WHAT ARE THE INFRASTRUCTURE CHOICES FOR CLIMATE ADAPTATION AND WHAT MIGHT MAKE SENSE?

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Overview

• Climate Projections & Impacts
• Categories of Infrastructure Adaptation
• Localized & Distributed Infrastructure Systems
  – New York City Case Study
• Observations/Conclusions
Climate Change Projections & Impacts

• Raise in sea-levels
• Increase in average temperatures
• Change in patterns and amounts of precipitation
• Decline in snow-cover, permafrost and sea-ice
• Acidification of the oceans
• Increase frequency, intensity & duration of extreme events
• Change eco-system characteristics

__________________________________________

• Water resources
• Infrastructure
• Food supply
• Ecosystems
• Human Health & Well Being

From EPA: https://www.epa.gov/climate-change-science/future-climate-change
Global Sea-Level Rise and Temperature Rise

Images from EPA: https://www.epa.gov/climate-change-science/future-climate-change
Projections for the U.S: Sea-Level & Temperature

Images from EPA: https://www.epa.gov/climate-change-science/future-climate-change
Projections for the U.S: Precipitation

Images from EPA: https://www.epa.gov/climate-change-science/future-climate-change
Broad Categories of Infrastructure Adaptation
Strategic Relocation

Relocating existing, or limiting new, development in high risk areas

From: https://trca.ca/conservation/climate-change/

From: U.S. Climate Resilience Tool Kit
“Climate proofing” through new infrastructure and/or restoration of natural systems

Above 16th Century Antwerp. Below from Big Team Big U project
Redundancy

Back-up/ Temporary Systems

From: https://ec.europa.eu/clima/policies/adaptation_en

From: dna info July 21st 2106

From: Geography.org.uk
Challenges

• Uncertainty in global climate projections
• Need for locally specific data
• Translate data into risk
• Approaches need to be technically, politically and economically viable

From: aswm.org
Localized and Distributed Infrastructure Systems
Is Localized and Distributed Infrastructure More Sustainable? A Multi-Sector Perspective

Lead PI & SRN Director: Anu Ramaswami, University of Minnesota

Co-Director & Co-Principal Investigator: Patricia Culligan, Columbia University

Co-Director & Co-Principal Investigator: Armistead Russell, Georgia Tech

Co-Director: Rick Feiock, Florida State University

Co-principal Investigator: Ben Orlove, Columbia University

Co-principal Investigator: Yingling Fan, University of Minnesota
Examples of Localized and Distributed Systems

CREDIT: Images obtained from SRN: Integrated Urban Infrastructure Solutions for Environmentally Sustainable, Healthy, and Livable Cities
### What is the best mix of local versus non-local?
What is the “best” scale-mix for local *provision*?

<table>
<thead>
<tr>
<th>Extent of Local vs. “Outside”</th>
<th>Scale of Distributed Infrastructure Production-Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Home Scale = Fully Decentralized</td>
</tr>
<tr>
<td><strong>Fully Localized</strong> = production-consumption fully in city boundary</td>
<td><img src="image" alt="Home Scale" /></td>
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<tr>
<td><strong>Partial Localized</strong> = some reliance on transboundary production</td>
<td><img src="image" alt="Home Scale" /></td>
</tr>
<tr>
<td><strong>Fully external</strong> = zero local production</td>
<td><img src="image" alt="Home Scale" /></td>
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</tbody>
</table>

*City Boundary*

(Ramaswami et al, In Prep Please Do Not Cite)
What is the “best” scale-mix for local or distributed infrastructure governance?

