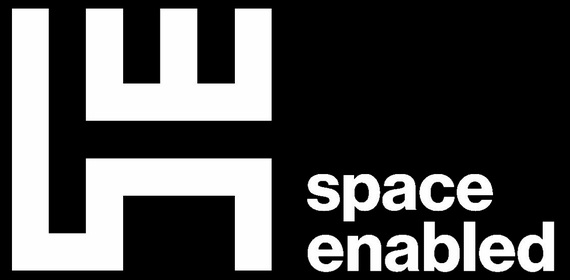
The Environment-Vulnerability-Decision-Technology Framework: A Process for Developing Multi-Disciplinary Decision Support Systems for Sustainable Development Applications

Jack Reid, Seamus Lombardo, Ufuoma Ovienmahda, Caroline Jaffe, Danielle Wood



This work centers on
exploring the efficacy and difficulties of ***collaboratively developing***
a ***systems-architecture-informed***,
multidisciplinary ***GIS decision support system***
for ***sustainable development*** applications
that makes significant use of ***remote observation data***.

Jack Reid
Graduate Student, MIT Media Lab
Space Enabled research group

Goals

- Leverage power of these technical fields
- Target specific smaller communities than is common
- High level of stakeholder involvement and collaboration

Jack Reid

Graduate Student, MIT Media Lab
Space Enabled research group

sustainable development

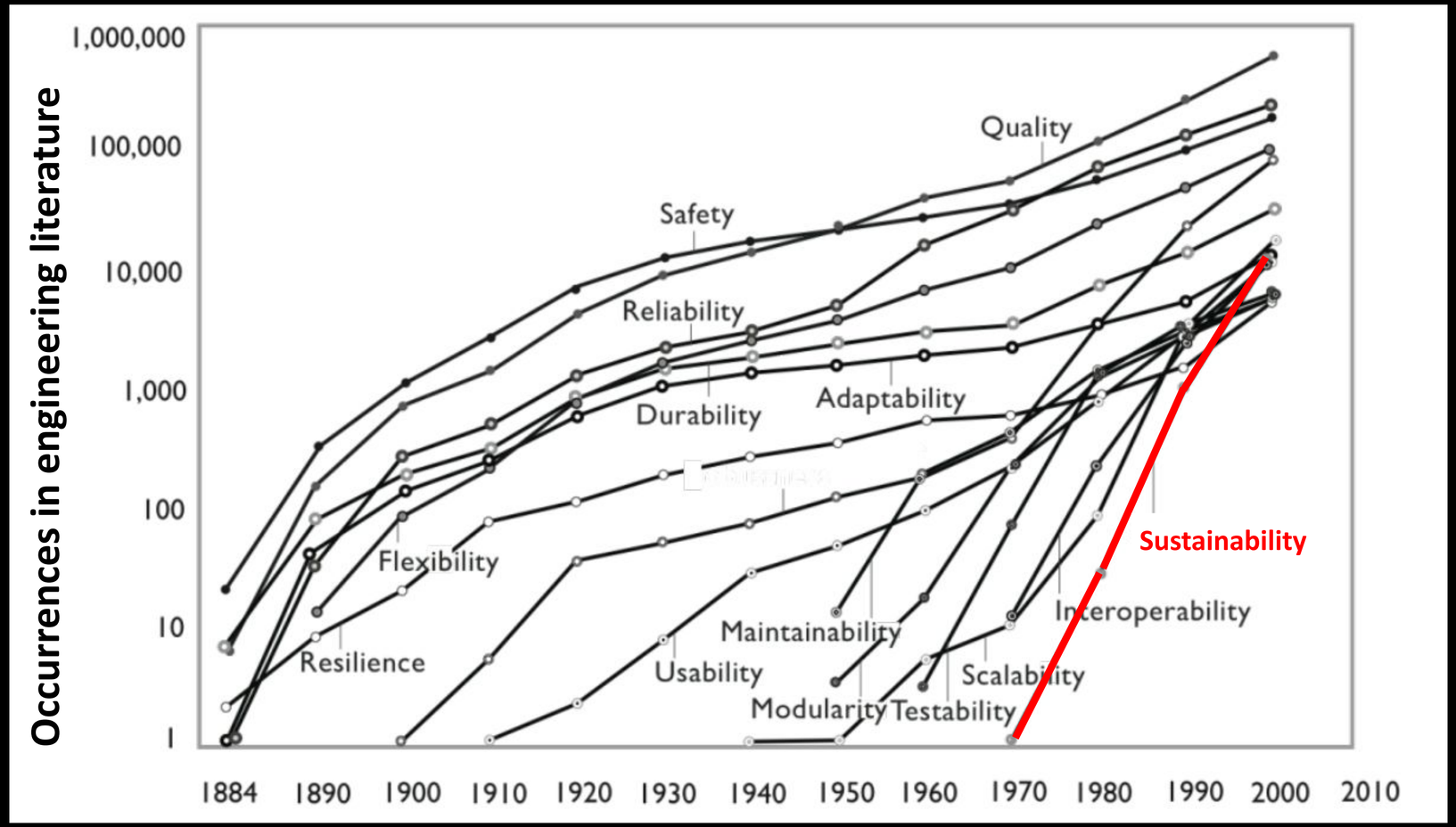
Campbell, Scott. "Green Cities, Growing Cities, Just Cities? Urban Planning and the Contradictions of Sustainable Development." *Readings in Planning Theory,* edited by Susan Fainstein and James DeFilippis, 4th ed., Wiley-Blackwell, 2016

