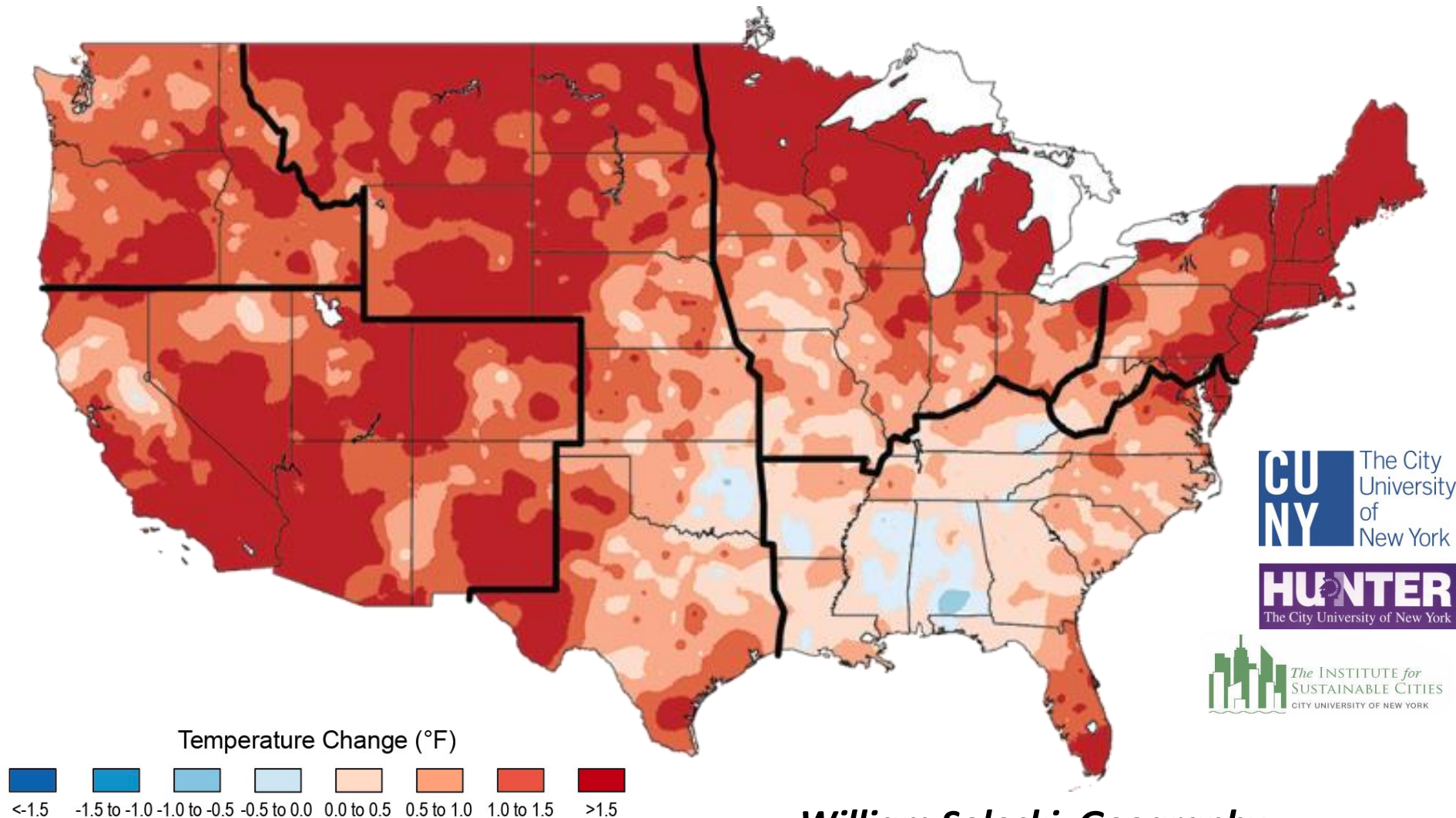


Climate Risk Resiliency in U.S. Cities and Towns: Current Processes and Emerging Trends



William Solecki, Geography
Hunter College, City University of New York

Outline

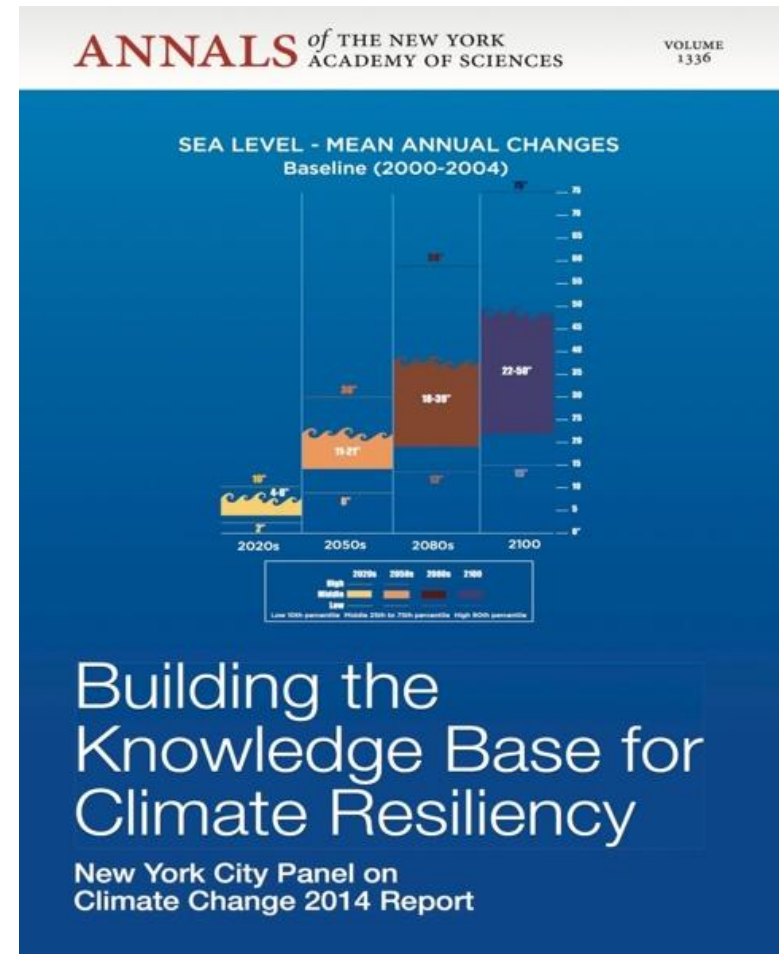
- Climate risk concerns
- Resiliency steps being taken to prepare for a different future
- Emerging lessons
- Extent of connection to other (e.g. federal) levels of governance for planning to adapt to the effects of a changing climate



Hurricane Sandy Storm Surge

Drawn from a Science Assessment Evidence Base

- New York City Panel on Climate Change
- Climate Change Risk in the Urban Northeast (CCRUN) – NOAA RISA
- National Climate Assessment NC3, Chapter 11; and NCA4, Northeast Region
- Intergovernmental Panel on Climate Change – AR5, WG2, and 1.5°C Special Report
- Assessment Report on Climate Change and Cities 2017 (ARC3.2)



Rosenzweig and Solecki eds. 2015

Key Concepts and Definitions

- Resilience
- Transformation
- Transition

Extreme events such as Hurricane Sandy provide a significant shock to a system which could result in a policy transition and transformation



Residential Fire During Hurricane Sandy

Climate Risk and Communities

Urban Climate Risks and Impacts

Climate Risk and Hazard	Potential Impacts
1. Increased frequency of extreme precipitation events	Threat to human health and welfare
	Inland and street level flooding
	Landslides
	Heavy snowfall
2. Increased frequency of extreme heat days and heat waves	Threat to human health and welfare
	Excessive heating of equipment and infrastructure; increased fatigue of materials
	Failed air conditioning systems
	Wildfires
	Droughts and water shortages
3. Sea level rise / coastal storm surge	Blackouts – e.g. from power failures during peak load demand
	Inundation and wide spread property damage and threats to human health and welfare
	Wave action and scour
	Salt water corrosion
4. Increased frequency of extreme wind events	Salt water intrusion in aquifers
	Threat to human health and welfare
	Obstructions and loss of equipment – e.g. localized loss of power and overhead wiring
	Blackout and large scale power loss

Shifting Environmental Baseline of Cities

Observed Climate Trends (1900 – 2013)

- **Temperature***

Mean **annual temperature** has **increased** at a rate of 0.3°F per decade (total of 3.4°F).

- **Precipitation***

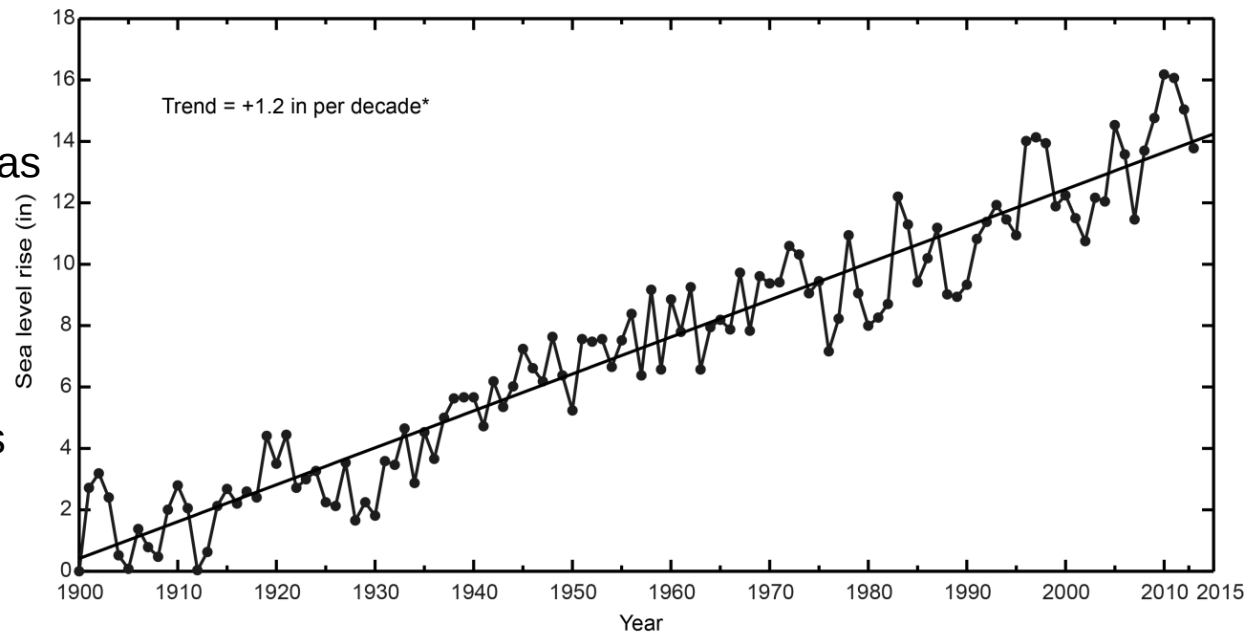
Mean **annual precipitation** has **increased** ~0.8 inches per decade (total of 8 inches).

