Cities as a Front Line for Climate Change Action

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HUNTER
The City University of New York

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Objective and Outline

- **Objective: Discuss how and why cities are responding to climate change. Cities are at the front line of impacts and vulnerabilities as well as the drivers of climate change. Cities are taking action to adapt to climate change and promote climate change mitigation.**

- **Outline**
  1. **Identify and discuss impacts and vulnerabilities that cities face with climate change**
  2. **Examine ways in which cities are responding to challenges and opportunities for climate change adaptation and mitigation**
  3. **How New York City as a global city leader is moving against climate risks and promoting greenhouse emission reduction activities.**

Climate Change with Dynamic Urbanization

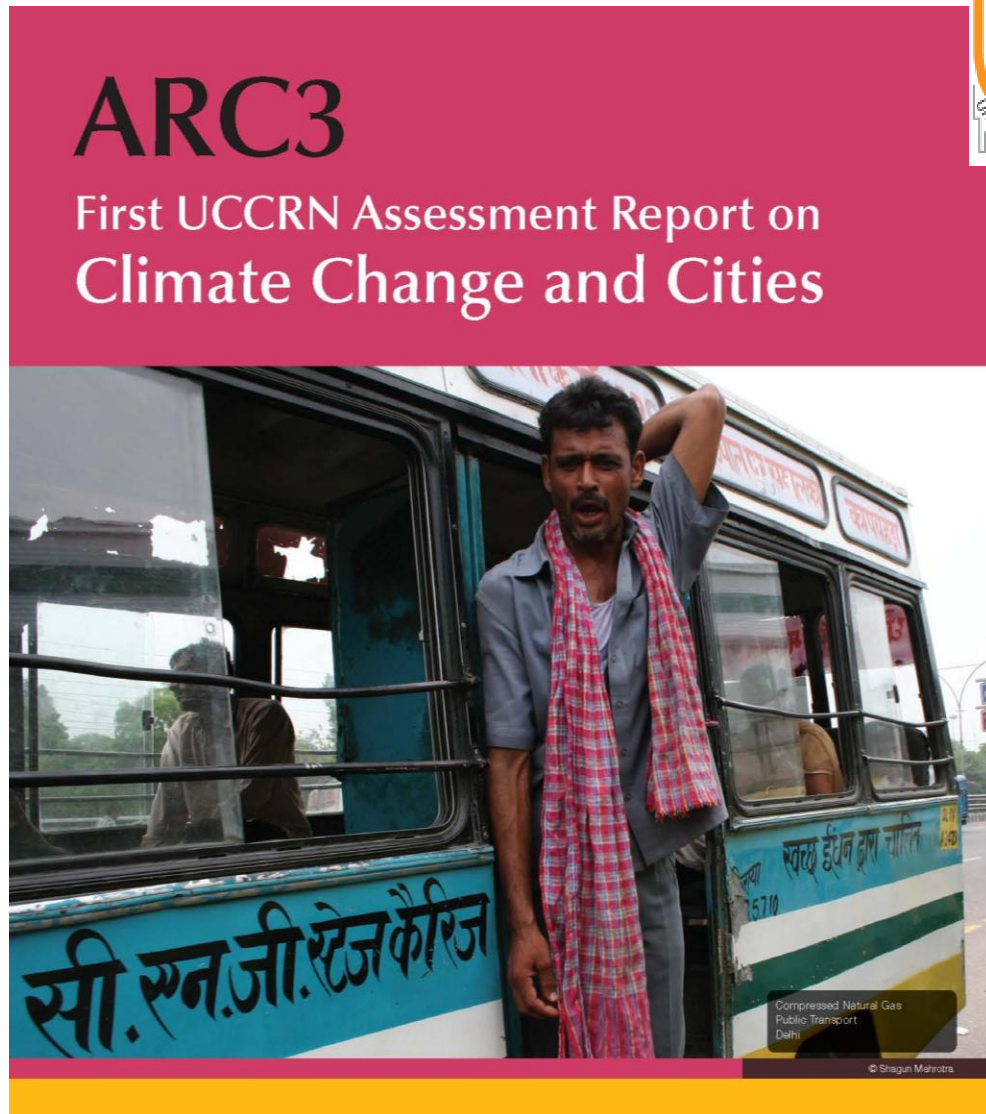
- The world's population now is slightly over 50% urban – 3.45 billion
- World's urban population is expected to grow to just over 9 billion by 2050; urban population is expected to grow to about 6.2 billion by 2050
- Within the U.S. urbanization process continues to take place even in places like NYC, and much of the infrastructure of cities and nation's infrastructure will need to be replaced. Cities are always "unfinished."

Cities and Climate Change Impacts and Vulnerabilities

- Concentration of population and critical infrastructure; much of it vulnerable to extreme climate events
- Often located in hazard prone areas – e.g. coastal zones
- Highly dynamic and stressed natural systems – hard to define environmental baseline
- Governance, civil society, and equity issues

ARC3: First UCCRN Assessment Report on Climate Change and Cities

Urban Climate Change Research Network
www.uccrn.org



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CLIMATE RISK, DISASTERS AND CITIES

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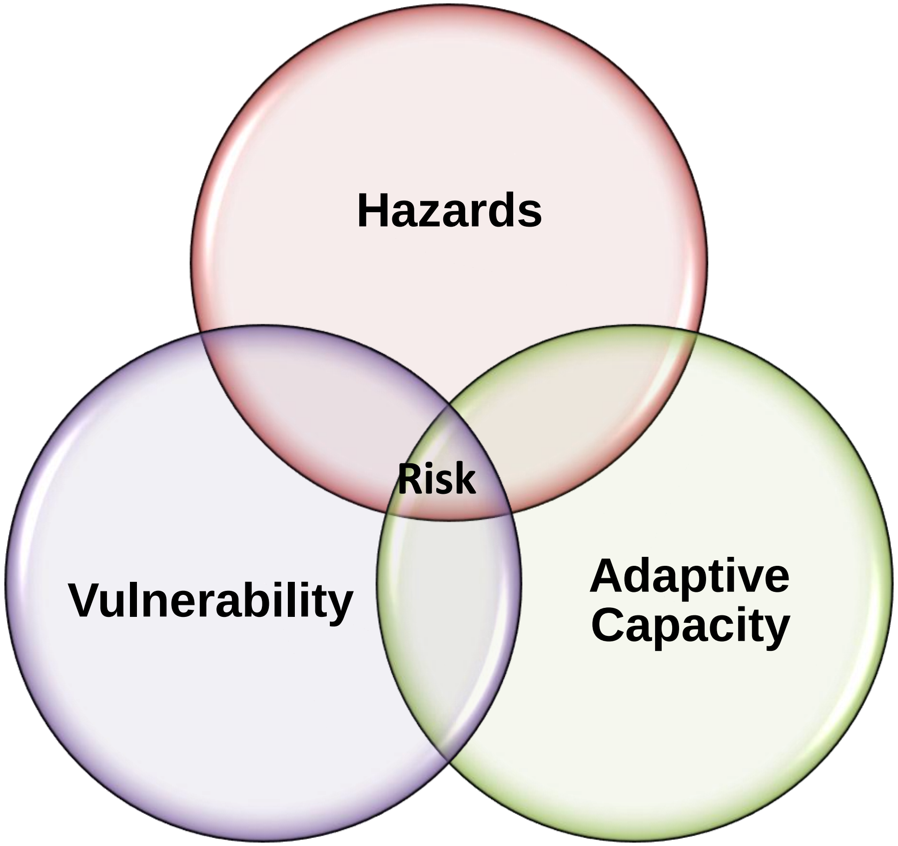
Climate Change and Cities