sustainable development

Jack Reid

Graduate Student, MIT Media Lab
Space Enabled research group

systems engineering & sustainability

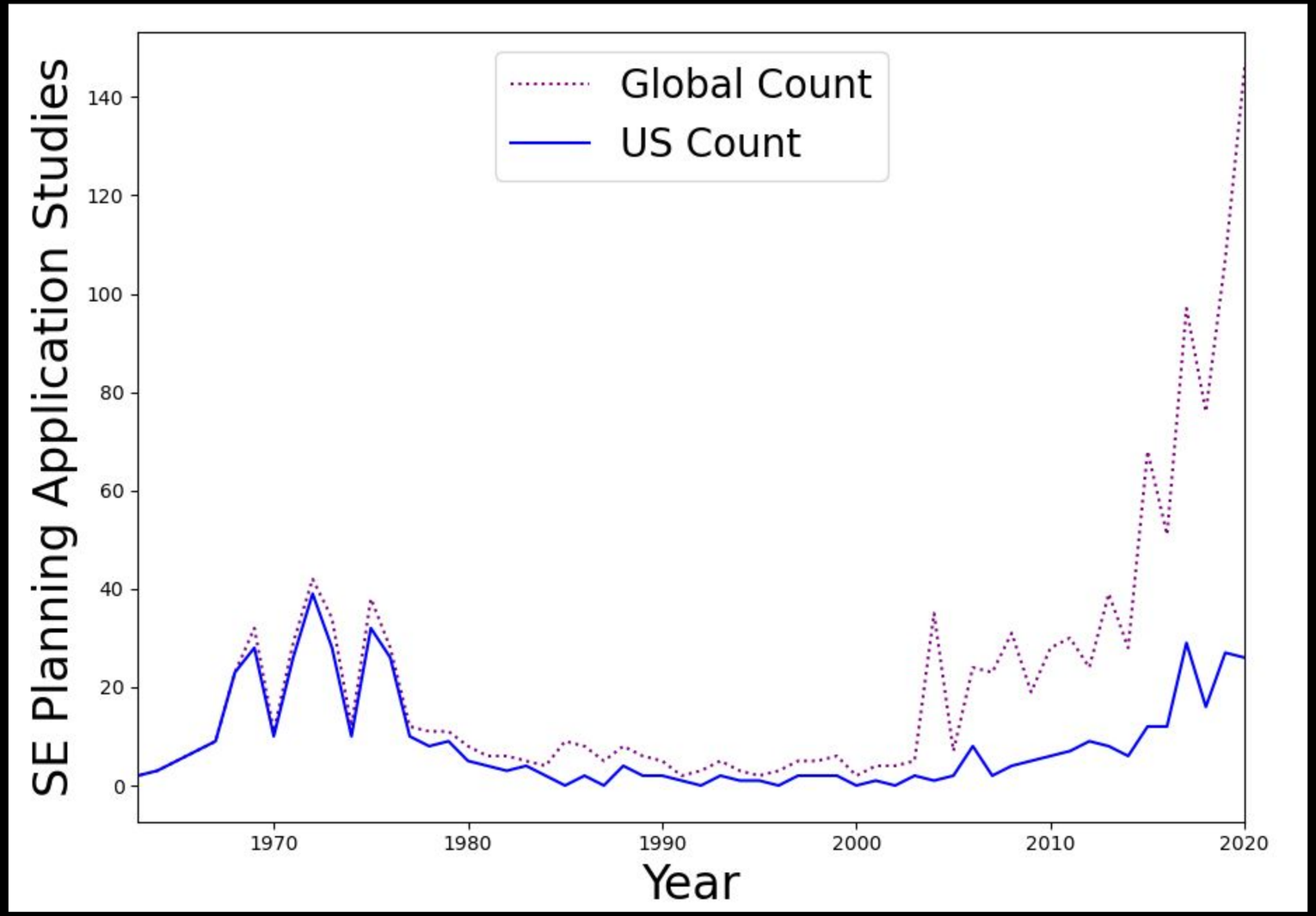


de Weck, Olivier L., et al. Investigating Relationships and Semantic Sets amongst System Lifecycle Properties (Ilities). Working Paper, Massachusetts Institute of Technology. Engineering Systems Division, Mar. 2012. dspace.mit.edu, https://dspace.mit.edu/handle/1721.1/102927.

Jack Reid

Graduate Student, MIT Media Lab
Space Enabled research group

systems engineering & planning/development

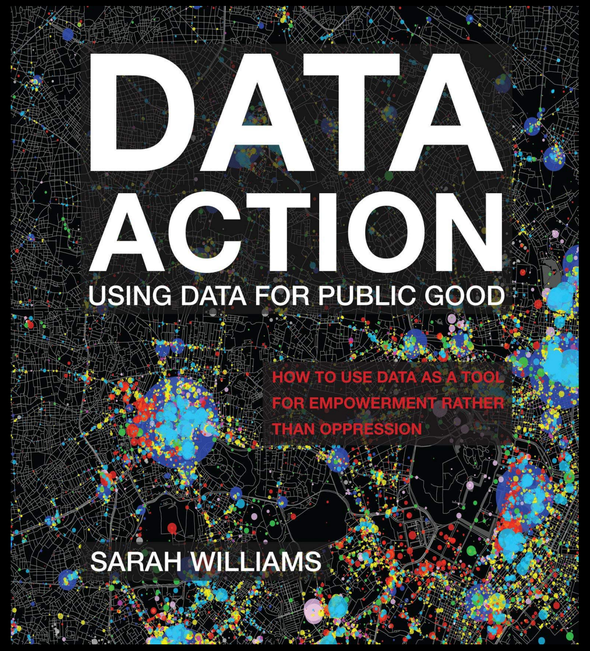


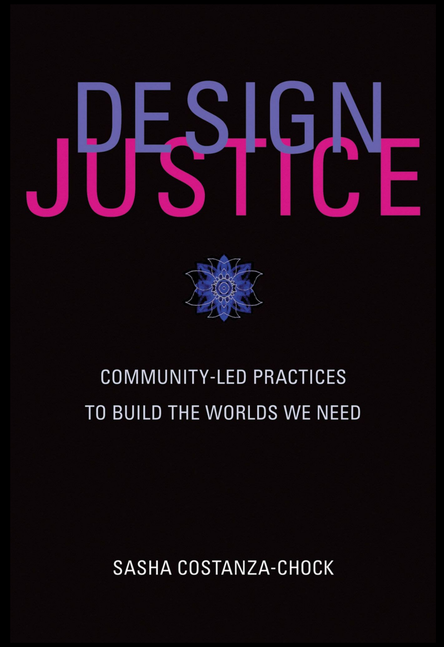
Reid, Jack, and Danielle Wood. “Systems Engineering Applied to Urban Planning & Development: A Review & Research Agenda.” Systems Engineering, 2022.