- Year-to-year (and multi-year) **variability** of precipitation has become **more pronounced**, especially since the 1970s.

- **Sea Level**

Sea level rise in New York City has averaged 1.2 inches per decade (total of 1.1 feet), nearly twice the observed global rate over a similar time period.

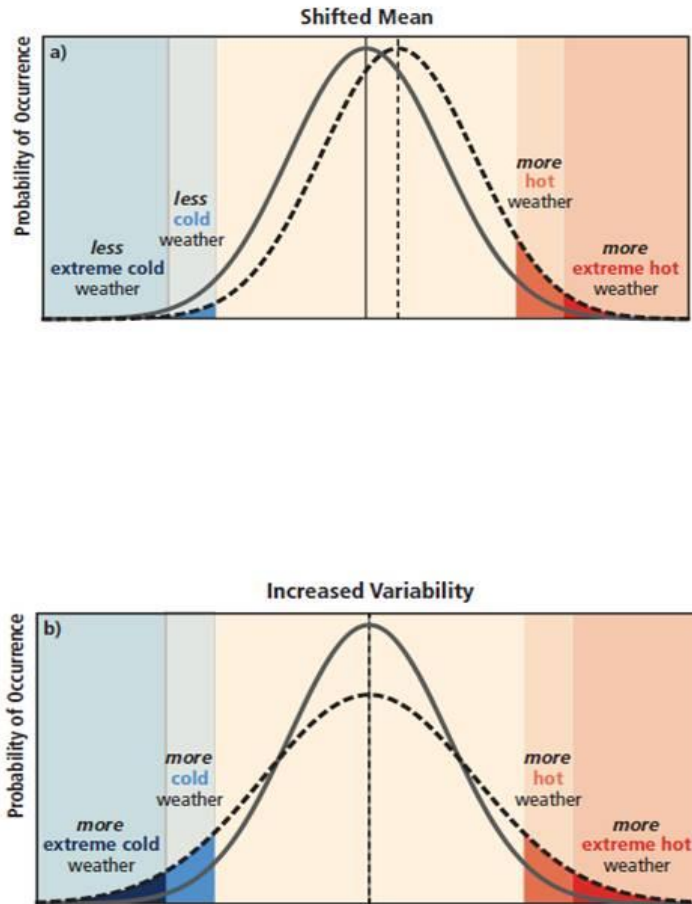
Changing Climate Conditions of New York City



Observed sea level rise at the Battery (southern tip of Manhattan) in New York City

* Observations made in Central Park.

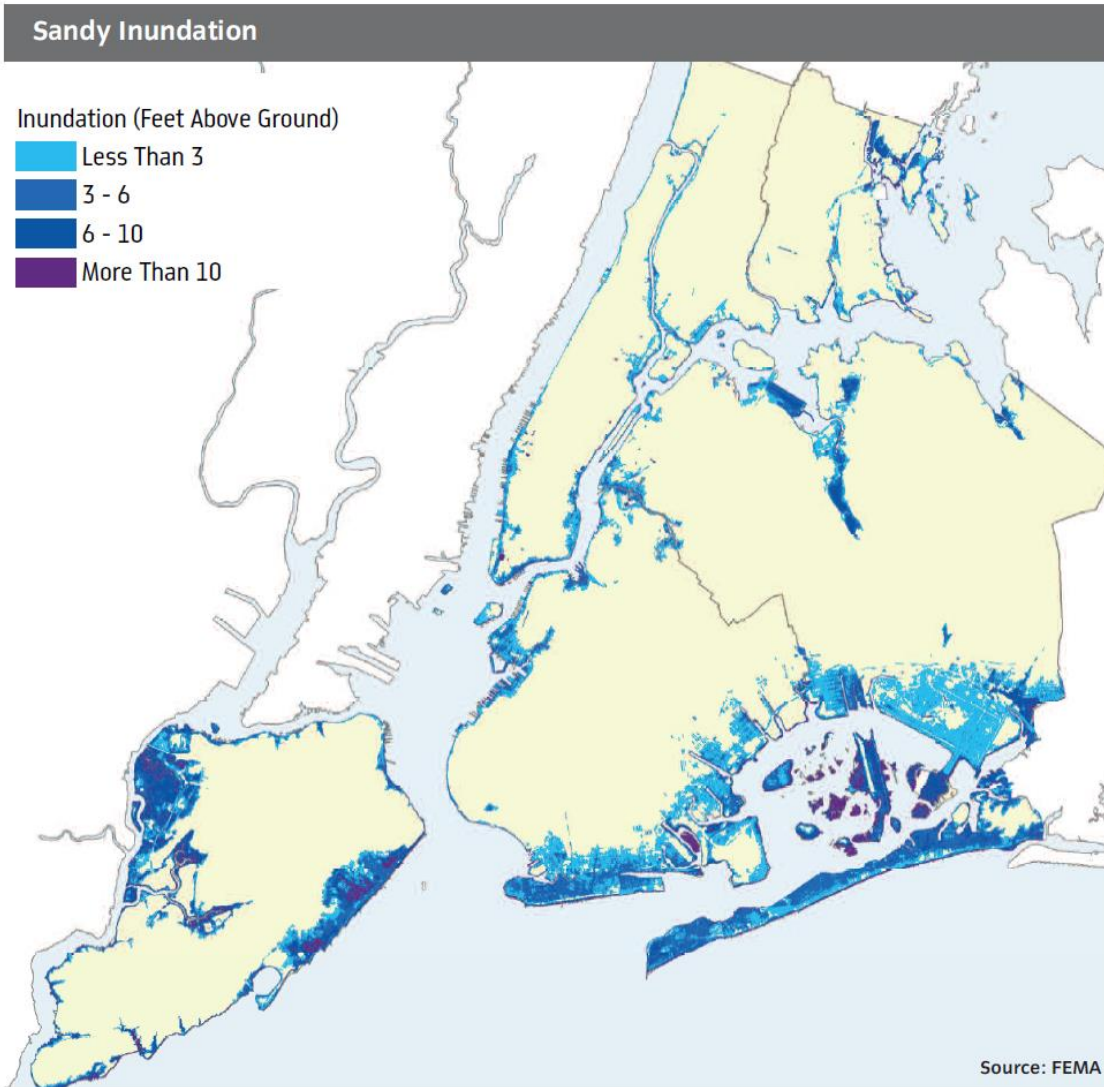
Climate Change Trends and Projections



Source: IPCC SREX 2012

Temperature and precipitation; Sea level rise; Other measures – snow cover, heat waves; Change in extreme events

Urban Lifelines and Infrastructure System Failures

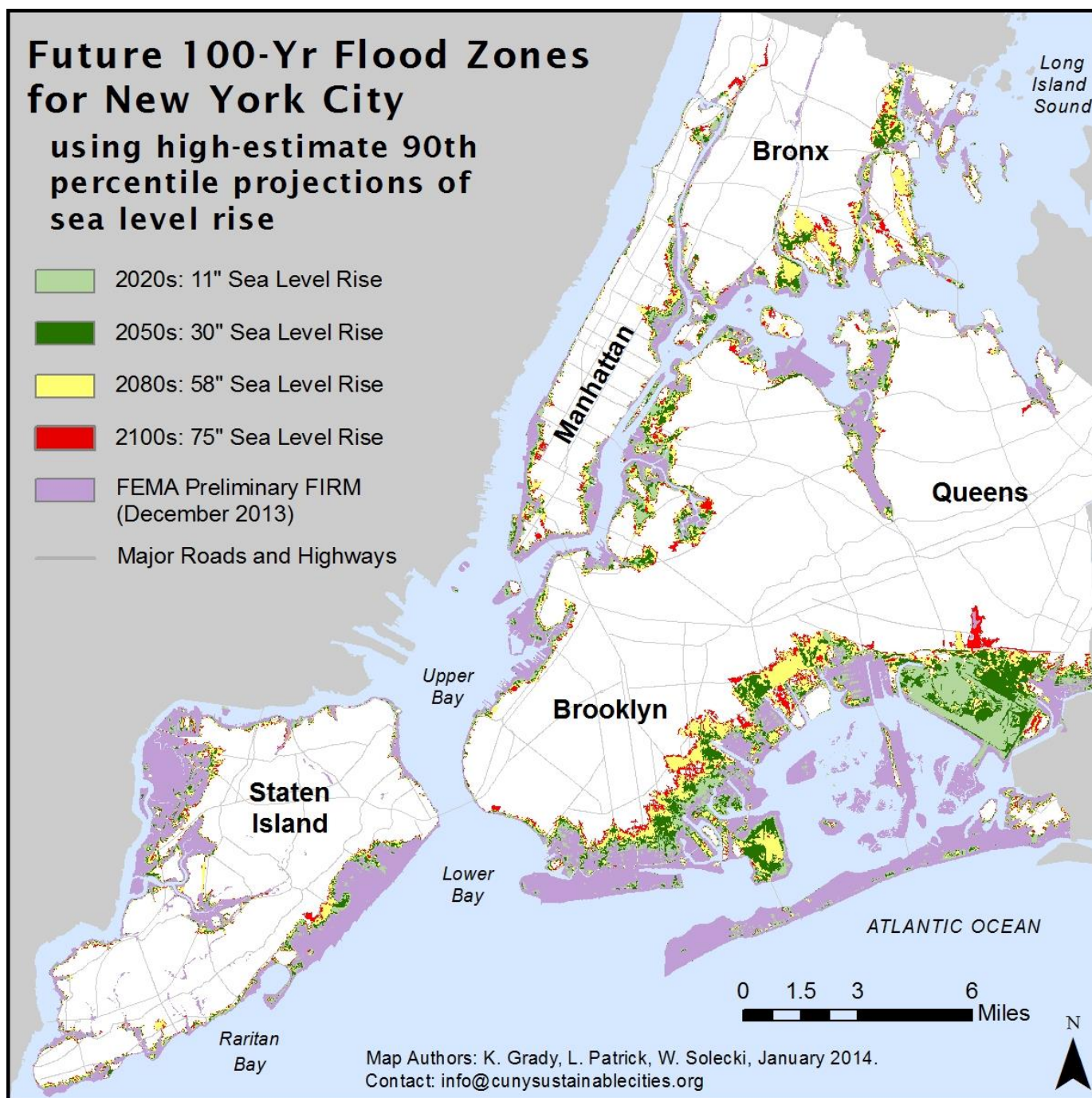


- Water; Electrical; Transportation; Gasoline Supply; Communications; Pharmacy – Drug Supply
- **General Observations**
 - Cascading impacts in complex systems
 - Context-specific vulnerabilities – e.g. health care system
 - Ecosystem protection opportunities – e.g. wetlands
 - Data rich (smart city yielding critical data) – challenge is how to use it
 - Uneven geography – social equity; More impact and vulnerability research needed