<table>
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<tr>
<th>Gradients of Social/Institutional Configuration of Infrastructure Governance Functions</th>
<th>Scale of Infrastructure Governance Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collective</td>
<td>Home Scale = Fully Decentralized</td>
</tr>
<tr>
<td>Formal</td>
<td>City Scale Network</td>
</tr>
<tr>
<td>Public</td>
<td></td>
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<tr>
<td>Personal</td>
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<tr>
<td>Informal</td>
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<tr>
<td>Private</td>
<td></td>
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</tbody>
</table>

Governance Functions
1) Financing
2) Operations & Management
3) Regulation

(Ramaswami et al., In Prep Please Do Not Cite)
Localized and Distributed Systems for Climate Adaptation?

- Systems are “flexible” – spatial development can occur over time, and financing can occur over time
- Often have co-benefits

But what are the challenges?

From: Sustainablehealthycities.org
New York City’s Green Infrastructure Plan

Goal: Maintain or restore the pre-development hydrologic regime of developed watersheds through design

~ 20 year implementation plan, at an initial estimated cost of $2.4 billion

Design Goal - Eliminate first inch of runoff from 10% of NYC’s impervious area

Pre-development Landscape

Image developed by the USEPA
A waste disposal problem!

Image developed by the USEPA
When It Rains, It Pollutes

Each year in New York, billions of gallons of sewage and runoff overflow through 490 points, or “outfalls,” into the harbor and rivers when heavy rains cause backup.

Estimated annual average sewage overflow through each outfall:
- 2.0 billion gallons
- 1.0 billion
- 100 million

Wastewater treatment plant

Before:
- Sewer to POTW
- Storm drain
- Outfall pipe to river

After:
- Separate storm sewer
- Sewer to POTW
- Storm drain
- Outfall pipe to river


http://water.ky.gov/permitting/Pages/CombinedSewerOverflows.aspx

November 22, 2009
Example Green Infrastructure Strategies

CREDIT: Columbia University Researchers
Stormwater Retention Design Curves

Central Park, NY (1949–2010)

CREDIT: Carson et al., 2013
Evapotranspiration Models

CREDIT: Marasco et al., 2014
Local Cooling

CREDIT: Gaffin, Columbia University

CREDIT: Gaffin, Columbia University
CO₂ Sequestration

[CREDIT: McGills, Columbia University]
New York City

From: Building the Knowledge Base for Climate Resiliency: Horton et al. 2015
Increased Flooding and Urban Heat Island Impacts

Image courtesy of Gaffin, Columbia University
A Vision for New York City?

http://ecobrooklyn.com/york-green-roof-installer-costs/

Challenges – related to Green Infrastructure

- Scale of implementation needed
  - Public-private partnerships
  - New zoning & planning policies

- Siting requirements
  - Local neighborhood conditions

- Maintenance requirements
  - Increased workforce
  - Stewardship programs
  - Low cost-monitoring technology

- Long-term performance

- Public/ Stakeholder acceptance
Public Acceptance

**What do People Value Green Infrastructure for?**

*Provisioning – Stormwater*  
*Regulating, Supporting, Maintenance*

**Cultural**

- In general, Cultural services were the highest and Provisioning were the lowest

- Cultural services had the most pronounced variation between GI groupings
Policy Integration Around Localized/Distributed Programs

More Localized Approaches

- Community and stakeholder engagement
- Coordination and Integration w/in City
- Fiscal capacity

Less Localized Approaches

- Less neighborhood and community engagement
- Less public support for sustainability
- Less staff or fiscal capacity

New Design Considerations

- Infrastructure systems with very, many components
  - How to define performance,
  - Quantify/monitor performance,
  - Maintain performance?

http://www.busitelce.com/data-visualisation/30-word-cloud-of-big-data

Observations/ Conclusions

This is a role for distributed infrastructure systems in climate adaptation

• Engineering/planning questions about system design, scale of implementation and system maintenance

• Data questions around monitoring requirements and ownership of data

• Governance questions about stakeholder engagement, coordination among city agencies and financial capacity - including role and design of public-private partnerships

• Societal questions concerning public values and acceptance

• Questions concerning equity
How Feasible is long-term climate adaptation in a short-term world?