resilience as a new way of dealing with risks in a complex environment.</i> It is argued that a probabilistic risk analysis is not an adequate approach for socio-economic systems that are confronted with non-linear and dynamic risks and are themselves characterized by a high degree of complexity. Instead of preventing risks and protecting the status quo, such systems should enhance their resilience by increasing their adaptive capacities.</p>
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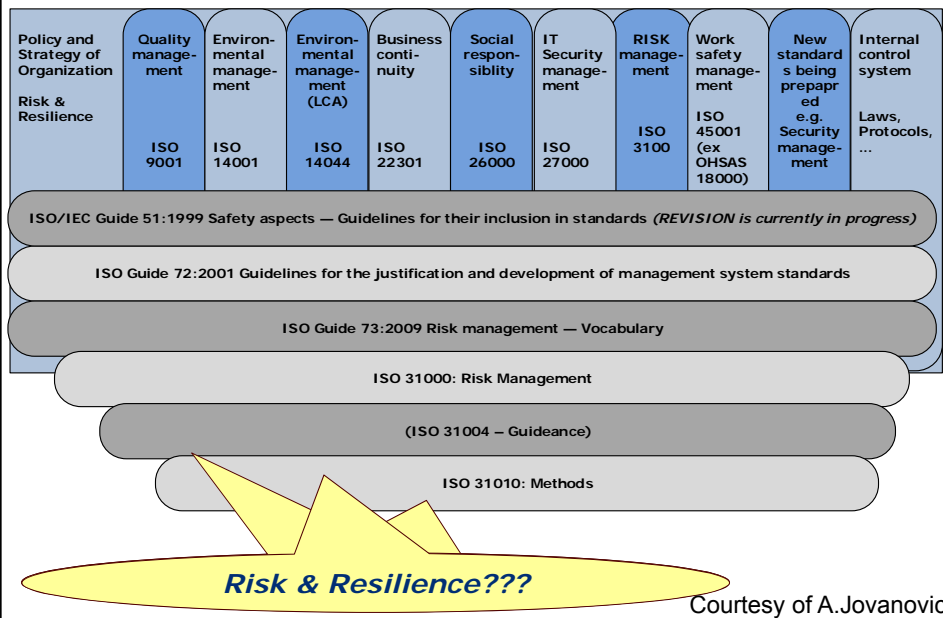
Focal Report 7 by Manuel Suter (2011) on Resilience and Risk Management in Critical Infrastructure Protection Policy:
Exploring the Relationship and Comparing its Use
http://www.css.ethz.ch/publications/DetaillansichtPubDB?rec_id=2207

Risk as Prepare/Absorb?

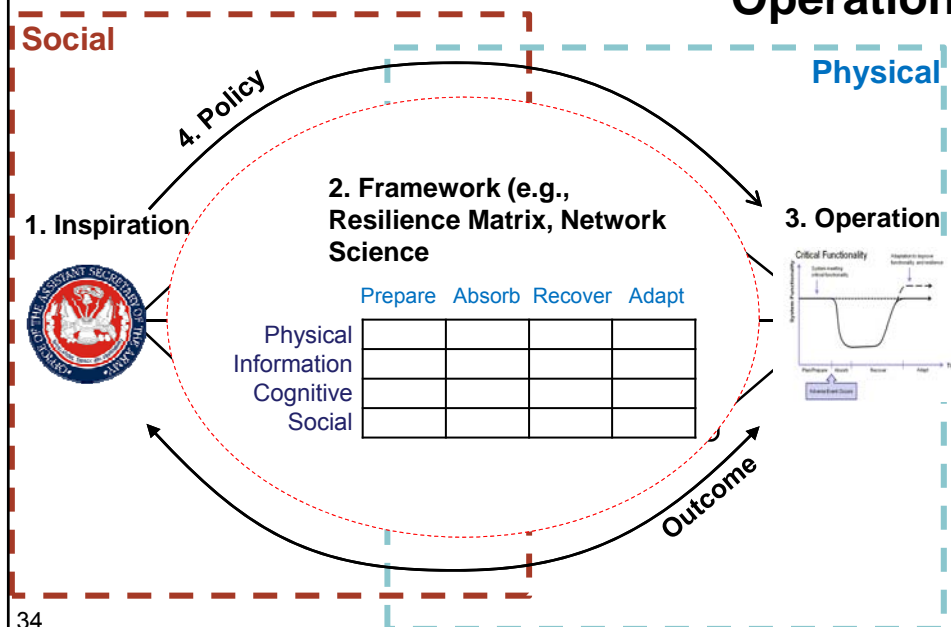




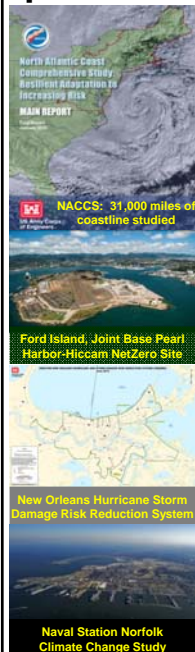
Risk/Resilience Standards?



Resilience: From Inspiration to Operation



Inspiration: USACE Resilience Strategy



What is Resilience?

“the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.” Executive Order 13653

Resilience in Action: **Plan, Absorb, Recover, and Adapt**

Why Resilience?

Resilience is a proactive approach to reducing damages, preventing losses, and shortening critical recovery times

USACE projects prevented \$13 B of damages in 2013; average annual damages avoided, 2004-2013, is \$48 B.