Future 100-Yr Flood Zones for New York City

using high-estimate 90th
percentile projections of
sea level rise

-  2020s: 11" Sea Level Rise
-  2050s: 30" Sea Level Rise
-  2080s: 58" Sea Level Rise
-  2100s: 75" Sea Level Rise
-  FEMA Preliminary FIRM
(December 2013)
-  Major Roads and Highways



Map Authors: K. Grady, L. Patrick, W. Solecki, January 2014.
Contact: info@cunysustainablecities.org

Source: New York City Panel on Climate Change

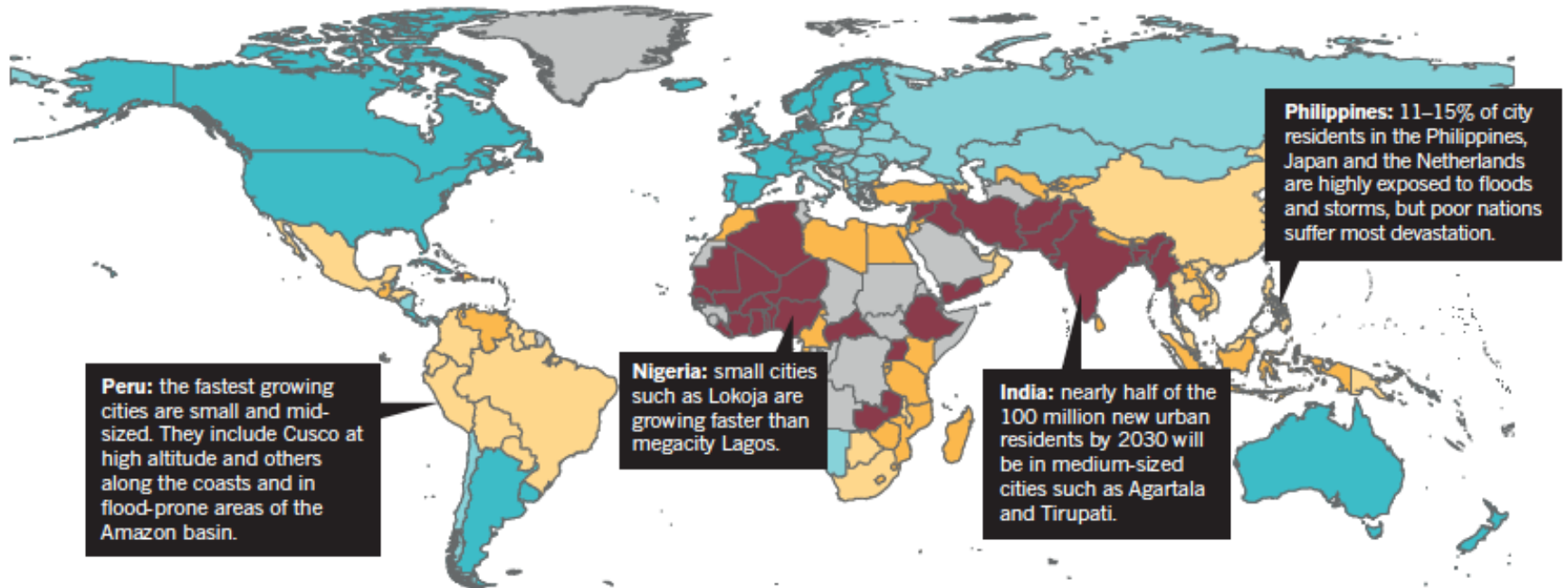
URBAN VULNERABILITY

City dwellers in parts of Africa and south and east Asia are most likely to suffer from the adverse effects of natural hazards because of poor infrastructure, governance and preparation (1). In countries where urban populations are highly vulnerable and unable to cope or adapt, small and mid-sized cities are growing rapidly (2).

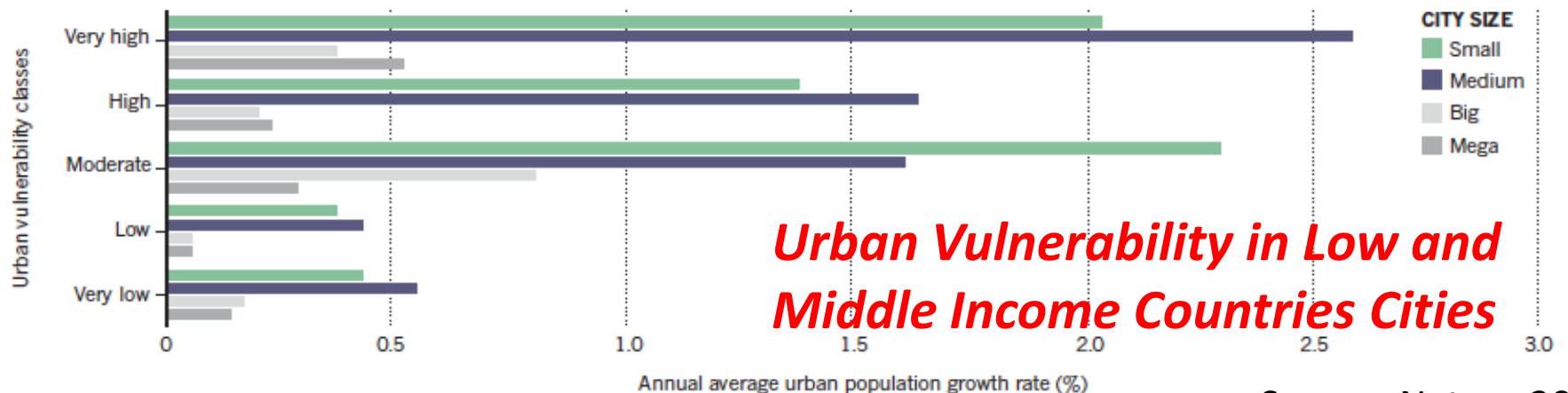
1 Vulnerability of urban population

URBAN VULNERABILITY CLASSES

Very high High Moderate Low Very low No data



2 City growth rates, according to relative vulnerability and proportion of urban population (2000–15)



Urban Vulnerability in Low and Middle Income Countries Cities

Source: Nature 2016

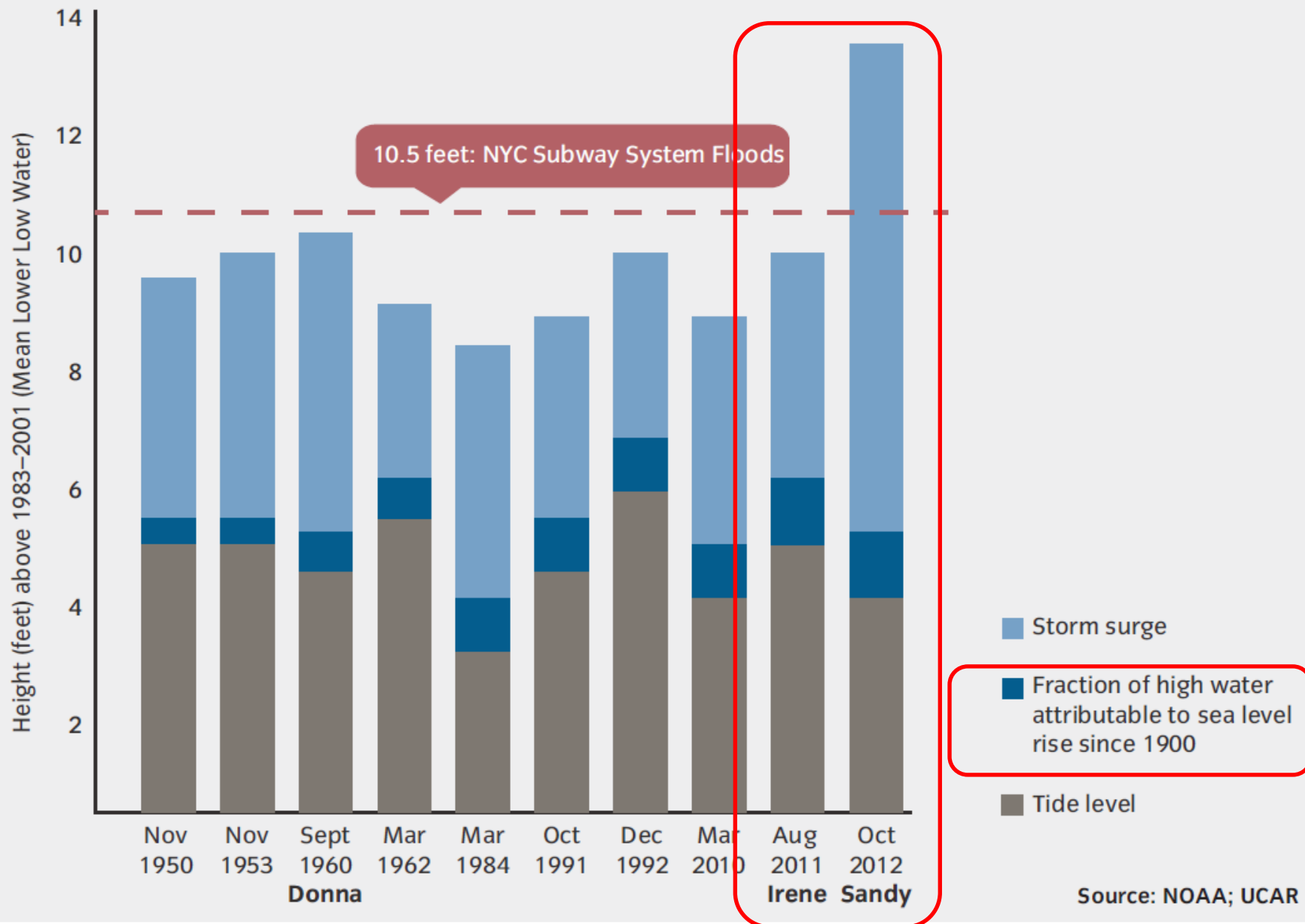
Urban Climate Resiliency – Current and Next Steps