Source: Mehrotra, et. al., 2009

Hazards
Heat Waves
Coastal Storms
Floods

Vulnerability
Size and Density
Topography
% of Poor
% of GDP

Adaptive Capacity
Information and Resources
Institutions and Governance
Change Agents

Key takeaway
Ample climate risk and response information is available for effective action, yet in limited use
The ability and willingness of major stakeholders to address climate change is critical

CLIMATE HAZARDS

RISK

ARC3
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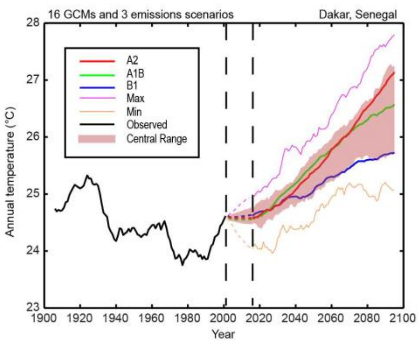
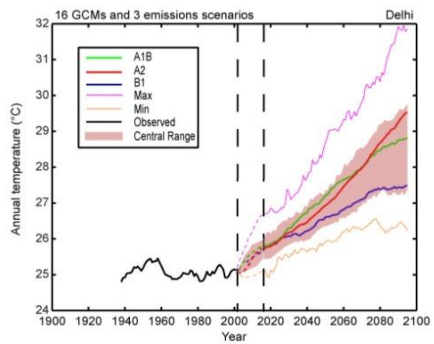
Climate Change and Cities

Dakar



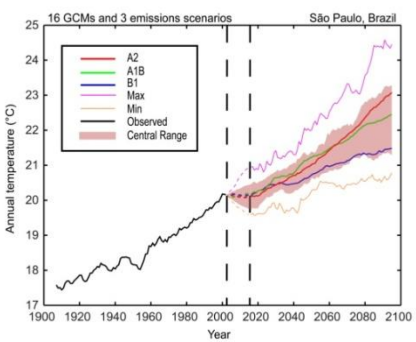
2050s Temperature Projection

Delhi



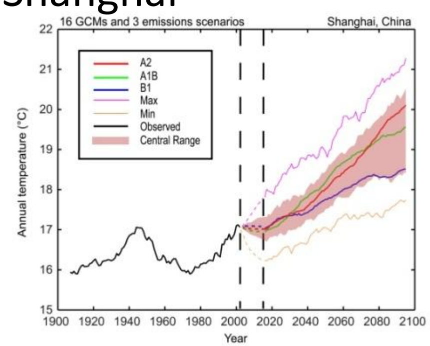
2050s Temperature Projection

Sao Paulo



2050s Temperature Projection

Shanghai



2050s Temperature Projection

12 Cities Analyzed

1. Athens
2. Dakar
3. Delhi
4. Harare
5. Kingston
6. London
7. Melbourne
8. New York
9. Sao Paulo
10. Shanghai
11. Tokyo
12. Toronto

2050s projected temperature increase between 1°C to 4°C

Source: Center for Climate Systems Research
Columbia University 2009

Key takeaway

1. More frequent/longer/hotter heat waves
2. More floods and droughts
3. Sea-level rise with enhanced coastal flooding

HEALTH

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Climate Change and Cities

Risks

1. Large size and high density amplify health risks
2. Increase in poor and elderly populations compounds threats of heat and vector-related illness
3. Cities with limited existing water services at greater risk of drought and vector-related illnesses

Adaptation and Mitigation Strategies

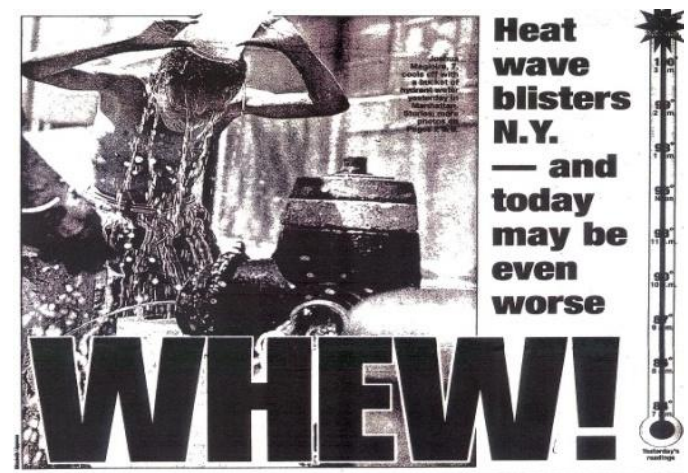
1. Passive approaches (tree planting, green roofs, permeable pavements) to reduce urban heat island
2. Improving and increasing water and energy services
3. Regulate settlement growth in flood plains
4. Expand health surveillance and early warning systems

Key takeaway

Climate change is likely to exacerbate existing health risks in cities and to create new ones

Source: Shagun Mehrotra, 2003

High Existing Health Risks, Kibera, Nairobi



Source:

Heatwave exacerbates existing health risks of poor & elderly in NYC, July 4-6, 1999

WATER

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Climate Change and Cities

Risks

1. Variance in precipitation significantly affects quantity and quality of water supply
2. Impervious city surfaces and increased precipitation intensity overwhelm current city drainage systems
3. Over 1/2 the people in large developing country cities rely on informal water supply vendors

Adaptation and Mitigation Strategies

1. Adjust water-intake locations
2. Rainwater harvesting and water reuse
3. Demand management—public education, industrial process changes to reduce water intensity

Source: Ademolo Omojola

Water Scarcity and Vendors, Lagos

Key takeaway

Formal and informal water supply services are highly vulnerable to drought, extreme precipitation, and sea level rise, and a range of adaptation measure will be required to insure the safe functioning of water supplies, especially in coastal regions

TRANSPORT

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Climate Change and Cities

Risks—contingent on local transport systems

1. Mass transit vs. individual vehicles
2. Underground vs. elevated roads and rail
3. Moving people vs. goods
4. Impacts on power and telecom systems create transport system risks

Adaptation and Mitigation Strategies

1. Technical vs. ecosystem-based approaches
2. Levees, dams, pumps to limit flood damage
3. Improve drainage to protect transport assets
4. Elevate equipment to eliminate flood risk
5. Temporarily move rolling stock in advance of storms
6. Diversify transport modal choices

Compressed Natural Gas, Cabs, Delhi

Civil society organizations and courts have been instrumental in legislating conversion of public transport to be fuelled by CNG

Key takeaway

Incorporate climate considerations into transit plans, construction, and management systems while retrofitting existing assets

ENERGY

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Risks – both supply and demand

1. Power plant flooding
2. Increased variance in water quantity and timing impact hydro-power
3. Increase in heat waves imply more frequent blackouts, damaging local economy
4. Demand may increase *or* decrease

Adaptation and Mitigation strategies

1. Demand management programs to cut peak load
2. "Harden" power plants and networks to increase resilience to flooding/storm/temperature risks
3. Diversify fuel-mix for city power to increase share of renewables

Key takeaway

Now is the time to put emphasis on adaptation as well as mitigation to help reduce the inevitable impacts of climate change on the energy sector

Coal Based Energy Supply, Baoshan, China

LAND USE

LAND USE

Risks

Land sensitivity factors:

- Natural setting, Urban form, Built environment
- Extent of heat island effect

- Adaptive capacity -- urban land management system including: legal/political, planning, land regulations, infrastructures and urban services, land markets, and fiscal systems

Adaptation and Mitigation strategies

- Reduce sprawl, increase densities and mix uses to reduce auto use and increase public transit use
  - Change in building codes to reduce energy use for heating and cooling
  - Land use restrictions in areas subject to climate change impacts such as sea level rise
  - Changes to building codes/land regulations to reduce damage from climate change hazards, e.g., elevating buildings in flood-prone areas
  - Increase urban trees and vegetation to reduce the heat island effect