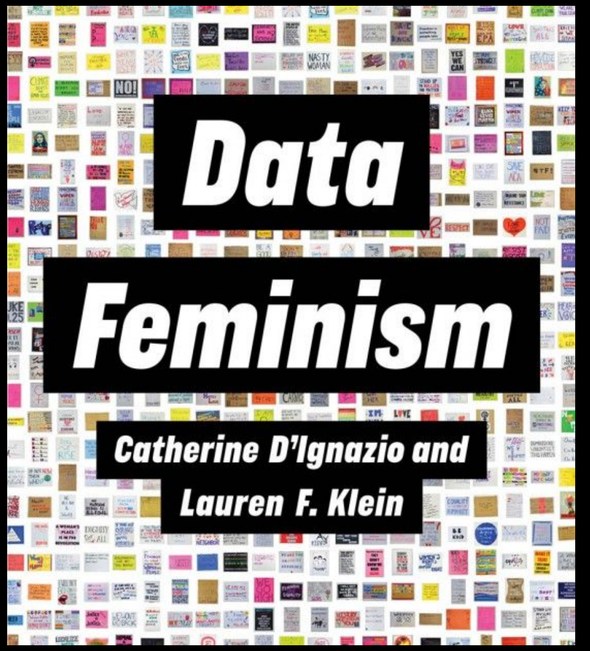
Jack Reid

Graduate Student, MIT Media Lab
Space Enabled research group

geospatial information system (GIS)







PGIS Participatory Geographic Information Systems

The politics of pixels: A review and agenda for critical remote sensing

Progress in Human Geography
2022, Vol. 46(3) 729–752

DOI: 10.1177/03091325221074691
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Mia M Bennett
Department of Geography, University of Washington, Seattle, WA, USA

Janice K Chen
Department of Geography, University of Oregon, Eugene, OR, USA

Luis F Alvarez León
Department of Geography, Dartmouth College, Hanover, NH, USA

Colin J Gleason
Department of Civil and Environmental Engineering, University of Massachusetts Amherst, Amherst, MA, USA

Jack Reid
Graduate Student, MIT Media Lab
Space Enabled research group

EVDT Framework Elements

1. Systems Architecture Framework (SAF)
2. Collaborative development of the decision-support system (DSS)
3. Environment-Vulnerability-Decisionmaking-Technology perspective
4. Interactive DSS
5. Reuse and capacity building

Jack Reid
Graduate Student, MIT Media Lab
Space Enabled research group

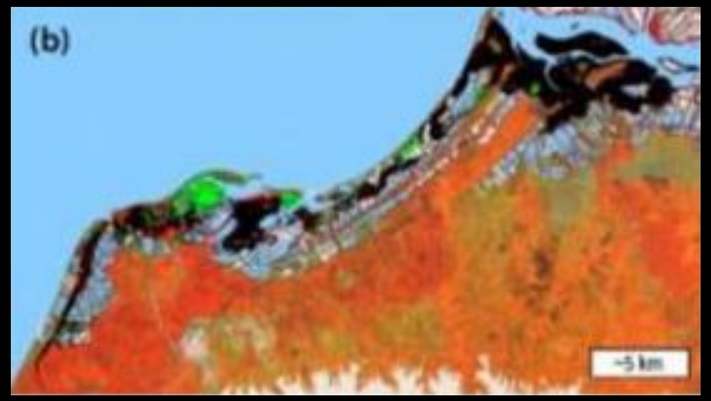
CS1: Massachusetts Cranberry Farming & Bog Restoration

Photos taken by Glorianna Davenport and Kirsten Foresto

Jack Reid

Graduate Student, MIT Media Lab
Space Enabled research group

CS2: Pekalongan Coastal Flooding and Subsidence



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Graduate Student, MIT Media Lab
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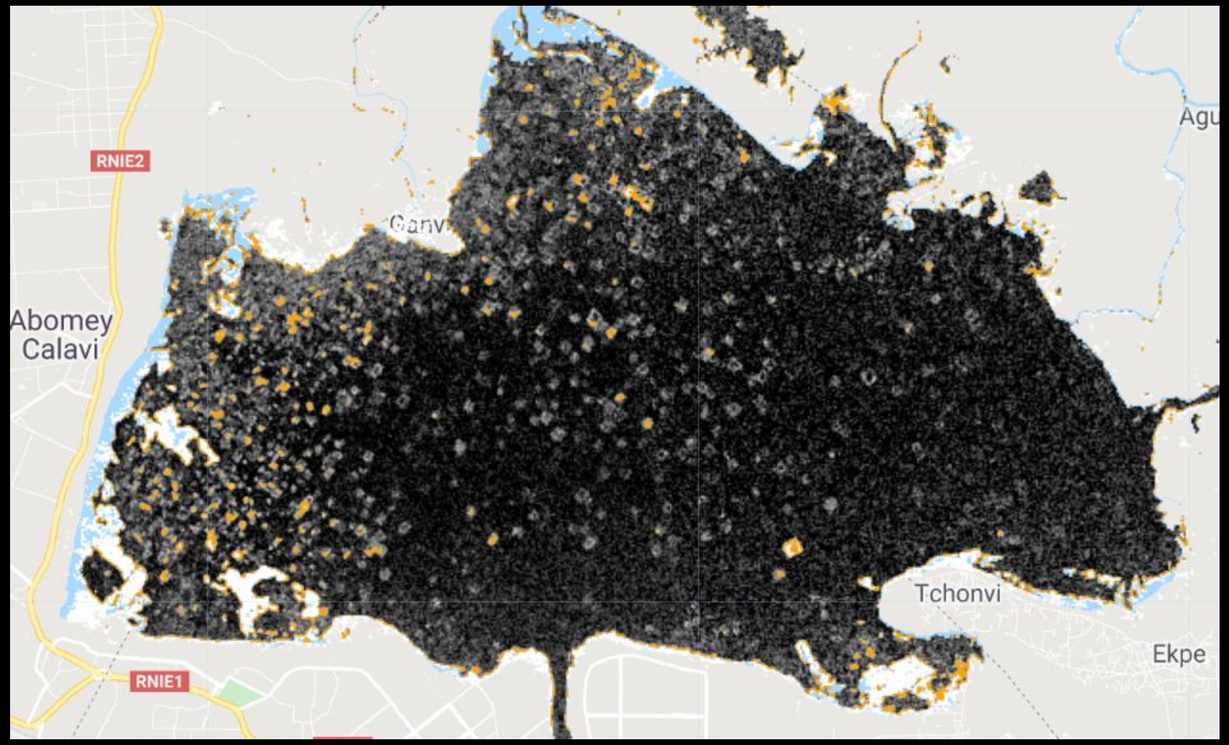
CS3: Invasive Plant Management on Lake Nokoué