Hurricane Sandy, 28 October 2012



Movement from disaster recovery to disaster rebuilding and resilience
Change in conceptualization of extreme events
From discrete acute events to events as part of a chronic process. Looking
into future dynamics as much as the present and past

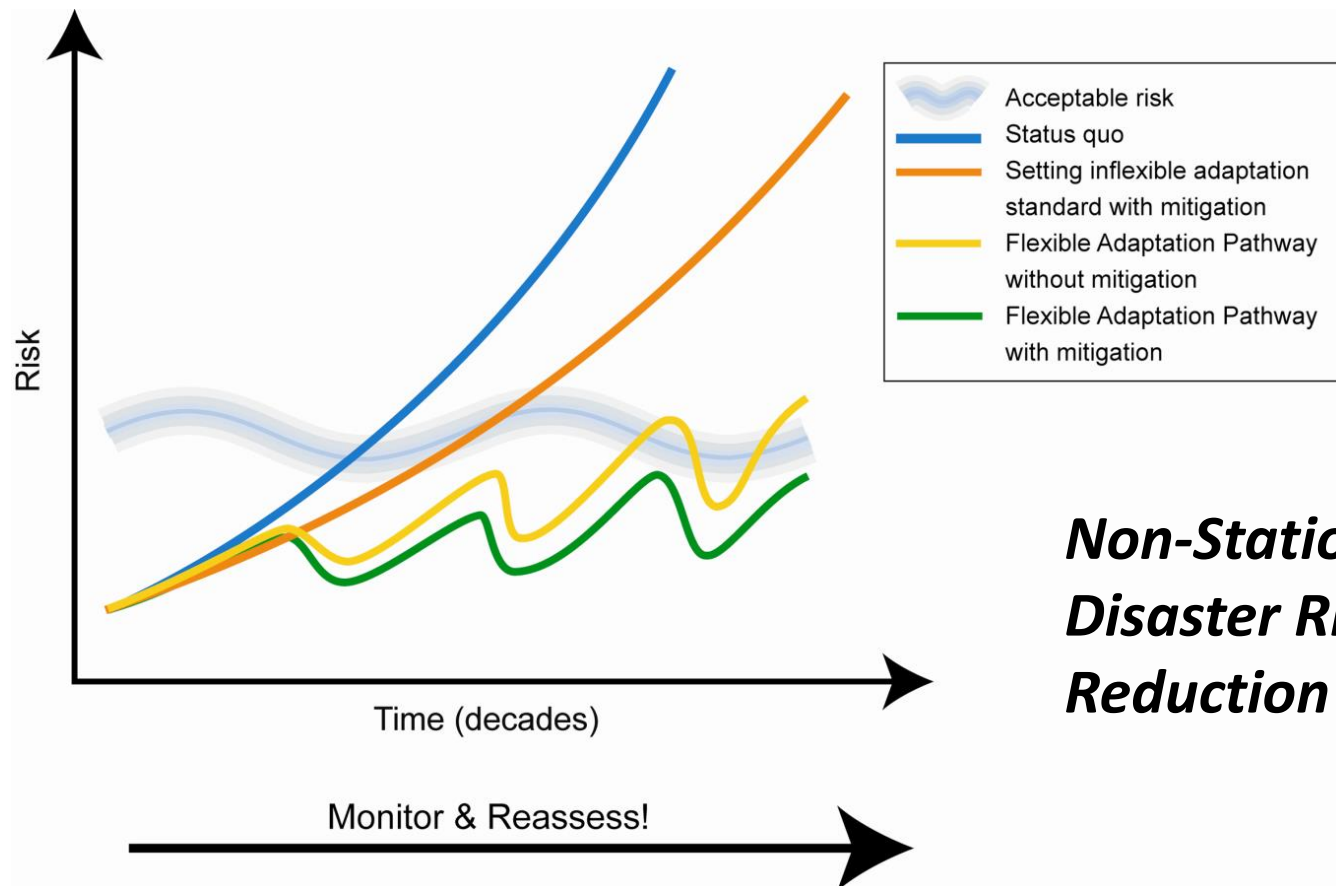
High-Water Events in Lower Manhattan



Flexible Adaptation Pathways

Climate change adaptation as a risk management issue

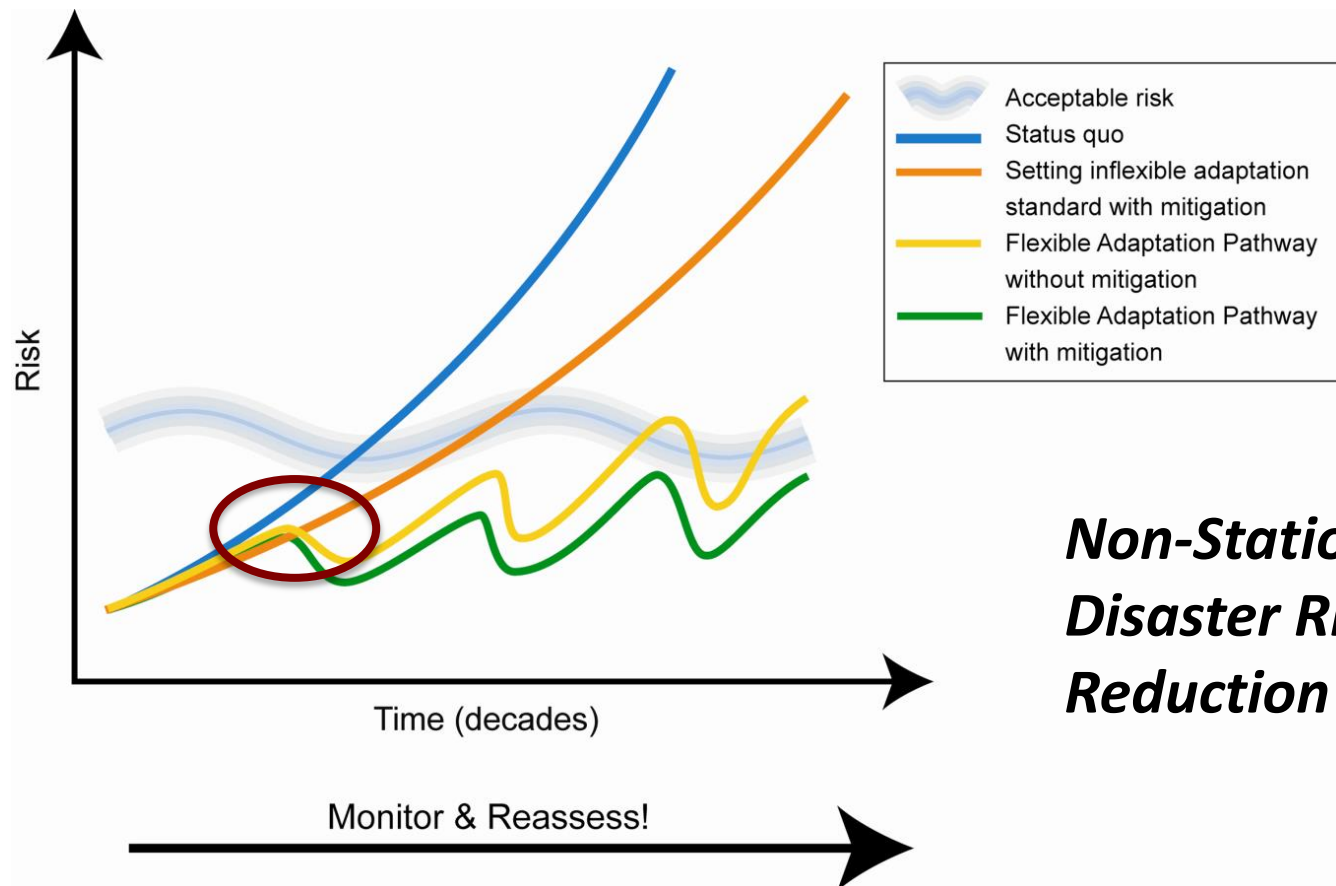
Flexible Adaptation Pathways as the response