Source: Marco Schmidt, 2003
Flavela Santa Marta, Rio de Janeiro, Brazil

Key takeaway

Climate and climate change can be an integrating factor in land-use planning

GOVERNANCE

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Challenges

1. Climate is one of many issues on local government's agenda
2. Tradeoffs between current priorities and long-term risks
3. Uncertainties about timing and scale of local impacts affects prioritization of investments and action
4. Local authorities constrained by policy and fiscal space
5. Jurisdictional conflicts, multiple stakeholders

Best Practices

1. Science-based policy-making
2. Effective leadership
3. Efficient financing
4. Jurisdictional coordination
5. Land-use planning,
6. Citizen participation

Key takeaway

Around the world, city authorities recognize the challenges to implementing mitigation and adaptation strategies and many are taking action

Cities Responding to Climate Change Challenges and Opportunities

- Cities focused on protecting vulnerable residents and assets
- Cities are adaptive and respond to challenges
- Climate change impacts and vulnerabilities can be observed in cities; not hidden
- Cities are associated with upwards of 70% of global greenhouse gas emissions
- City leaders attempt to maintain the quality of life of local residents and a vibrant business environment

Meeting Urban Environment Crises in New York City

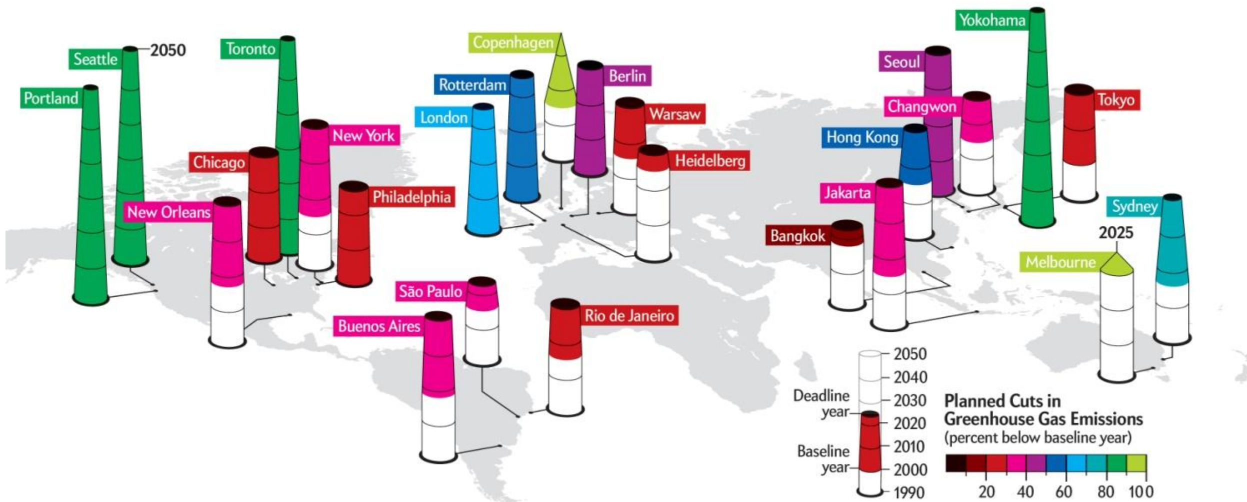
- Water quality and supply - 1830s
- Open Space and Recreation -1850s
- Public Health and Sanitation – 1870s
- Mobility and Congestion – 1910s
- ‘Urban Renewal’/Loss of Community – 1950s
- Air Pollution – 1960s
- Climate Change – 2010s?

Looking south over Central Park in 1861


New York City Environs - 1900


Smog - November 1953

In 2010s, Cities as Emerging First Responders

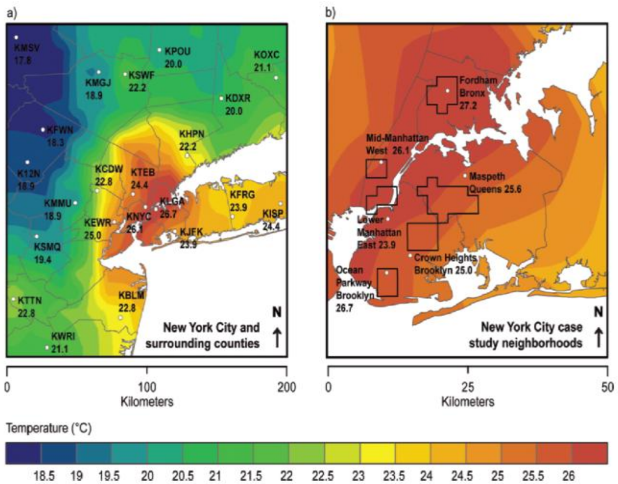


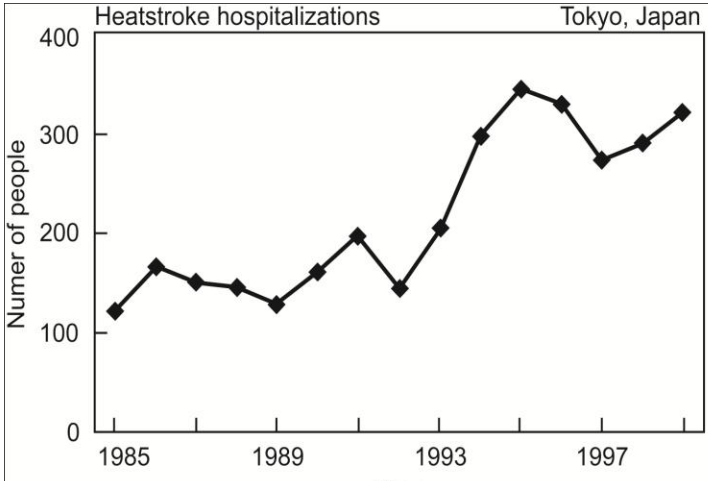
- **Action at the national/international level is slow**
- **Urban leaders are taking the lead in responding to climate change in both mitigation and adaptation**
  - **C40 Cities Climate Leadership Group launched in London 2005**
  - **World Mayors Council on Climate Change (WMCCC) launched 2010**
  - **<190 mayors and other local authorities have signed voluntary WMCC pact to reduce greenhouse gas emissions (as of June 2011)**
  - **C40 and Clinton Climate Initiative joined forces with World Bank**
  - **ICLEI key actor**

Rosenzweig, *Scientific American*, 2011

Cities Are Aware of and Can Intervene to Ameliorate Multiple Environmental Stresses – Co-Benefits of Adaptation and Mitigation

Esmeraldas, Ecuador
UN-HABITAT





Urban Heat Island Impacts in Tokyo, Japan
Tokyo Metropolitan Government

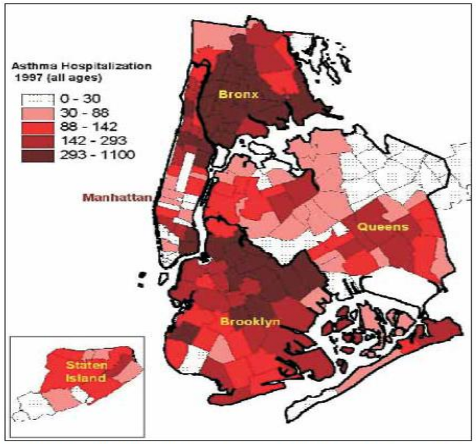


FIGURE 7-2 NYC asthma hospital admissions in 1997 by zip code.