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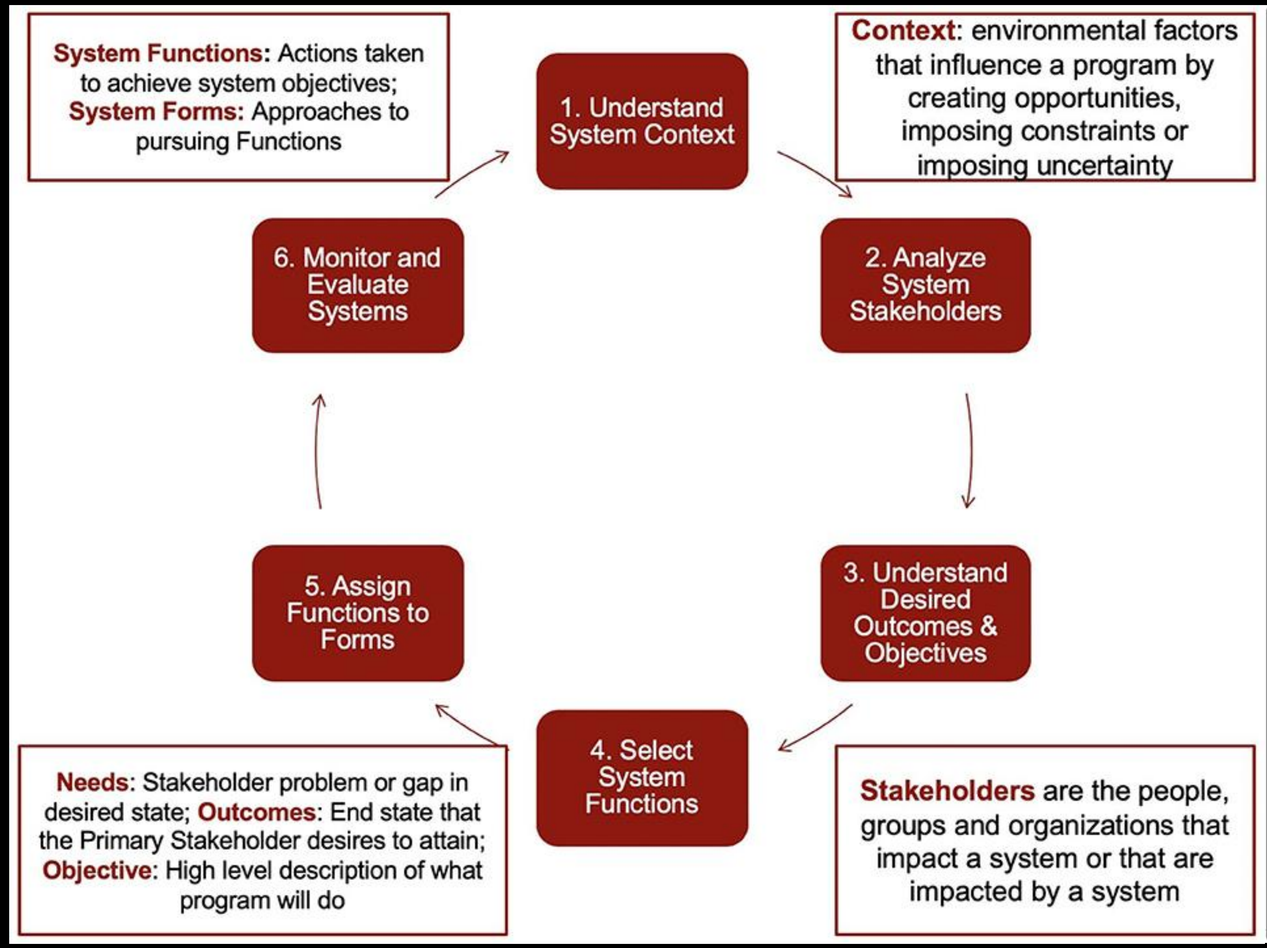
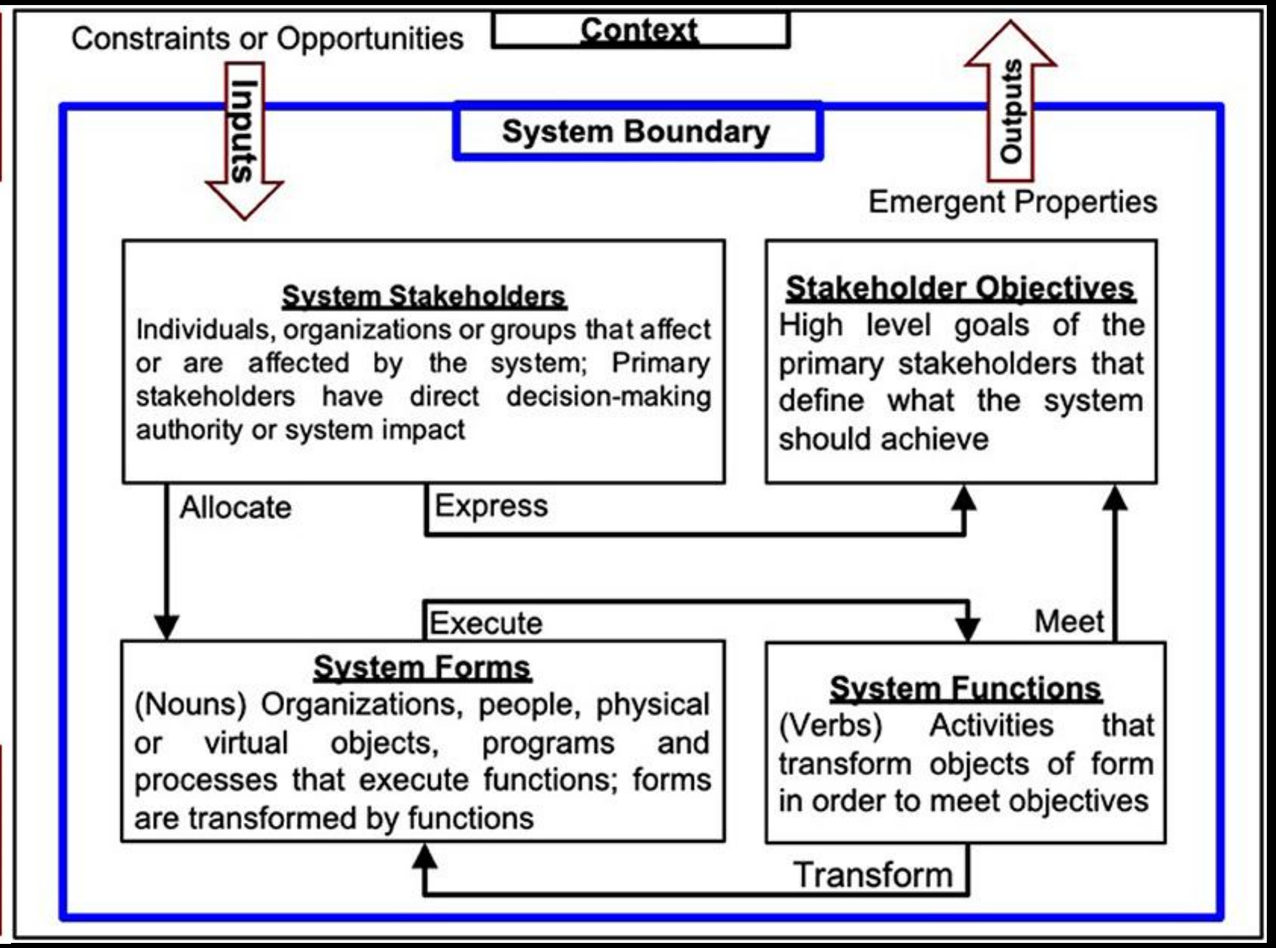
Graduate Student, MIT Media Lab
Space Enabled research group