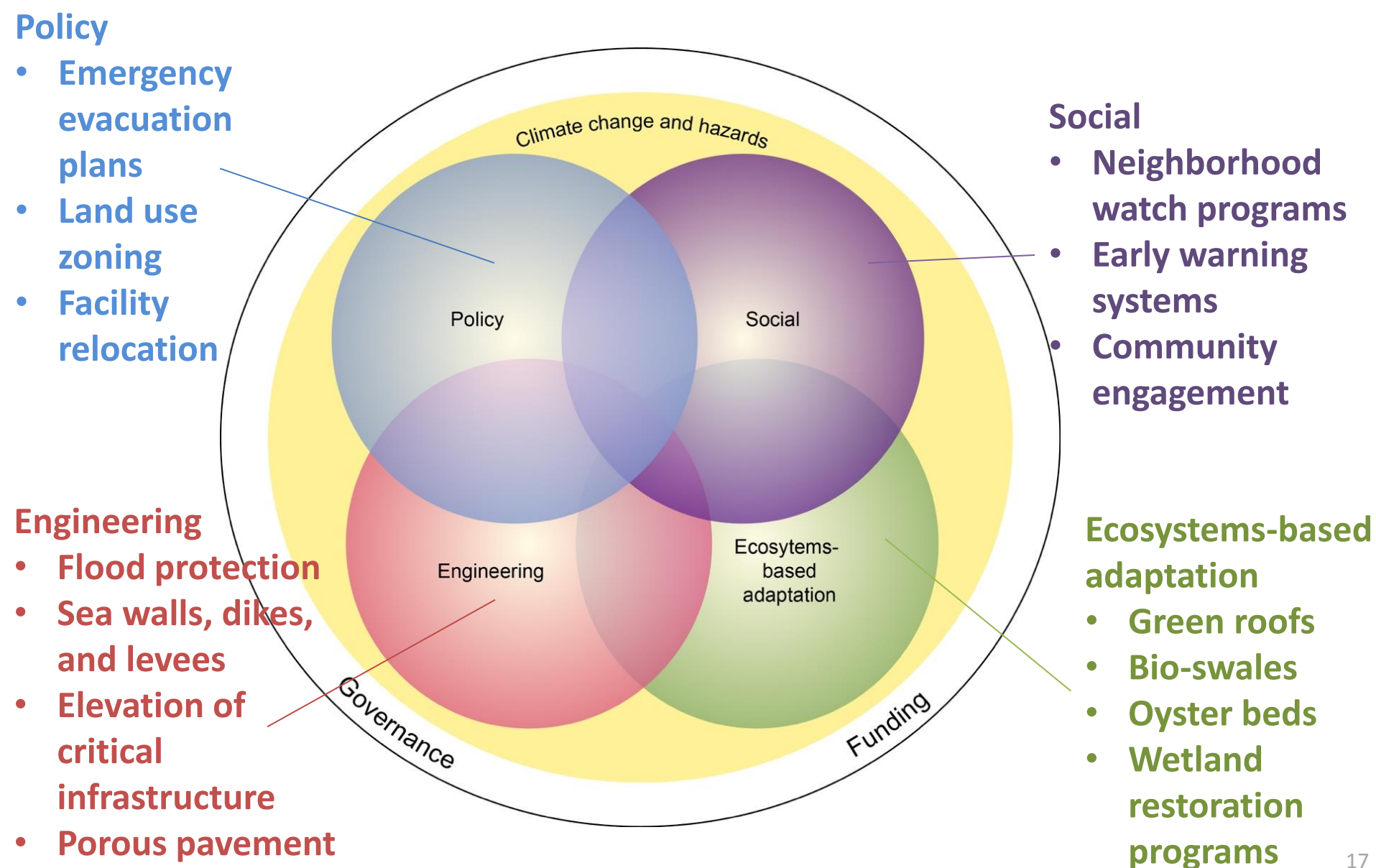
Flexible Adaptation Pathways

Climate change adaptation as a risk management issue

Flexible Adaptation Pathways as the response

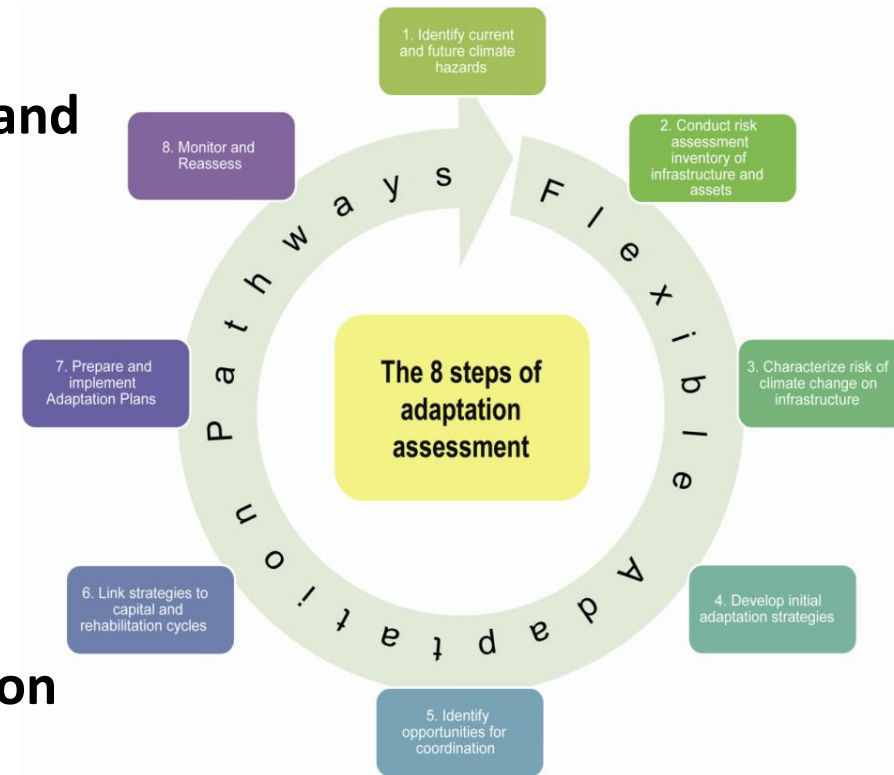


Approaches to Resilience Action



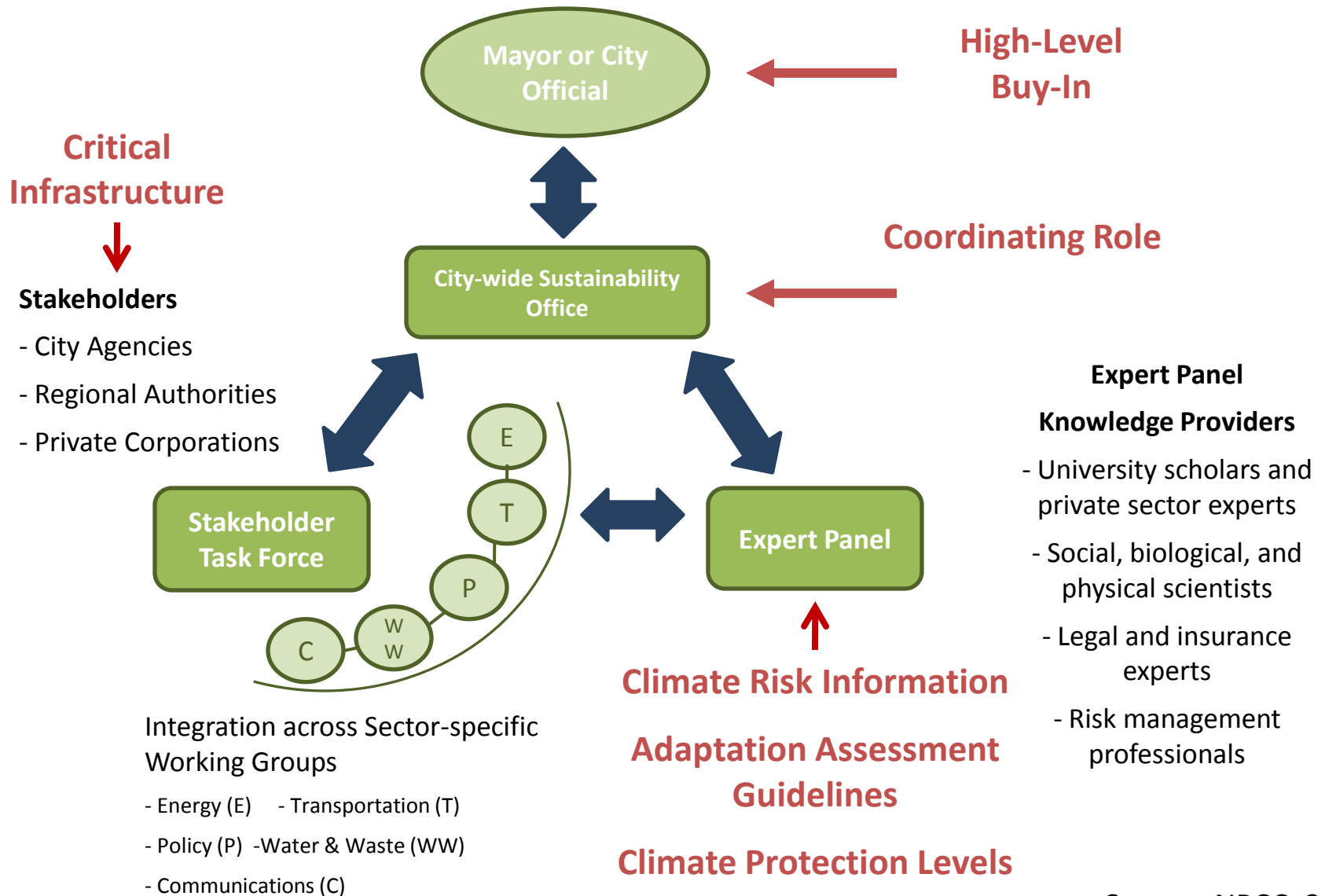
Steps of Resiliency Assessment and Plan Implementation

1. Identify current and future climate hazards
2. Conduct inventory of infrastructure and assets and begin to identify vulnerabilities
3. Characterize risk
4. Develop initial list of strategies
5. Identify opportunities for coordination
6. Prioritize strategies
7. Prepare and implement Resilience Plans
8. Monitor and reassess