NYC Asthma-related hospital entries
MEC, 2001

Stress	**Goal**	**Intervention**
Excess heat	Reduce ↓	White, green roofs
Exacerbated runoff	Reduce ↓	Porous pavements
Poor air and water quality	Improve	Emissions regulations; treatment
Lack of biodiversity	Increase ↑	Green spaces

Cities have Experience in Responding to Climate-related Extreme Events

Hurricane Irene
August, 2011 -New York

Key lessons

- Climate disasters are the product of interactions between natural processes and human interactions
- On front lines experiencing the power of climate disruption on citizens
- Preparedness is important
- Climate change may increase these risks

Box 3.5, ARC3, 2011

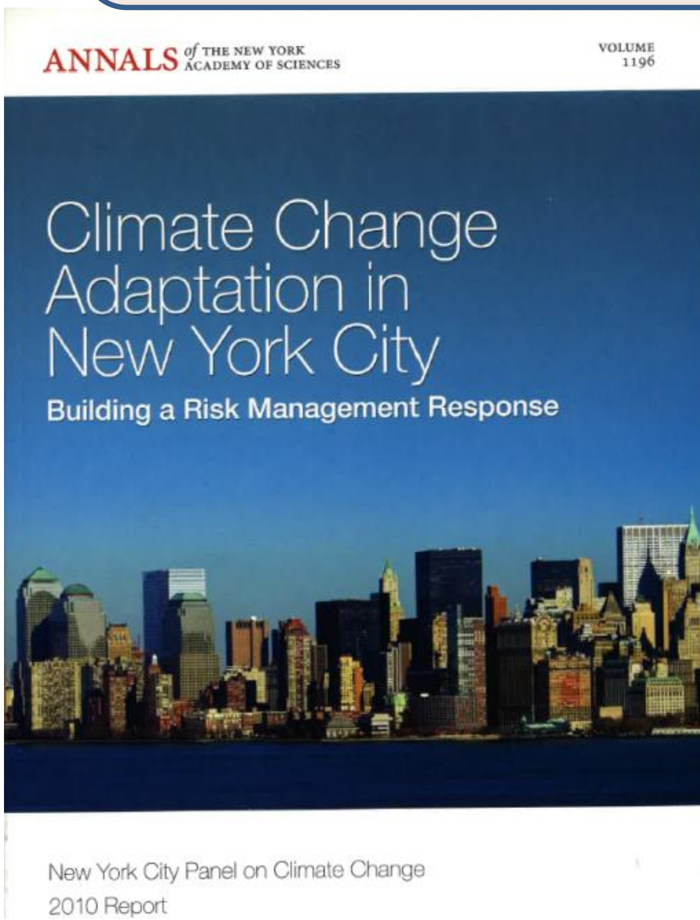
City Leaders Can Take Climate Action

- More direct contact with constituents
- Involved in day-to-day management; more practical
- Able to form coordination networks with other cities

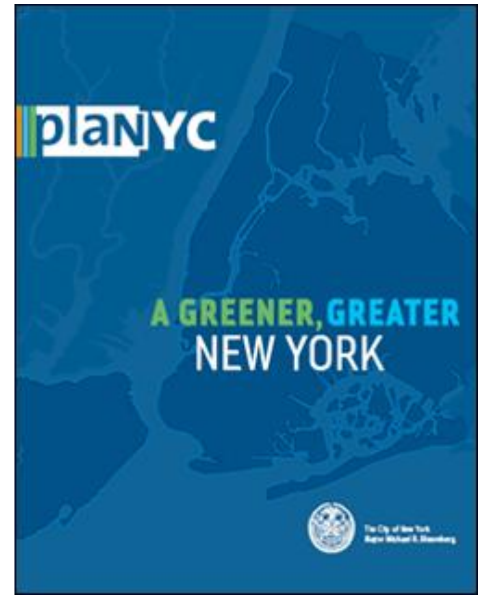
However, there remain many challenges:

- Limited institutional capacity and expertise
- Multiple jurisdictions
- Financing mitigation and adaptation measures
- Uptake (within and across cities)
- Roles of small, medium, and large cities
- Maintaining momentum across election cycles

Climate Change Actions in New York City



New York City Panel on Climate Change (NPCC)
Climate Change Adaptation in New York City:
Building a Risk Management Response



Part of PlaNYC

New York City Climate Adaptation Process

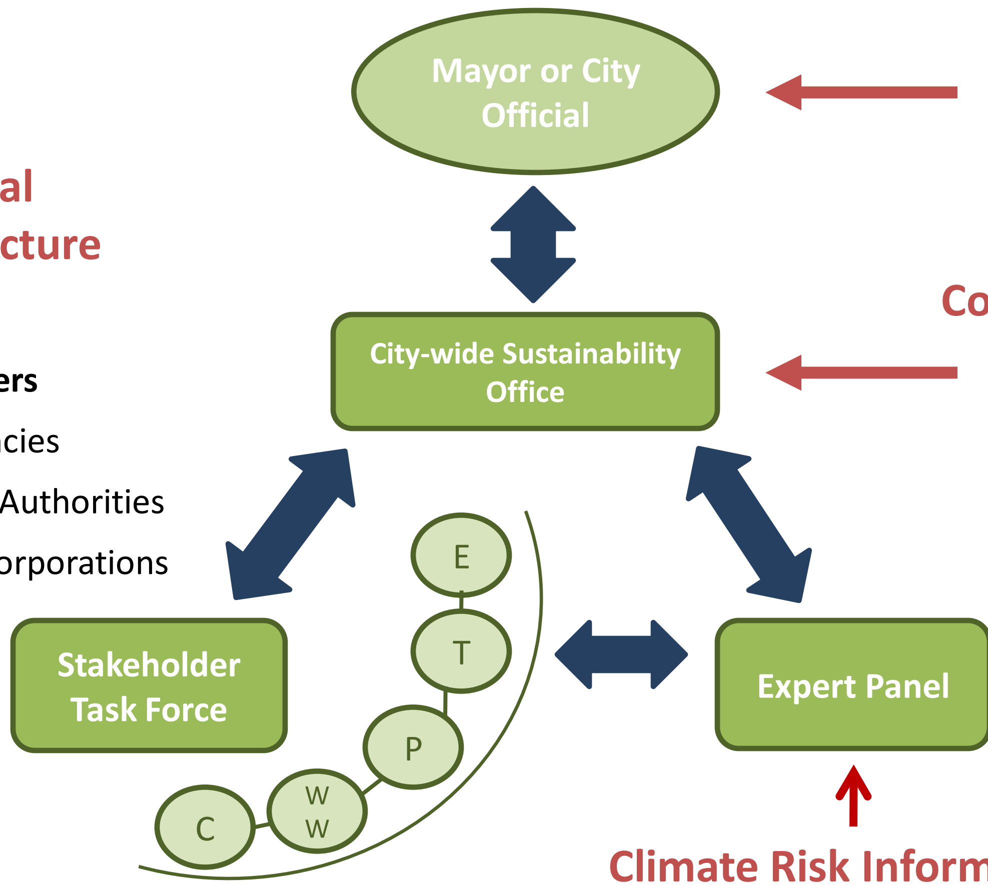
High-Level Buy-In

Critical Infrastructure

Stakeholders

- City Agencies
- Regional Authorities
- Private Corporations

Coordinating Role



Expert Knowledge Providers

- University scholars and private sector experts
- Social, biological, and physical scientists
- Legal and insurance experts
- Risk management professionals

Integration across Sector-specific Working Groups

- Energy (E) - Transportation (T)
- Policy (P) -Water & Waste (WW)
- Communications (C)