1) Systems Architecture Framework (SAF)





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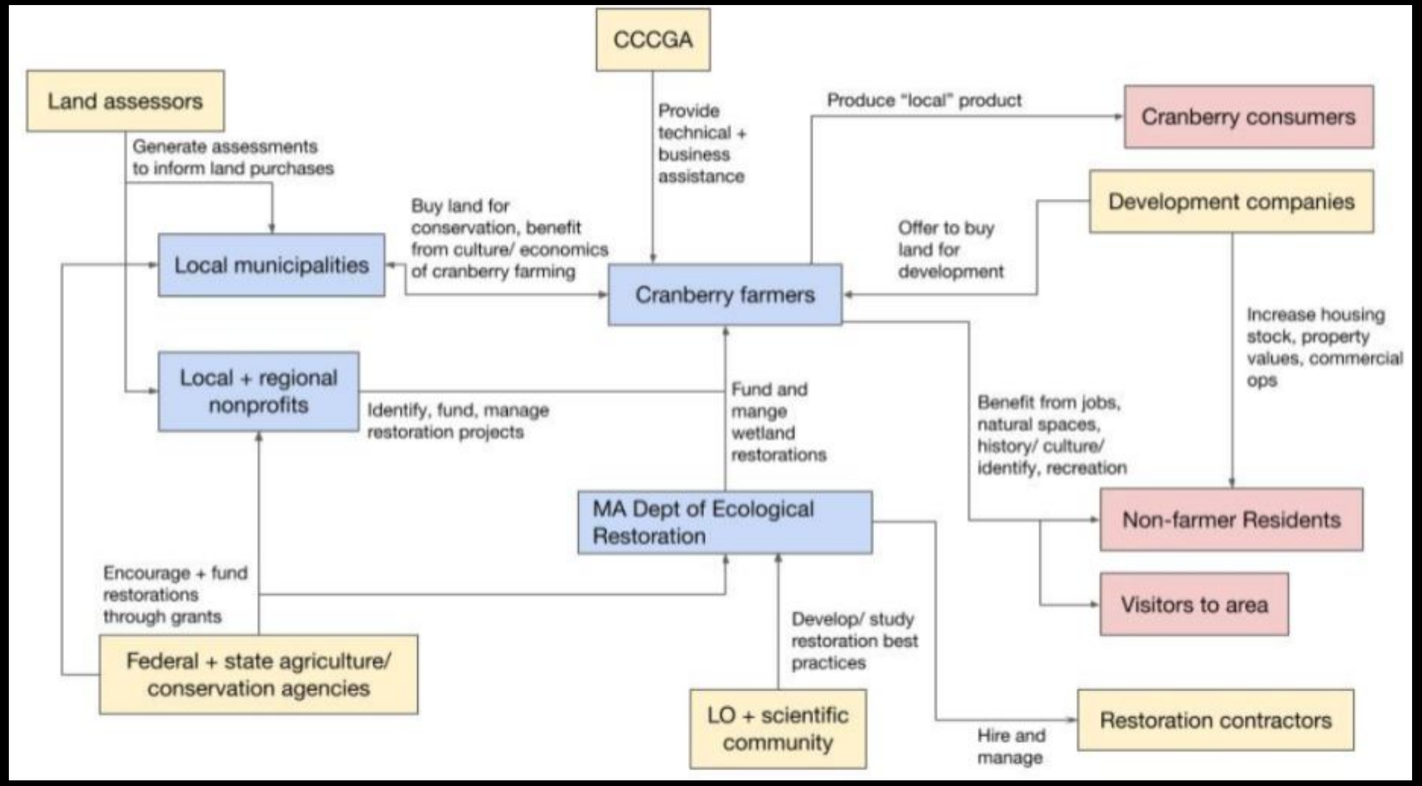
Graduate Student, MIT Media Lab
Space Enabled research group

1) Systems Architecture Framework (SAF)