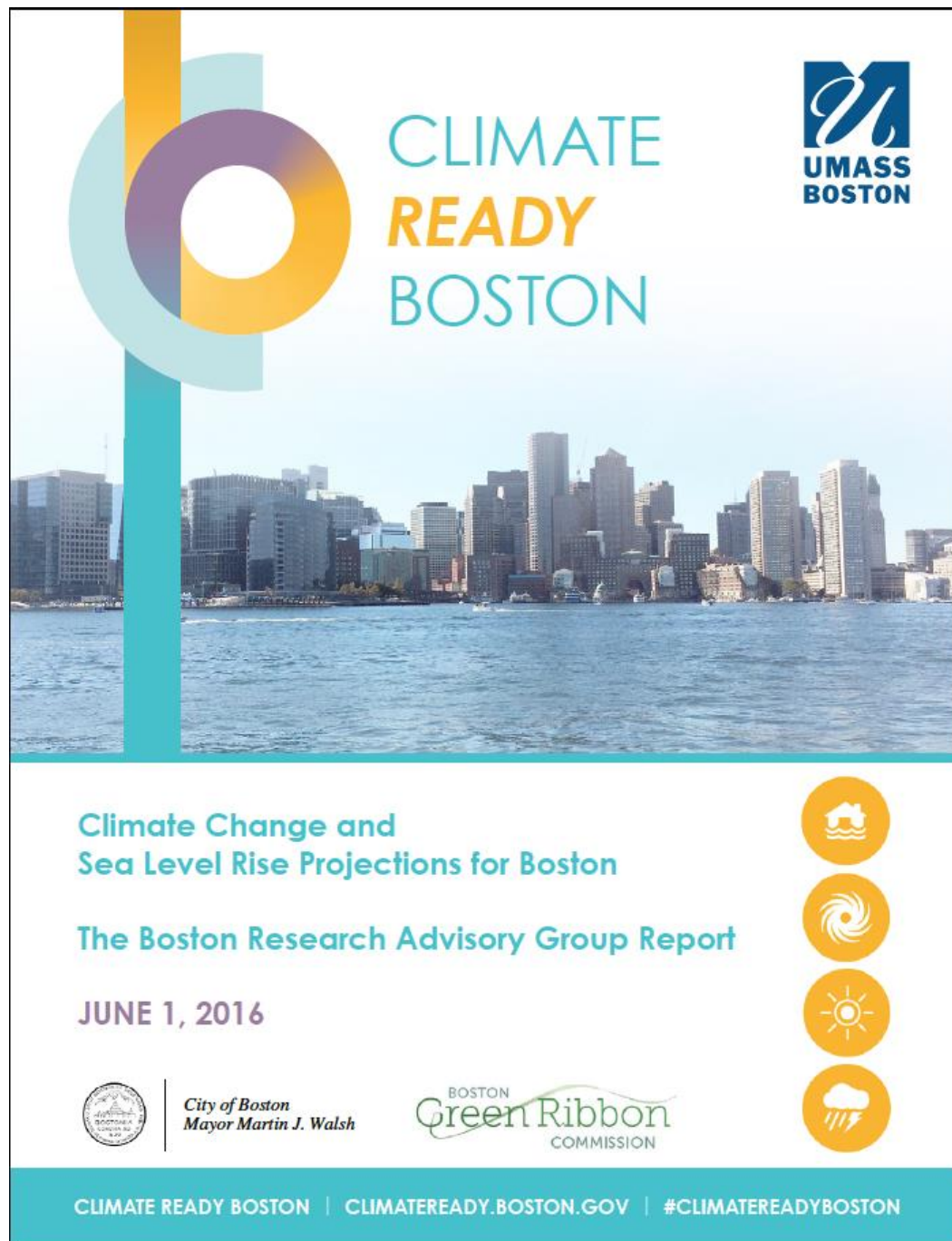


Source: NPCC 2010

New York City Climate Adaptation Process



Possible Need for Transformative (Macro) Adaptation



CLIMATE
READY
BOSTON

Climate Change and
Sea Level Rise Projections for Boston

The Boston Research Advisory Group Report

JUNE 1, 2016



City of Boston
Mayor Martin J. Walsh

BOSTON
Green Ribbon
COMMISSION



CLIMATE READY BOSTON | CLIMATEREADY.BOSTON.GOV | #CLIMATEREADYBOSTON

Relative Sea Level Rise Projections for Boston, MA (in ft, relative to 2000) categorized by exceedance probabilities

			Likely Range					Maximum
	0.99	0.95	0.833	0.5	0.167	0.05	0.01	0.001
RCP8.5								
2030	-0.1	0.1	0.3	0.5	0.7	0.9	1.0	1.2
2050	0.1	0.4	0.7	1.1	1.5	1.8	2.1	2.4
2070	0.6	1.0	1.5	2.2	3.1	3.7	4.3	4.8
2100	1.6	2.4	3.2	4.9	7.4	8.6	9.5	10.5
2200	18.9	19.9	21.4	26.1	32.8	34.1	35.3	36.9
RCP4.5								
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2050	0.1	0.4	0.7	1.0	1.4	1.7	2.0	2.3
2070	0.4	0.9	1.3	1.9	2.6	3.1	3.6	4.1
2100	0.9	1.7	2.4	3.6	5.1	6.1	7.0	8.0
2200	5.5	6.2	7.2	10.9	16.5	18.0	19.3	20.9
RCP2.6								
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2070	0.3	0.7	1.1	1.7	2.3	2.7	3.1	3.6
2100	0.4	1.2	1.8	2.8	3.8	4.6	5.3	6.2
2200	3.6	4.4	5.2	6.4	7.7	8.8	9.9	11.8

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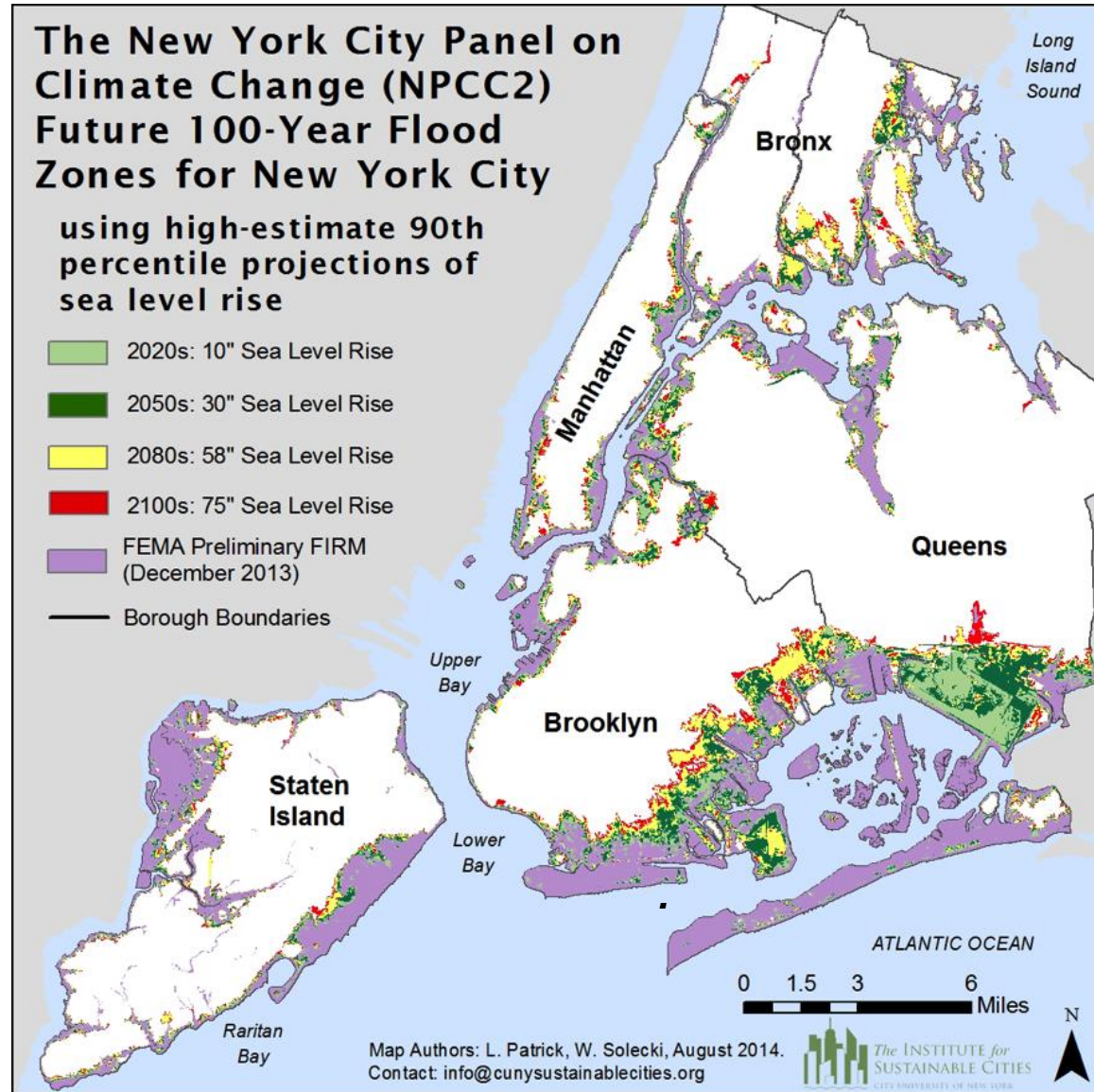
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Increasingly Frequent Coastal Flooding

- NYC Stakeholder Comment:
“I think the fundamental issue is a lack of acknowledgement of what we are heading towards. Beautiful maps show sea level rise and describe impacts, but *at our core we can't acknowledge that we have to fundamentally change* how we live in NYC.”
- What are the challenges and opportunities within existing and potential future policies to allow for macro adaptation – transformation?



**100-year flood map developed using
the static approach**

Nuisance Coastal Flooding



Broad Channel, Jamaica Bay, NY
during a Super Moon high tide

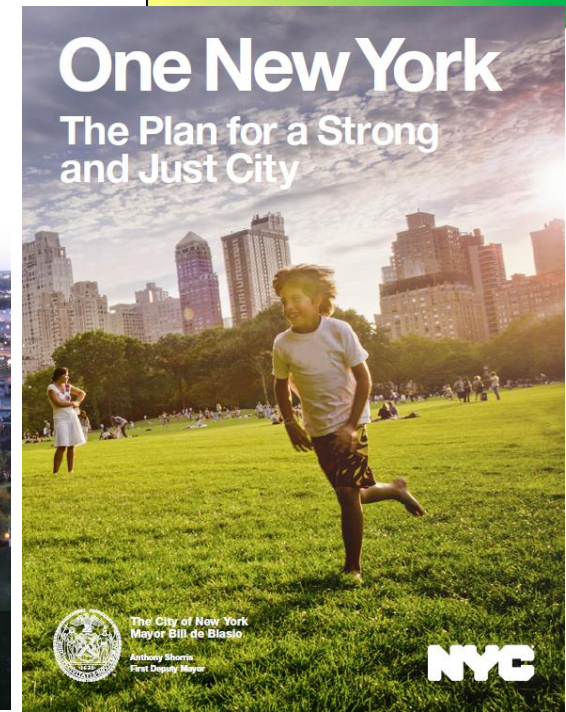
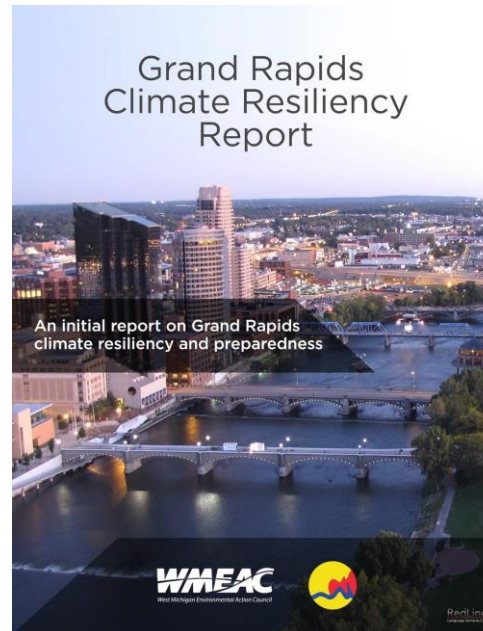
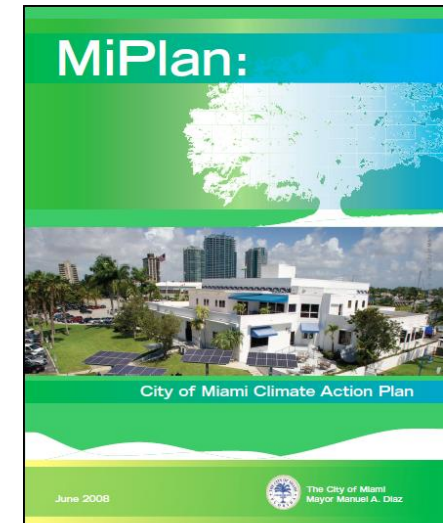