Climate Risk Information

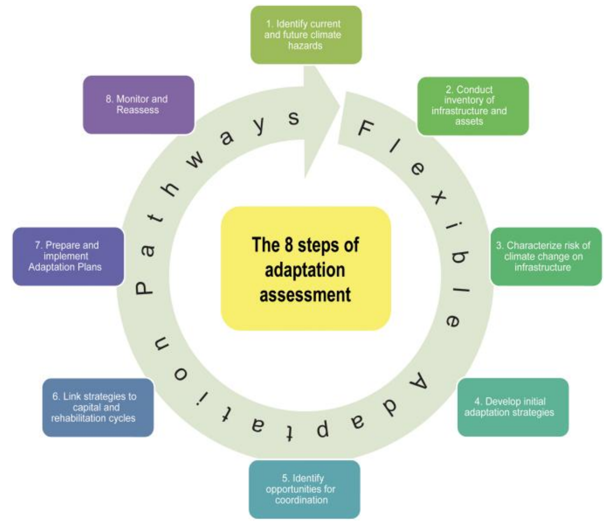
Adaptation Assessment Guidelines

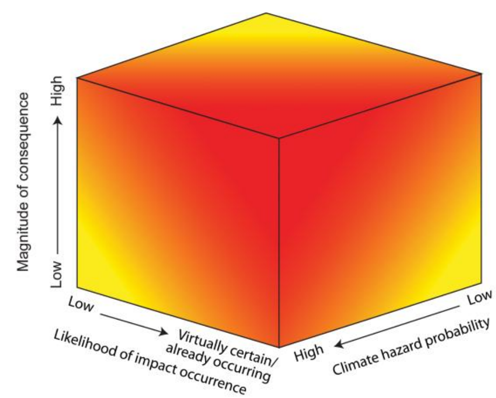
Climate Protection Levels

Source: NPCC, 2010

Climate Change Adaptation Assessment

- Climate scenarios developed for New York City were used to identify impacts on infrastructure and start the adaptation assessment process
- Climate information helped guide stakeholders through:
  - Inventory of At-risk Infrastructure
  - Risk Assessment Matrix
  - Strategy Prioritization Framework



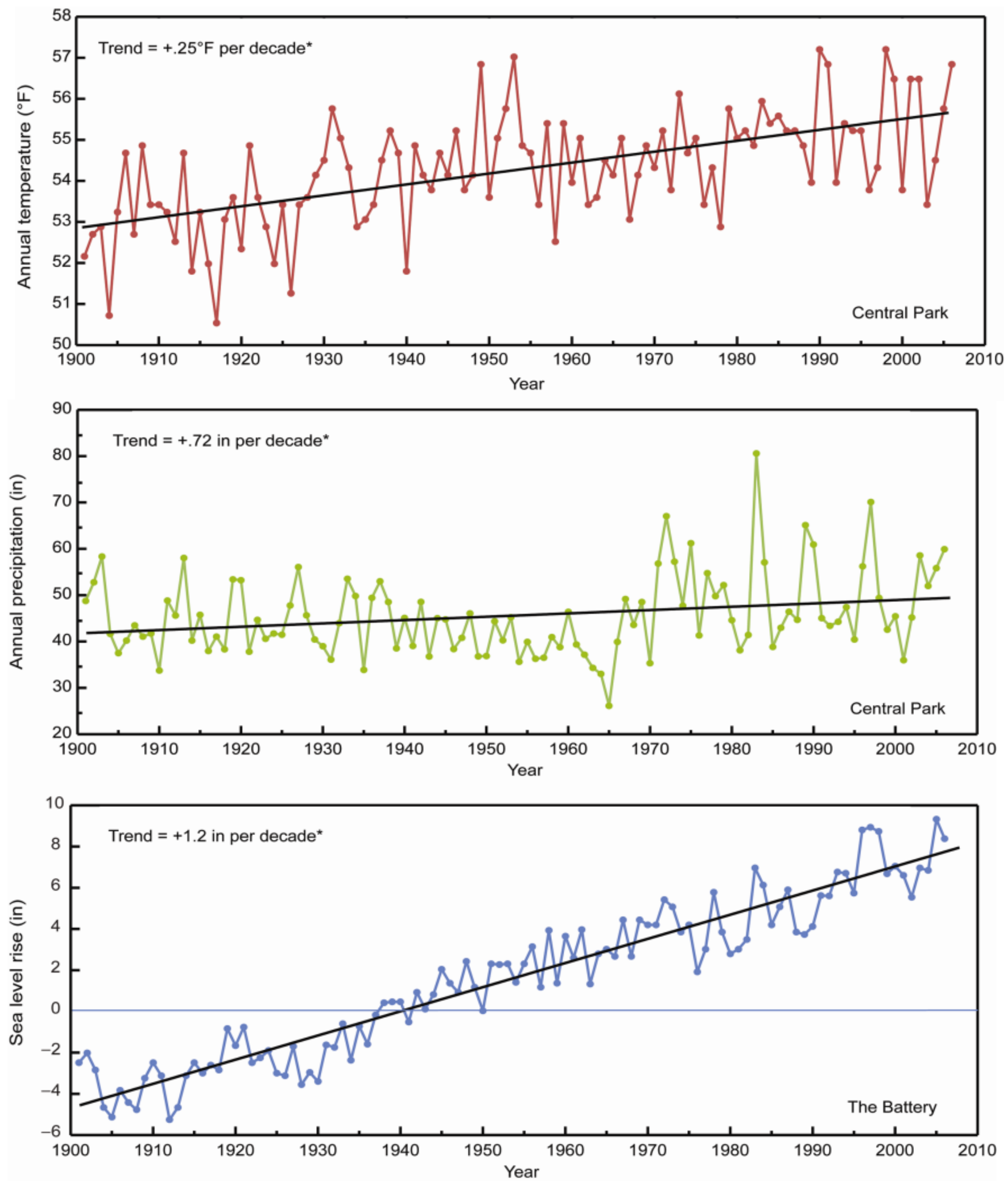


RED	*Risks for which adaptation strategies should be developed.*
ORANGE	*Risks for which adaptation strategies may need to be developed or for which further information is needed.*
YELLOW	*Risks for which impacts should be monitored but which may not need actions at this time.*

Source: NPCC, 2010

Observed Climate in New York City

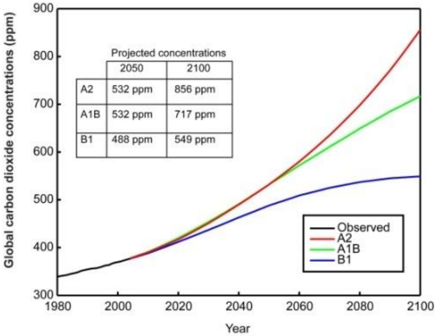
- **Temperature**
  - Significant warming at century timescale
- **Precipitation**
  - Interannual variability dominates long-term trend
- **Sea level**
  - Significant increase over the 20th century at the Battery

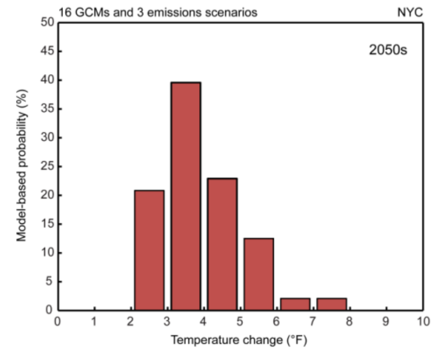


Observed climate in Central Park, New York City.
Temperature data are not adjusted for urbanization effects.
*Trend is significant at the 95% level.

