Community Sustainable Resilience: Using Data Analytics to Evaluate Uncertain and Dynamic Linkages with Infrastructure and Environmental Systems

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What is driving up the cost of disasters?

Source: Smith, A. NOAA. 2018's Billion Dollar Disasters in Context. February 2019
“Disasters are never natural. [. . .] They are the accumulation of the constant breach of economic, social, and environmental thresholds.”

— Yeb Sano, Philippines’ lead negotiator at the UN Climate Change Convention (COP19)

- Decrease (~25%) in the overall number of Atlantic hurricanes and tropical storms
- Increase (1-10%) in hurricane intensities

“We’re seeing ever-larger losses simply because we have more to lose - when an earthquake or flood occurs, more stuff gets damaged”
Community resilience is a function of interactions across infrastructure, social, and environmental systems

- Complex
- Dynamic
- Uncertain

We know more about individual systems and less about their connections
Sustainable Resilience - the ability to maintain desired system performance while simultaneously considering intra-system and inter-generational distribution of impacts and sustainability capital.
Risk

- Complex and intangible levels of interdependencies introduce additional uncertainty
  - community resilience
  - financial impact
  - supply chain

How does the uncertainty in interactions propagate across systems?

- Shelby County, Tennessee, USA
  - Population: approx. 1 million
  - Serviced by Memphis Light, Gas, and Water, the largest three-service utility company in the U.S.
  - Vulnerable to earthquakes, storms, and flooding

• Interaction between community social vulnerability and infrastructure systems
• Address issues of social equity in disaster recovery
• Inform restoration strategies based on social aspects


Resilience of infrastructure is improved by 60%
Integrating the human decision maker

For example:

Future Risk

Current Loss
Sri Lanka
- Energy sources
  - Hydropower
  - First coal power plant in 2011
- Development
  - Increase demand of energy and water
  - Lack of resources
  - Poverty
- Future energy plans
  - Significant delays due to stakeholder disagreements

Decision

How should stakeholders be engaged in the decision process?

Preparong power Generation Plan
- Disapprove
- Approve or disapprove plan

Implementation
- Generation plan
- Disapprove/disagree
- Approve
- Acceptance of Decision

Power Utility
- Legal action
- Parliament involvement
- Expert committee

Regulator
- Disapprove/disagree
- Approve or disapprove plan

Public Consultation
- Pass

Technical clarification
- Evaluate Plan’s compliance with standards and regulations

Government Ministries and institution, Universities
- Guidelines and Standards: Energy policy, technical, financial, environmental
- Data: Economic parameters, water, fossil fuel, technical

How should stakeholders be engaged in the decision process?
Envisioning Workshop
(van Asselt et al. 2019)

Participant sectors
- Planners
- Regulators
- Energy specialists
- Finance sector
- Environmental and social groups

- Diversity of stakeholders preferences
- Different risk perceptions about renewable energy
- Priorities between sustainability and economic resilience

• **BIG data**
  - Daily operations
  - Systems characteristics
  - Social media
  - Customer data
  - Walmart (disaster relief)
  - Google search (flu detection)

• **Little data**
  - Past disasters
  - Interconnection between systems
  - Hurricane Katrina (system performance)
  - Hurricane Matthew (1000-year flood)

• **No data**
  - Post-disaster decisions
  - Recovery strategies
  - Resource allocation
  - Lessons learned from past decisions
  - Decision maker’s input
Data

Bangladesh is considered one of the most vulnerable countries to climate change

- Natural hazards
  - Flooding, cyclones, sea level rise
  - Sediment transport, deposition, and erosion

- Community resilience
  - More than 50 million people live in coastal areas
  - More than 1 million people lose their homestead

- Inland waterways sustainable resilience
  - 50% of all cargo traffic
  - 25% of all passenger traffic

Infrastructure data challenges

- Decentralized systems
- Privately owned
- Expensive

Can we leverage data from social and environmental systems to inform infrastructure systems?
Water, water, everywhere,
Nor any drop to drink.

The Rime of the Ancient Mariner
by Samuel Taylor Coleridge
Data needed

- Infrastructure topology
  - Ports
  - Channels
- Capacity
  - Flow of commodity
  - Flow of passengers
- Changes of channel width over time
Figure 1: Channel (blue) and island (red) instability in the Sundarban Brahmaputra-Meghna Delta between 1988 and 2017. Light colors represent stable regions, dark colors represent unstable regions.

Critical channels
Concluding Remarks

- Transdisciplinary research for community resilience
- Tradeoff between data and models
- Cultural and religious diversity
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Photographs of Bangladesh are provided by Andre Leroux.
Thank you!

For more information: www.hibabaroud.com