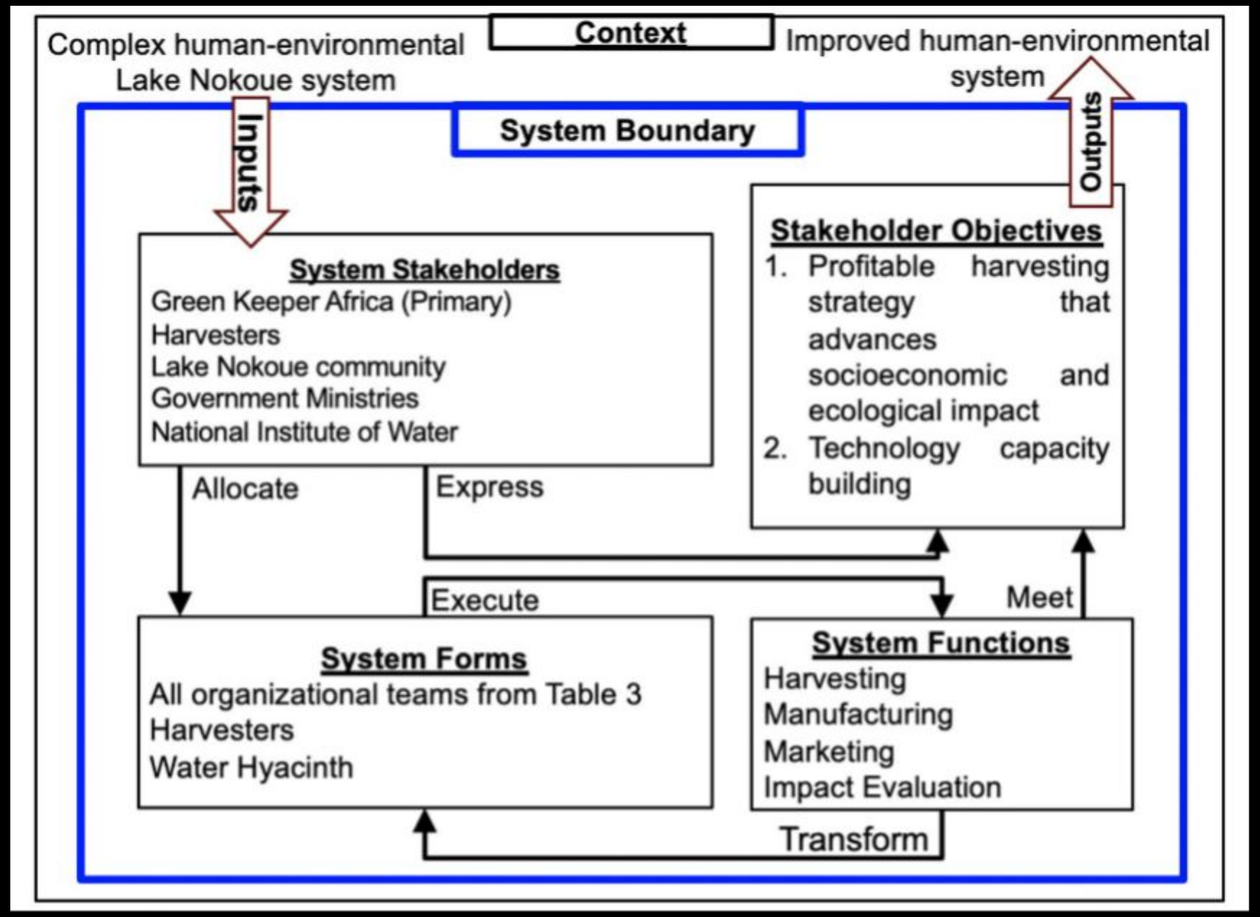
Stakeholder Category	Stakeholder Name	Stakeholder Organization
Academic	Dr. Muhammad Helmi	Universitas Diponegoro
	Dr. Joga D. Setiawan	
Local Goverment	Ibu Anita Heru	Pekalongan City Regional Development and Planning Agency
	Mr. Slamet Miftakhudin	
NGO	Mr. Arif Gandapurnama	Mercy Corps
	Ibu Henni Hendarti	Deltares
	Mr. Aji Abimayu	Kemitraan

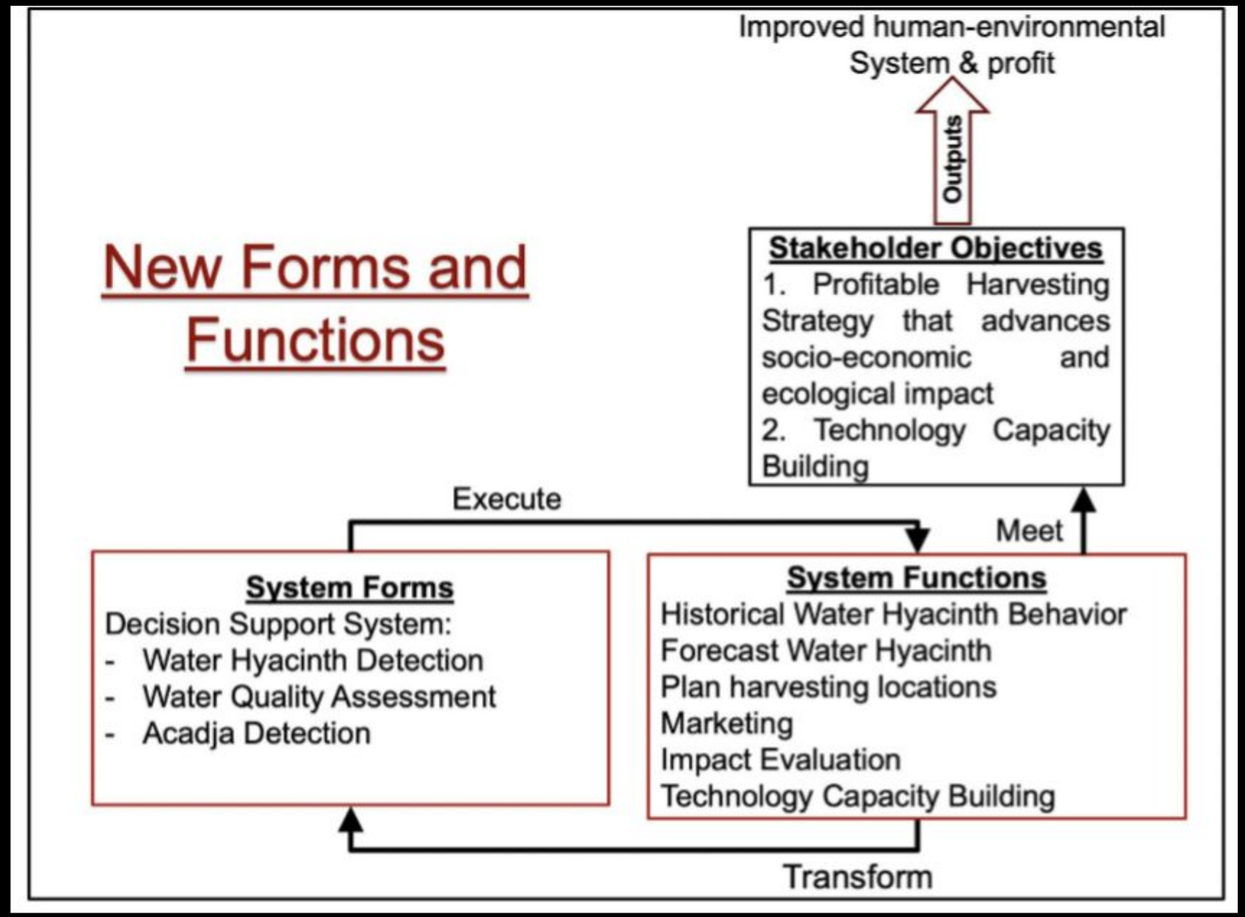
	Primary	Secondary	Tertiary
Description	those that make direct decisions about the design of the system	those that have influence on the Primary Stakeholders via authority or funding	those that exert little or no control over the system but are impacted by it
Stakeholders	• Green Keeper Africa	• National Institute of Water • GKA investors • Benin government ministries	• People who participate in Fishing or Acadja practices • GKA harvesters • Lake Nokoue community and surrounding cities