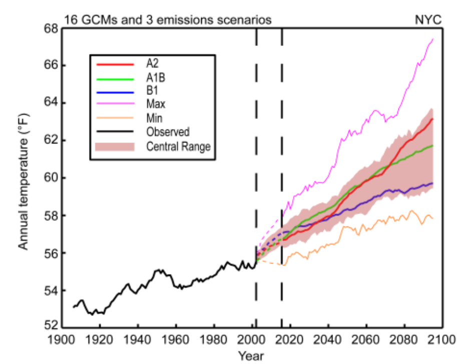
Climate Scenario Methods

- Regional climate projections are based on 16 GCMs (7 GCMs for sea level) and 3 emissions scenarios
  - Model output for the single gridbox covering New York City is used
- Future changes are presented for time slices relative to the 1971 – 2000 baseline period (2000 – 2004 for sea level)
  - Time slices are 30 year periods (10 for sea level) centered around a given decade, for example, the 2050s is 2040 – 2069.
- Model-based probability
  - The combination of GCMS and emissions scenarios produce 48 outputs for temperature and precipitation
  - For each scenario time period and variable, the results constitute a model-based probability function
- Bias-corrected, spatially downscaled output from the 16 GCMs now being used (Maurer, 2007)





Frequency distribution of model based temperature changes for the 2050s relative to the 1971-2000 base period.



Mean Annual Changes

New York City Infrastructure shed

Baseline Climate and Mean Annual Changes

	Baseline 1971-2000	2020s	2050s	2080s
Air temperature Central range	55° F	+ 0.5 (1.5 to 3.0) 3.5° F	+ 2.5 (3.0 to 5.0) 7.5° F	+ 3.0 (4.0 to 7.5) 10° F
Precipitation Central range	46.5 in	-5 (0 to 5) 10 %	-10 (0 to 10) 10 %	-10 (5 to 10) 15 %
Sea level rise Central range	NA	+ 2 to 5 in	+ 7 to 12 in	+ 12 to 23 in
Rapid ice-melt scenario	NA	~ 5 to 10 in	~ 19 to 29 in	~ 41 to 55 in

Shown is minimum, the middle 67% of values, and maximum values from model-based probabilities; temperatures ranges are rounded to the nearest half-degree, precipitation to the nearest 5%, and sea level rise to the nearest inch.

- Stakeholders requested the central range of values along with the maximum and minimum values be shown

- Climate information was presented in a "tearsheet" format so that stakeholders could easily reference it

Source: NPCC, 2010

Extreme Events

New York City
Infrastructure-shed

Quantitative Changes

The central range (middle 67% of values from model-based probabilities) across the GCMs and greenhouse gas emissions scenarios is shown.

	Extreme Event	*Baseline (1971- 2000)*	2020s	2050s	2080s
Heat waves & Cold Events	# of days/year with maximum temperature exceeding: 90°F	*14*	23 to 29	29 to 45	37 to 64
	# of days/year with minimum temperature at or below 32°F	*72*	53 to 61	45 to 54	36 to 49
Intense Precipitation	# of days per year with rainfall exceeding: 1 inch	*13*	13 to 14	13 to 15	14 to 16
Coastal Floods & Storms	1-in-100 yr flood to reoccur, on average	*~once every 100 yrs*	~once every 65 to 80 yrs	~once every 35 to 55 yrs	~once every 15 to 35 yrs
	Flood heights (in ft) associated with 1-in-100 yr flood	*8.6*	8.8 to 9.0	9.2 to 9.6	9.6 to 10.5

Qualitative Changes

Based on observations, model process studies, and expert judgment

Extreme Event	Probable Direction Throughout 21st Century	Likelihood[1]
Heat index[2]	↑	Very likely
Ice storms/ Freezing rain	↑	About as likely as not
Snowfall frequency & amount	↓	Likely
Downpours (precipitation rate/hour)	↑	Likely
Lightning	*Unknown*	
Intense hurricanes	↑	More likely than not
Nor'easters	*Unknown*	
Extreme winds	↑	More likely than not

Source: Columbia University Center for Climate Systems Research

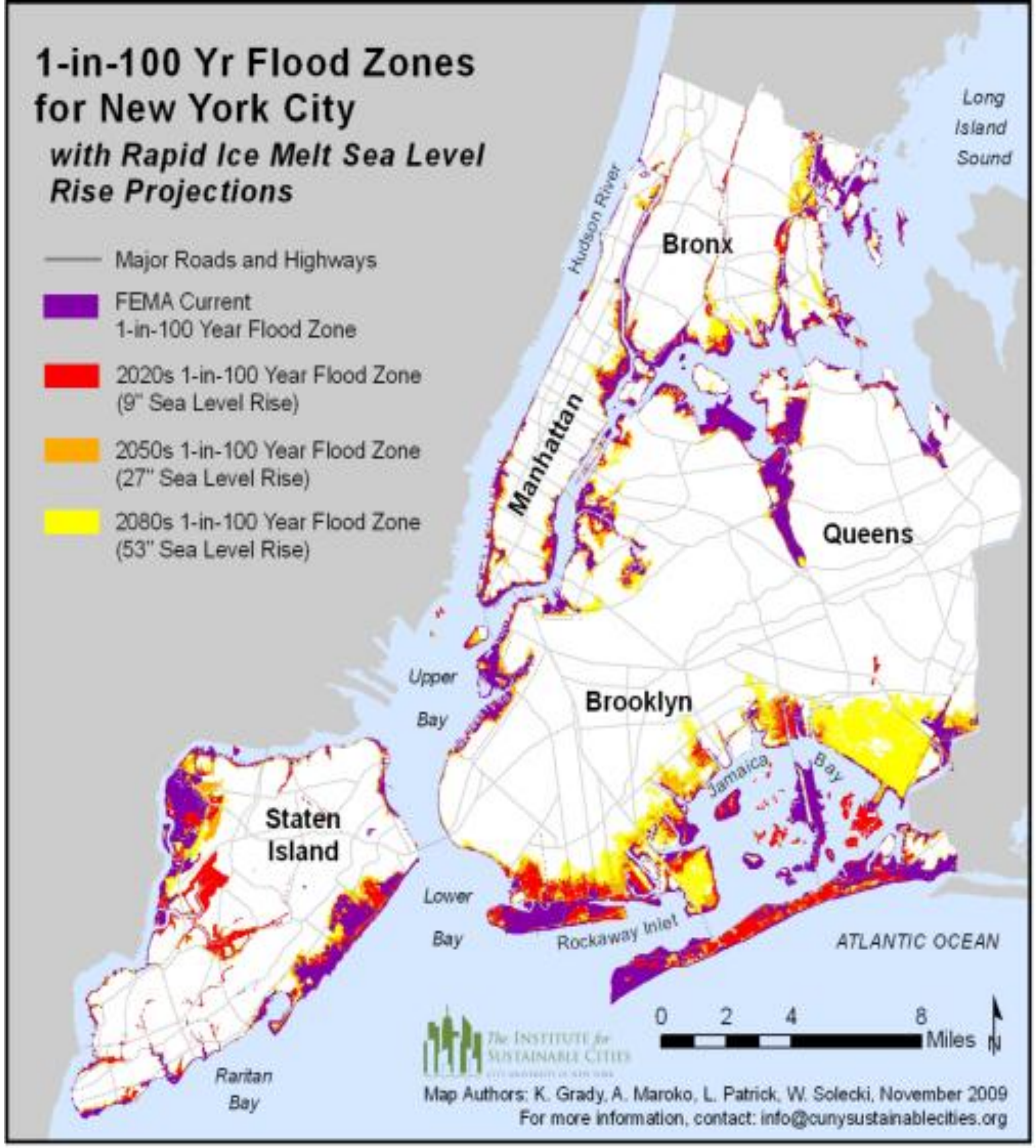
[1] Likelihood definitions found in the first section, "Definitions and Terms."