Flooding in downtown historic
Annapolis, Maryland

URBAN CLIMATE RESILIENCY: SOME LESSON LEARNED

Climate Resiliency and Adaptation – Key Conditions for Success

- Flexibility, broad cross-disciplinary involvement and buy-in
- Embedding climate change into work and planning streams rather than developing a special system



Climate Resiliency and Adaptation – Key Conditions for Success

- Prioritizing "no-regrets" strategies and meeting multiple goals; multi-policy approach to adaptation; co-benefits
- Coordinating with other infrastructure and service providers within the service-shed of urban systems
- Integrating resiliency and adaptation into regular infrastructure capital upgrades; institutionalization
- Top level engagement with a central point of coordination; policy entrepreneur
- Using an integrated approach that includes engineering, ecosystems, and social strategies

More Conditions for Success ...

- Connect policy-maker, practitioner, and scientific communities; ongoing and continuous process
- Develop effective indicator and monitoring system
- Establish legal mandate for resiliency efforts
- Coordinate with state and federal partners on climate change projections and resiliency programs
- Connect with city level networks – e.g., Urban Sustainability Directors Network (USDN) – red and blue state cities
- More pro-active use of extreme events as learning moments



USDN Cities and Regional Networks



The Dryline – Flood Protection Proposal in New York



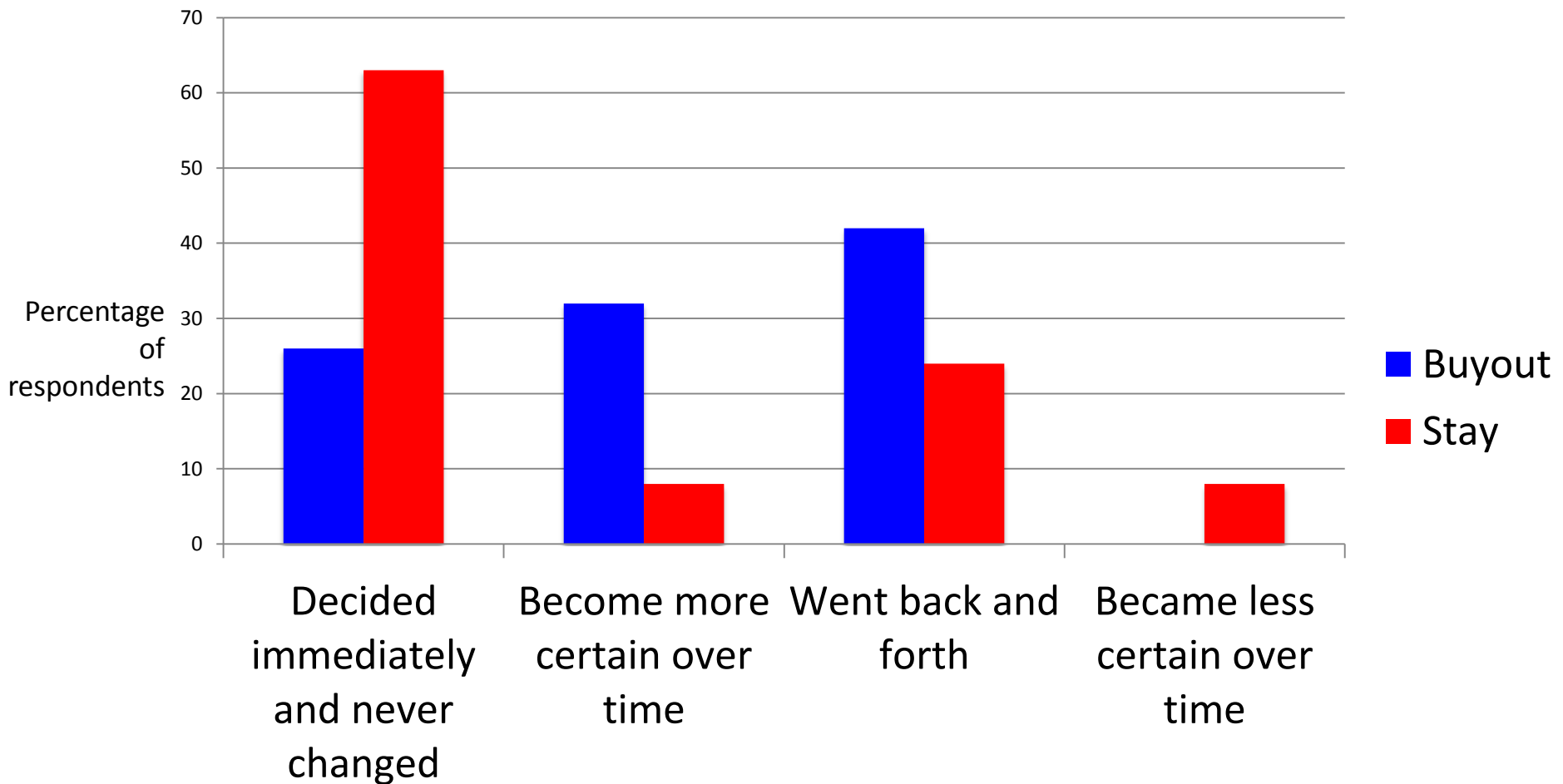
Climate Resiliency and Adaptation – Key Challenges

- Funding
- Actionable Data
- Confidence in climate science and climate scientists
- Coordination across varying urban infrastructure systems and interconnecting systems
- Connecting short term planning with long term planning
- Ensuring that adaptation and mitigation activities are synergistic; not in conflict
- Metropolitan region coordination
- Communication and engagement with local residents



Source: <https://hyperallergic.com>

Relocation and Dislocation: Certainty about Post-Sandy Housing



Role of Cities in Climate Resiliency

Cities as Leaders
and
Cities as Followers

CITIES AS CLIMATE RESILIENCE LEADERS

Urban Environment Crises and Cities as Solutions

- Water quality and supply - 1830s
- Open Space and Recreation -1850s
- Public Health and Sanitation – 1870s
- Mobility and Congestion – 1910s
- ‘Urban Renewal’ /Loss of Community –1950s
- Air Pollution – 1960s
- **Climate Change - 2020s?**



Looking south over
Central Park in 1861



New York City Environs - 1900



Smog - November 1953

2015 Paris Climate Agreement and Cities

*“Agreeing to uphold and promote regional and international cooperation in order to mobilize stronger and more ambitious climate action by all **Parties** and non-Party stakeholders, including civil society, the private sector, financial institutions, **cities** and other **subnational authorities**, local communities and indigenous peoples . . .”*



United Nations



Framework Convention on
Climate Change

FCCC/CP/2015/L.9/Rev.1

Distr.: Limited
12 December 2015

Original: English

Conference of the Parties

Twenty-first session

Paris, 30 November to 11 December 2015

Agenda item 4(b)

Durban Platform for Enhanced Action (decision 1/CP.17)

Adoption of a protocol, another legal instrument, or an
agreed outcome with legal force under the Convention
applicable to all Parties