USACE's Approach to Resilience

Mainstream project lifecycle resilience enterprise-wide to improve system and community resilience

Examples: North Atlantic Coast Comprehensive Study
Naval Station Norfolk

USACE Support to Community Resilience

With our partners, USACE provides projects, resilience assessment tools, data, and other resources

Examples: USACE Support to Silver Jackets
Studies & Projects in Jamaica Bay, NY



Framework

■ Tiered Framework

■ Tier 1 – Community System-Scale Assessment

Linkov et al. (2014)

■ Tier 2 – Coastal System Infrastructure Assessment

Rosati et al. (2015)

■ Tier 3 – Risk and Resilience Bayesian Network Analysis

Schultz et al. (2012)

➤ Planning

- Rapid relative assessment of alternatives for 3x3x3 studies

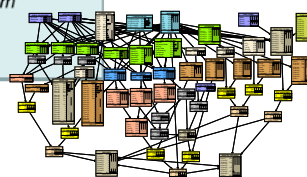
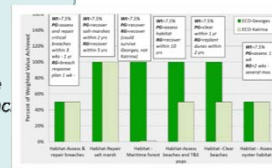
➤ Operations & Maintenance

- Dredging & placement; structure rehabilitation; timing of multiple actions

➤ Engineering & Construction

- Optimization of engineering designs, adaptation measures & system operations

	Prepare	Absorb	Recover	Adapt
Physical	90%	81%	62%	10%
Information	80%	19%	23%	75%
Cognitive	68%	95%	22%	40%
Social	76%	88%	92%	34%



After Rosati et al, 2015

Operations

- Resilience PDT

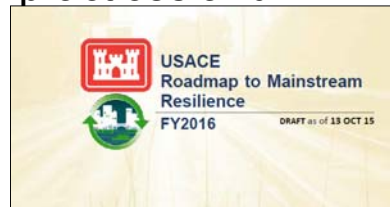
Quantification

Standardization

Visualization

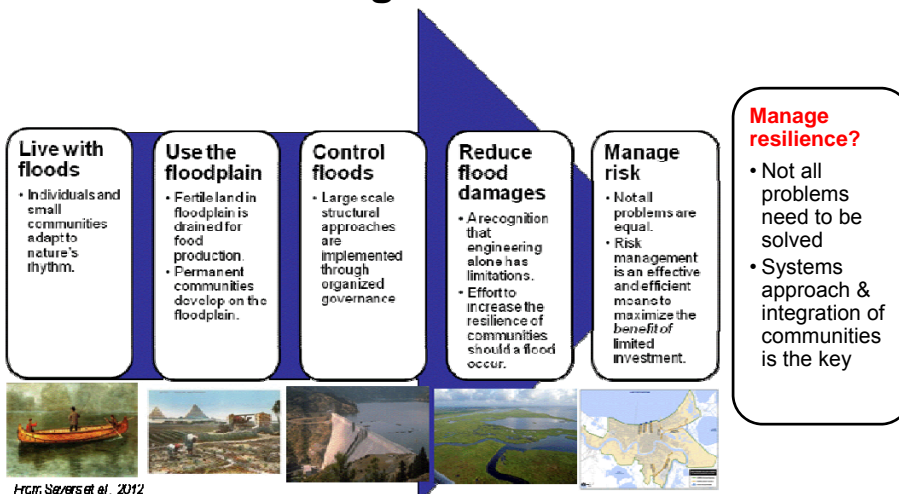
- Goals and indicators of improvement
- Involvement and input from all major subordinate commands (MSCs)

- Living document to capture best practices and



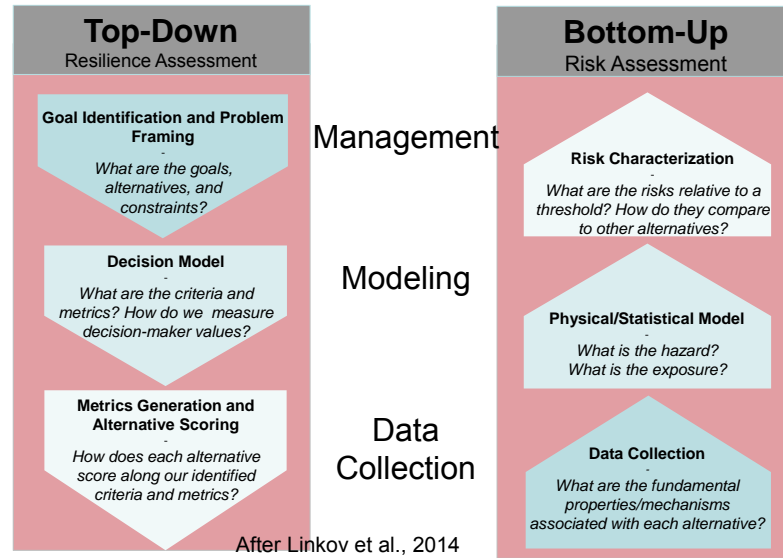
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Future: Evolution of Approaches for Flood Risk Management



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Framework –Science of Risk and Resilience



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Future Meeting



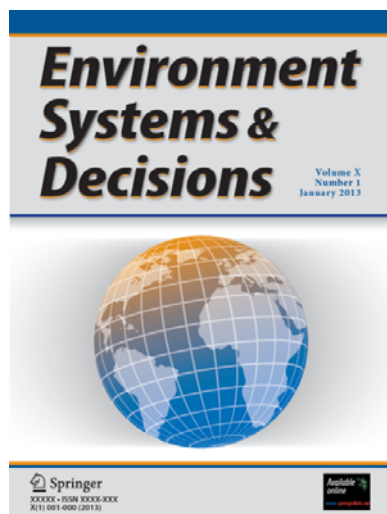
Resilience-Based Approaches to Critical Infrastructure Safeguarding

NATO Workshop
26-29 June 2016, Azores, PORTUGAL

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