[2] The National Weather Service uses a heat index related to temperature and humidity to define the likelihood of harm after "prolonged exposure or strenuous activity" (http://www.weather.gov/om/heat/index.shtml).

Probability of occurrence

Virtually certain	>99% probability of occurrence
Extremely likely	>95% probability of occurrence
Very likely	>90% probability of occurrence
Likely	>66% probability of occurrence
More likely than not	>50% probability of occurrence
About as likely as not	33-66% probability of occurrence

Source: NPCC, 2010



Note. This map is subject to limitations in accuracy as a result of the quantitative models, datasets, and methodology used in its development. The map and data should not be used to assess actual coastal hazards, insurance requirements, or property values or be used in lieu of Flood Insurance Rate Maps issued by FEMA.

Interpretation. The floodplains delineated above in no way represent precise flood boundaries but rather illustrate three distinct areas of interest: 1) areas currently subject to the 1-in-100 year flood that will continue to be subject to flooding in the future, 2) areas that do not currently flood but are expected to potentially experience the 1-in-100 year flood in the future, and 3) areas that do not currently flood and are unlikely to do so in the timeline of the climate projection scenarios used in this research (end of the current century).

Showing Additional Areas that Could be Flooded during Extreme Coastal Storms

Climate Protection Levels Workbook
Chapter 6 Insurance
NPCC Report, 2010

Science-Policy Linkages and Adaptation Decisions

- **Actions**

  - Enhance existing programs

  - Moving pumps at the Rockaway Wastewater Treatment Plant to 14 feet above sea level from 25 feet below

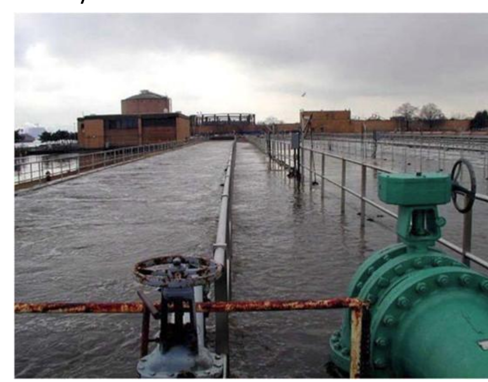
- **Planning**
  - **NYC DEP Climate Change Integrated Modeling Project (CCIMP) analyzing climate impacts on NYC water supply**
  - **NYC DEP RFP to study impacts of rising sea level on Wastewater Pollution Control Plants (WPCP), tide gates and other structures**

- **Standards and Regulations**

  - NPCC Recommendation to change 1/100 year floodplain standards

- **Urban Design - MOMA**

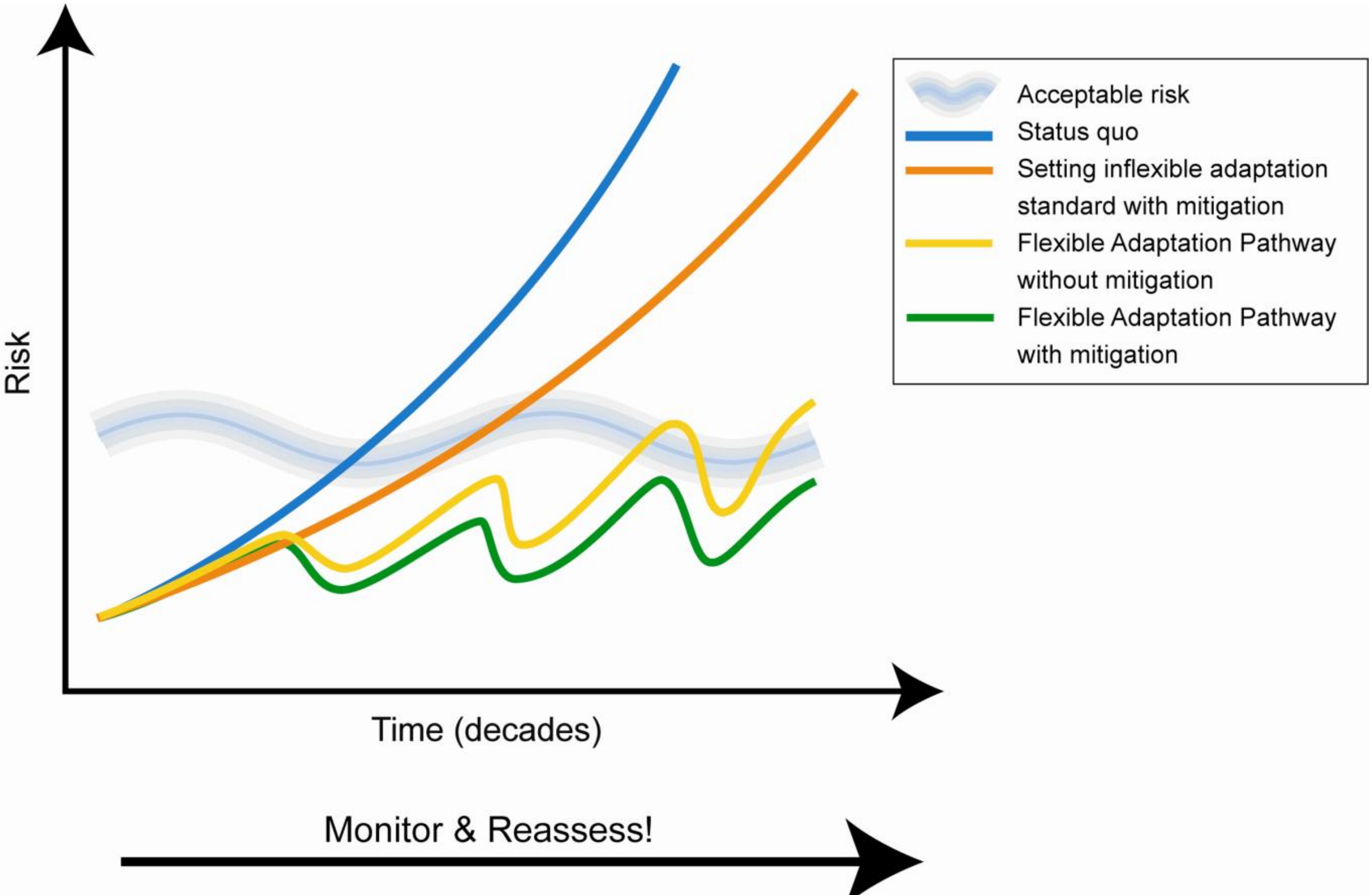
Ashokan Reservoir, a component of the New York City Water Supply System



WPCP in Bronx, New York

Source: NYC DEP

Summary: Adaptive Urbanization - Climate Risk Management in Cities, Flexible Adaptation Pathways and Interactive Mitigation and Adaptation



Graphic adapted from: Lowe, J., T. Reeder, K. Horsburgh, and V. Bell. "Using the new TE2100 science scenarios." UK Environment Agency

Source: NPCC, 2010

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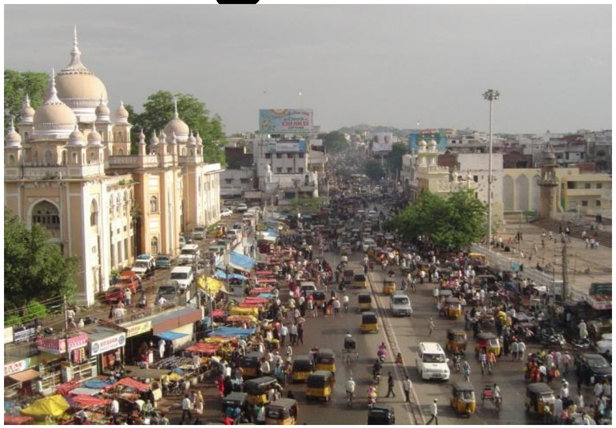
THANK YOU