ADOPTION OF THE PARIS AGREEMENT

Proposal by the President

Draft decision -/CP.21



Cities Are First Responders: Mitigation



Established June 2016

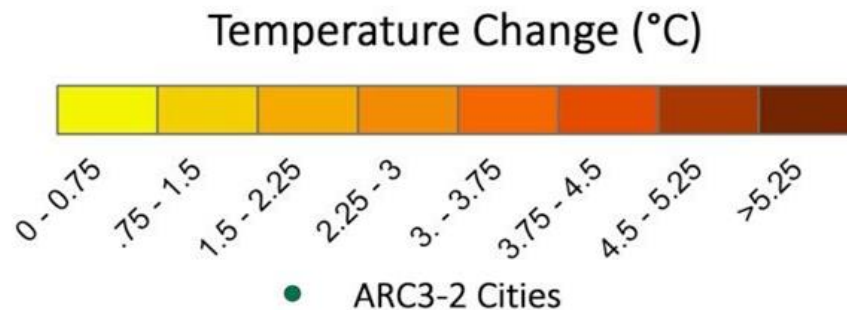
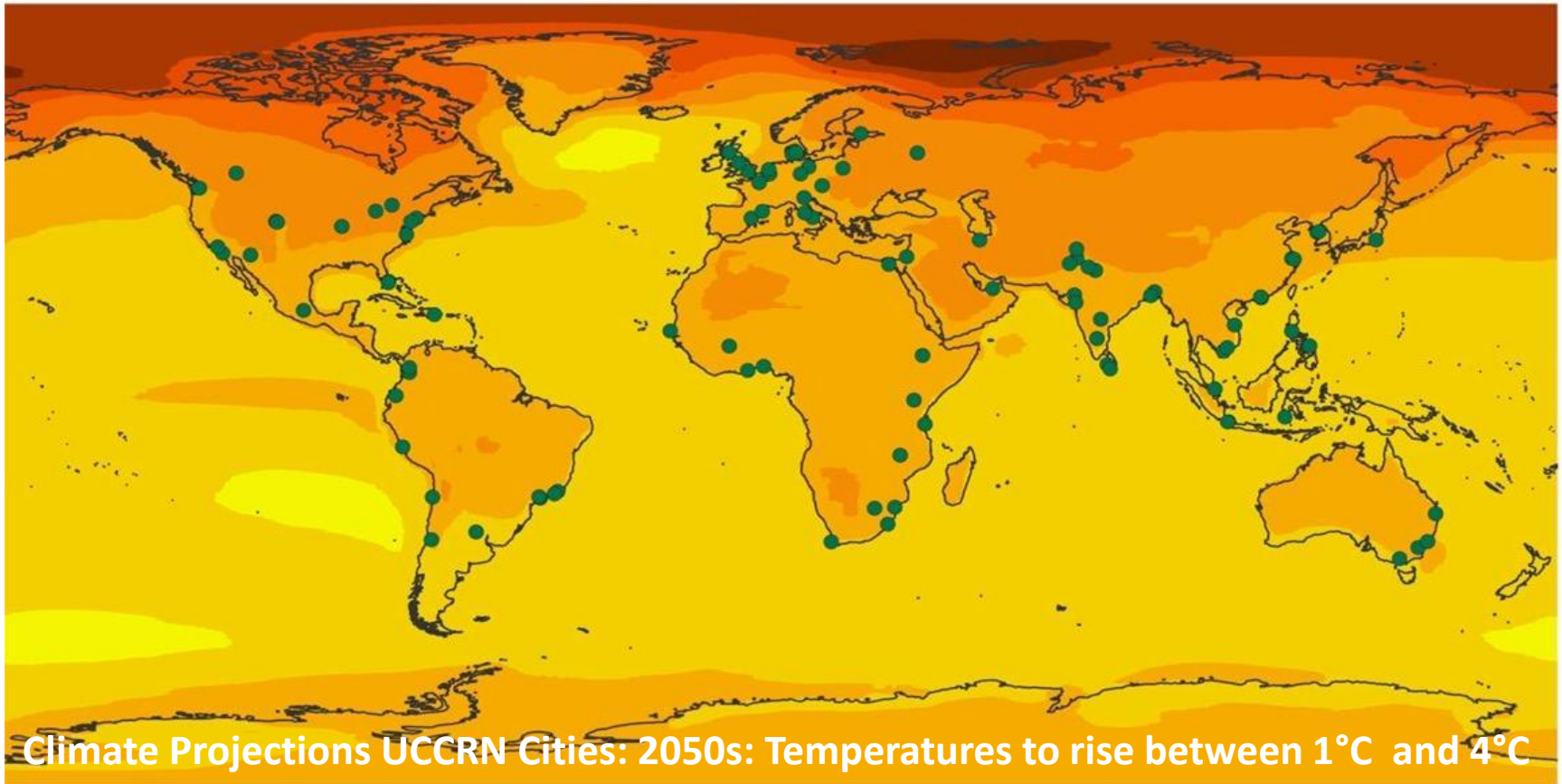
Source: NASA Goddard Space Flight Center, Conceptual Image Lab

"The largest global coalition of cities committed to climate leadership, building on the commitments of more than **7,100** cities from **119** countries and **six** continents, representing more than **600** million inhabitants, over **8%** of the world's population"

~600 Compact cities commit to reducing GHG emissions by nearly **1 billion tons** annually by 2030, or **11.6 billion tons** between 2010 and 2030.

~6,000 cities of the EU Covenant of Mayors projected to have an estimated reduction of **240 Megatons of CO₂e**, a reduction of 27% by 2020.

Cities Are First Responders: Adaptation



Urban Climate Change Research Network Pathways for Urban Climate Transformation

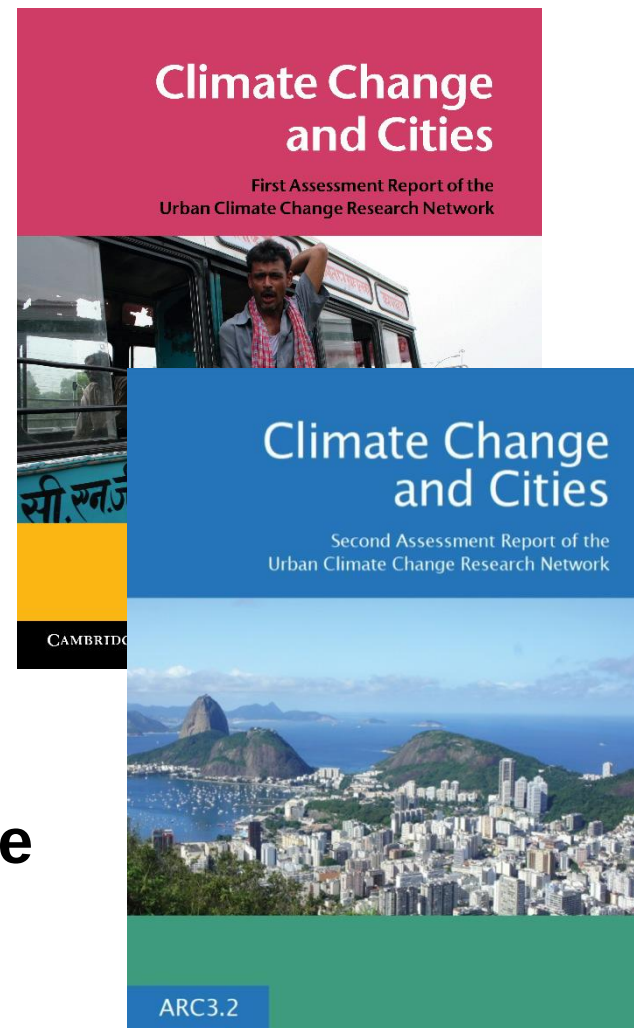
Integrate Mitigation and Adaptation

**Coordinate Disaster Risk Reduction
and Climate Change Adaptation**

Co-generate Risk Information

**Focus on Disadvantaged
Populations**

**Governance, Finance, and Knowledge
Networks**



New York City Resiliency – Connecting to State and National Efforts



- Integration of NPCC 2010 risk framing of climate resiliency into the America's Climate Choices – NAS

- NYC Special Initiative on Rebuilding and Resiliency – June 2013

- Rebuild by Design Competition

- Presidential Executive Order on use of advanced local climate data

- Revised NYC Flood Maps (Flood Insurance Rate Maps)

- Insurance based resiliency incentive program

- Resiliency Design Guidelines – draft statements released in April 2017



CITIES AS CLIMATE RESILIENCE FOLLOWERS

Limits to Urban Climate Resiliency Planning and Need for Synergy with State and Federal Governments

- Sovereignty
- Financing and revenue generating capacity
- Metropolitan scale administrative capacity
- Jurisdictional control over infrastructure development, resource supply chains
- Network synergies have promoted resiliency advances but limits being realized

Some Conclusions

Key Messages

- Urban climate resiliency has evolved significantly in the past decade: balance economic, quality of life, equity
- Dynamic and in keeping with history of urban environmental action
- Increasing incorporation of indicators and monitoring
- Increasing focus on ecosystem services
- Increasing understanding on some hard limits to resiliency practices; technology, governance, and equity
- Overall, just the beginning

Next Steps – Promoting Movement from Resilience to Macro Adaptation

- Need for additional case study analysis of policy transitions
 - Ongoing work on the impacts of Hurricane Sandy in the region
- Specification of the drivers and early warning signals of the climate policy switches
 - development of indicators, metrics and monitoring strategies, economic benefits and costs
- Climate Toolkits for practitioners and stakeholders
 - Ongoing work on a post extreme event learning toolkit and a resilience to macro adaptation toolkit;
<https://toolkit.climate.gov>

Ongoing Assessments of Urban Climate Resiliency Science

Intergovernmental Panel on Climate Change - AR6 and AR7 Cycle Special Reports

- IPCC to provide **AR6 Special Reports on Impacts of Global Warming of 1.5 °C; Land; and Oceans and Cryosphere**.
- **Special Report on Climate Change and Cities** will be included in the AR7 cycle(2023-2028).
- **International Scientific Conference on Climate Change and Cities** will take place early in the AR6 cycle, in March 2018, in Edmonton, Canada.
- Science Conference on Climate Change and Cities, Edmonton, March 2018

U.S. National Climate Assessment NCA4

- **Chapters on Built Environment, Urban Systems, and Cities, Transportation, Air Quality, and Human Health**
- **Chapter on Northeast Region**
- **New National Climate Science Report - U.S. GLOBAL CHANGE RESEARCH PROGRAM CLIMATE SCIENCE SPECIAL REPORT (CSSR)**



Funding and Sponsors



References

- Rosenzweig C, Solecki W, Romeo-Lankao P, Shagun M, and Dhakal S. Eds. (2017). *Second Assessment of Research on Climate Change in Cities*. Cambridge University Press. In press.
- Solecki W, Pelling M, Garschagen M. 2017. A framework for urban risk management regime shifts. *Ecology & Society*. In press.
- Sanderson E, Solecki W, Waldman J, and Parris, eds. (2016). A. *Prospects for Resilience: Insights from New York City's Jamaica Bay*. Island Press. Washington. D.C. USA.
- Birkmann J, Welle T, Solecki W, Lwasa S, and Garschagen M. (2016). Boost resilience of mid-sized cities. *Nature*. September 26.
- Horton, R.M., C. Rosenzweig, W. Solecki, D. Bader, and L. Sohl. (2016). Climate Science for Decision-Making in the New York Metropolitan Region. In *Climate in Context: Science and Society Partnering for Adaptation*. Edited by Adam S. Parris, Gregg M. Garfin, Kirstin Dow, Ryan Meyer, and Sarah L. Close. Climate in Context, Wiley and Sons: New York.
- Solecki W. (2016). Climate Change and U.S Cities: Vulnerability, Impacts, and Adaptation. In *Land and City*. McCarthy, G W, Gregory K I, and Moody S A Eds. Lincoln Land Institute, Chicago, IL.
- New York City Panel on Climate Change. (2015). *A Knowledge Base for Climate Resilience in New York City: Post-Hurricane Sandy Science and Assessment*. New York Academy of Sciences. C. Rosenzweig and W. Solecki editors.
- Solecki W., Patrick L, and Springings Z. (2015). Urban Climate Change Policy Transitions: A View from New York City. In *Adaptive Challenge of Climate Change*, K. O'Brien and E. Selboe editors. New York, Cambridge University Press.
- Rosenzweig, C. and Solecki, W. (2014). Hurricane Sandy and adaptation pathways in New York: Lessons from a first-responder city. *Global Environmental Change* 28: 395-408.
- Solecki, W. and Rosenzweig C. (2014). Climate change, extreme events, and Hurricane Sandy: From Non-Stationary Climate to Non-Stationary Policy. *Journal of Extreme Events*. 1(1): 5-25.

Thank you.

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