Stakeholders are described as Primary, Secondary, and Tertiary.

Jack Reid
Graduate Student, MIT Media Lab
Space Enabled research group

1) Systems Architecture Framework (SAF)



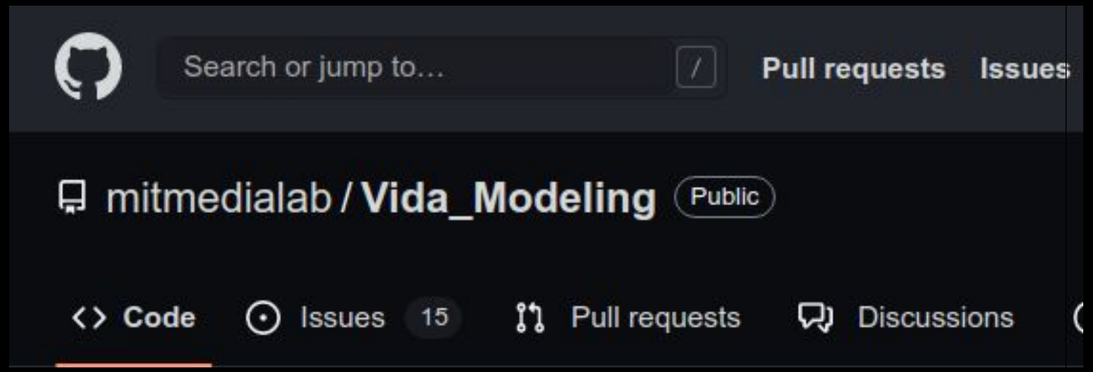


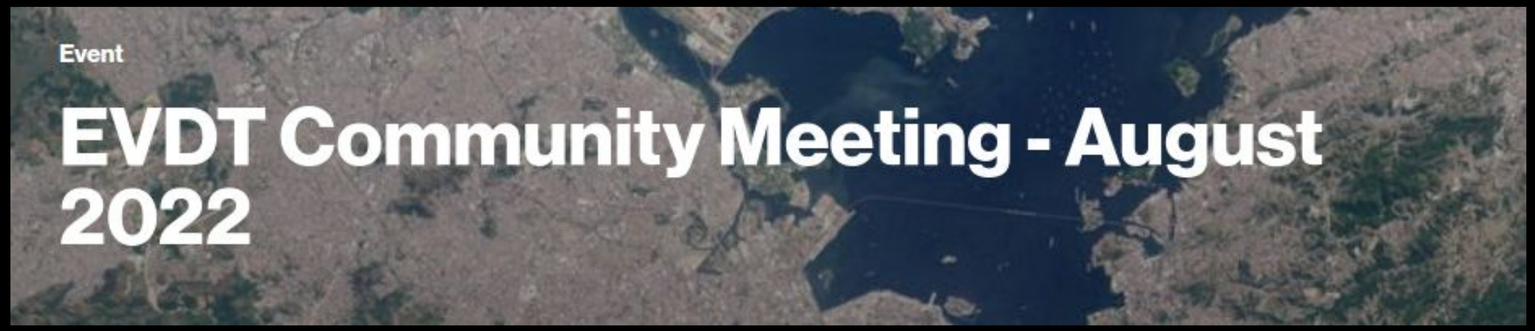
Jack Reid

Graduate Student, MIT Media Lab
Space Enabled research group

2) Collaborative Development

- Online code repositories
- Remote community meetings
- In-person collaborative work