Cities and Climate Change Moving Forward

Shanghai, China



Hyderabad, India

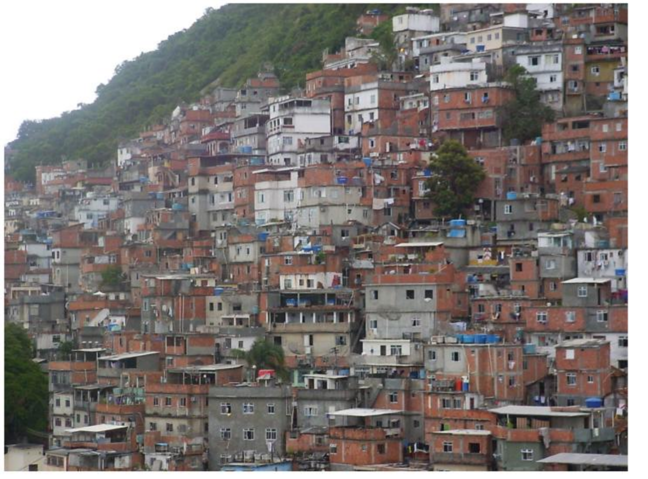
Esmeraldas, Ecuador

- **Embed climate change mitigation and adaptation into urban infrastructure projects – work toward tipping points for up-take**
- **Entrain and enable range of city types and sizes – e.g., small, mid-size, and large**
- **Develop and implement common sets of standards for reporting**
  - **Greenhouse gas emissions and reductions**
  - **Impacts of climate on cities**
  - **Adaptations**
- **Engage citizens**
  - **Especially those from the poorest and most vulnerable neighborhoods who are likely to suffer most from climate change**

Source: Rosenzweig, *Scientific American*, 2011

‘All Climate is Local’
Distinct Features of Urban Climate

- Changes in surface morphology - building shapes, height, density
- Changes in surface cover – fragmented vegetation and human-made materials
- Anthropogenic sources of heat, water, gases, and particulates
- Intense, place-based climate-related stresses, depending on physical and biological features, layout and built environment, and social vulnerability



Informal settlements in Rio de Janerio
Marco Schmidt

Manhattan-Manahatta
Source: Markley Boyer / The Manahatta Project / Wildlife Conservation Society / Amiaga Photographer

Source: Grimmond, 2007

Recent Assessment of Climate Change in Cities

- **International Scale**
  - **UN Habitat – *Global Report on Human Settlements 2011;* World Bank - Climate Change, *Disaster Risk, and the Urban Poor*; UCCRN (Urban Climate Change Research Network) – *First Assessment Report of the Urban Climate Change Research Network (ARC3 Report)***
- **City Scale**
  - **Boston, King County (Seattle), London, Miami, New York, Quito, and many more**

Global Organizations

- *UN Habitat Program* (http://www.unhabitat.org/)
- *World Bank Cities Alliance Program* (http://www.citiesalliance.org/ca/wb)
- *ICLEI* (International Council for Local Environmental Initiatives) *Local Governments for Sustainability program* (http://www.iclei.org/).
- IPCC Working Group II and III (many chapters focused on urban infrastructure issues)

City and Local Stakeholder Organizations

- *C40* (http://www.c40cities.org)
- *Mayor Summits* http://www.worldmayorscouncil.org associated with the *UNFCCC, COP* process (http://unfccc.int/2860.php)
- Researcher-stakeholder partnerships -*Urban Climate Change Research Network (*http://www.uccrn.org/)
- Researcher networks such as the *Urbanization and Global Environmental Change Research Network* (http://www.ihdp.unu.edu/article/read/ugec)

Developing Climate Scenarios

Process used to develop climate risk factors for New York City

Global climate scenarios

•SRES greenhouse gas emissions pathway

•GCM simulations

→

Local climate change information

•Observed data

•Quantitative GCM-based projections

•Qualitative GCM-based projections

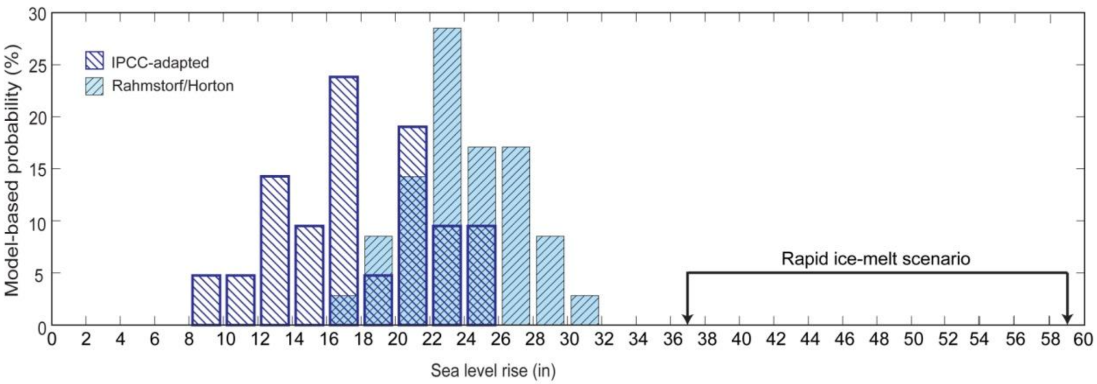
→

Climate risk factors

•Generalized climate hazards of most conse-quence to NYC infrastucture used to determine critical infrastructure at-risk.

High Impact Sea Level Rise Scenarios

Sea level rise projections for New York City for the 2080s

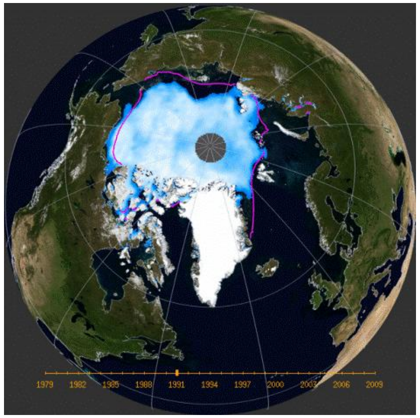


Two sea level rise scenarios were developed for New York City.

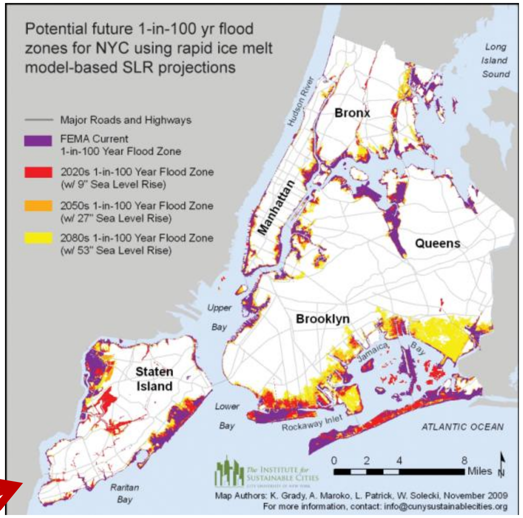
1) GCM model-based method used for sea level rise similar to what was done for temperature and precipitation. These projections include local and global components.

2) “Rapid Ice-melt scenario” was developed based on melt rate and paleoclimate studies to account for the possibility that future changes in polar ice sheets are not captured by the GCMs and may accelerate melting beyond currently projected levels.

Minimum Sea Ice Extent 1979-2009



median minimum ice extent(1979-2009)



Impacts

Source: NPCC, 2010