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Graduate Student, MIT Media Lab
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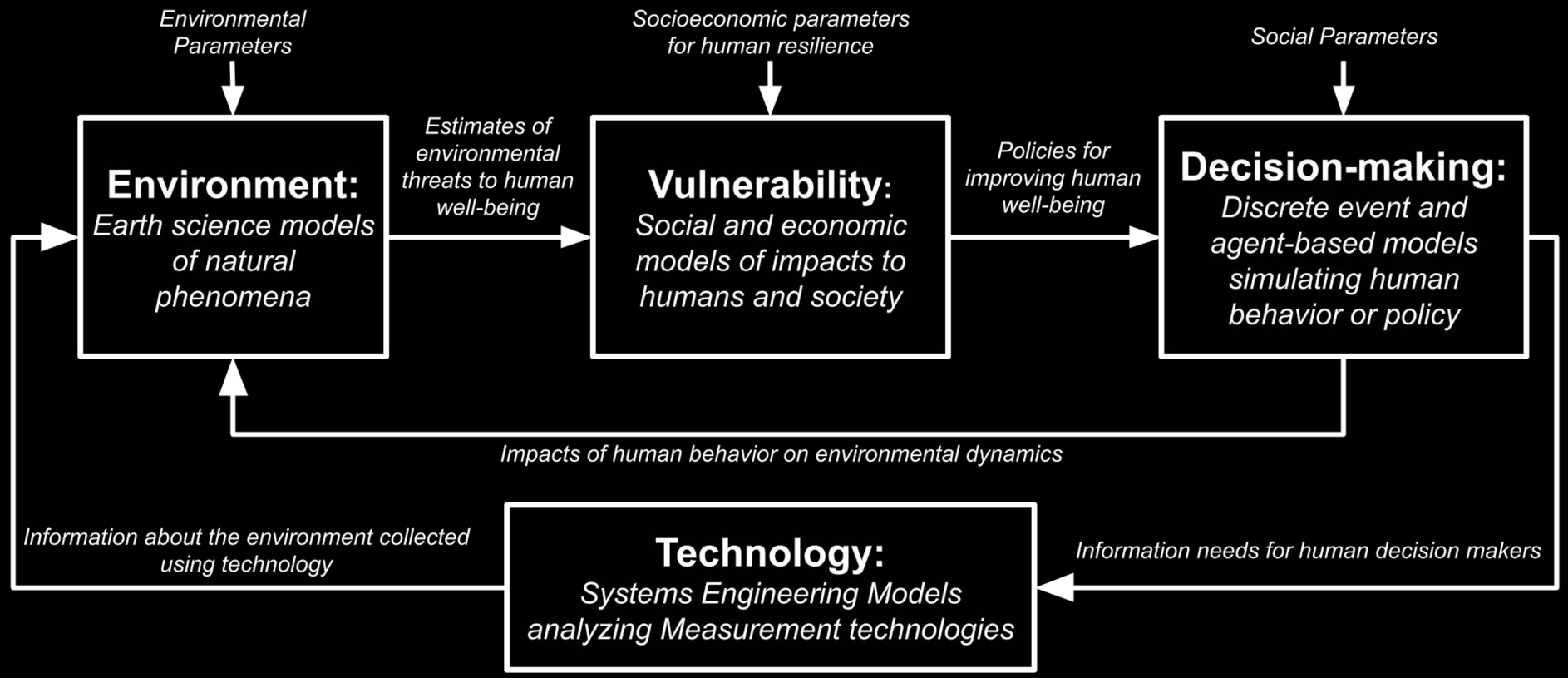
3) EVDT



- What is happening in **the natural environment**?
- How will **humans be impacted** by what is happening in the natural environment?
- What **decisions are humans making** in response to environmental factors and why?
- What **technology system** can be designed to provide high quality information that supports human decision making?

Jack Reid

Graduate Student, MIT Media Lab
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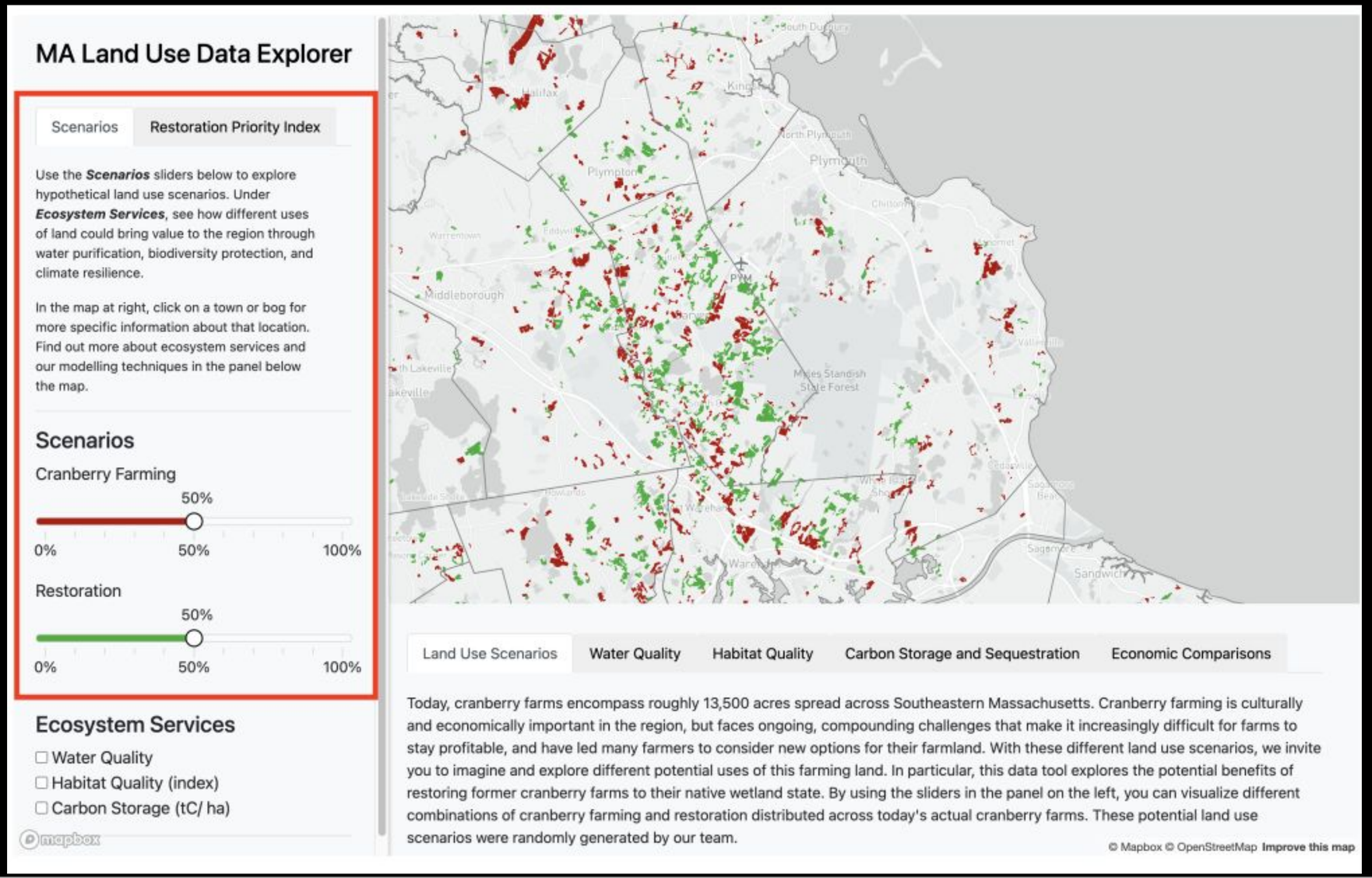
4) Interactive DSS - CS 1 Cranberry Bogs



Jack Reid

Graduate Student, MIT Media Lab
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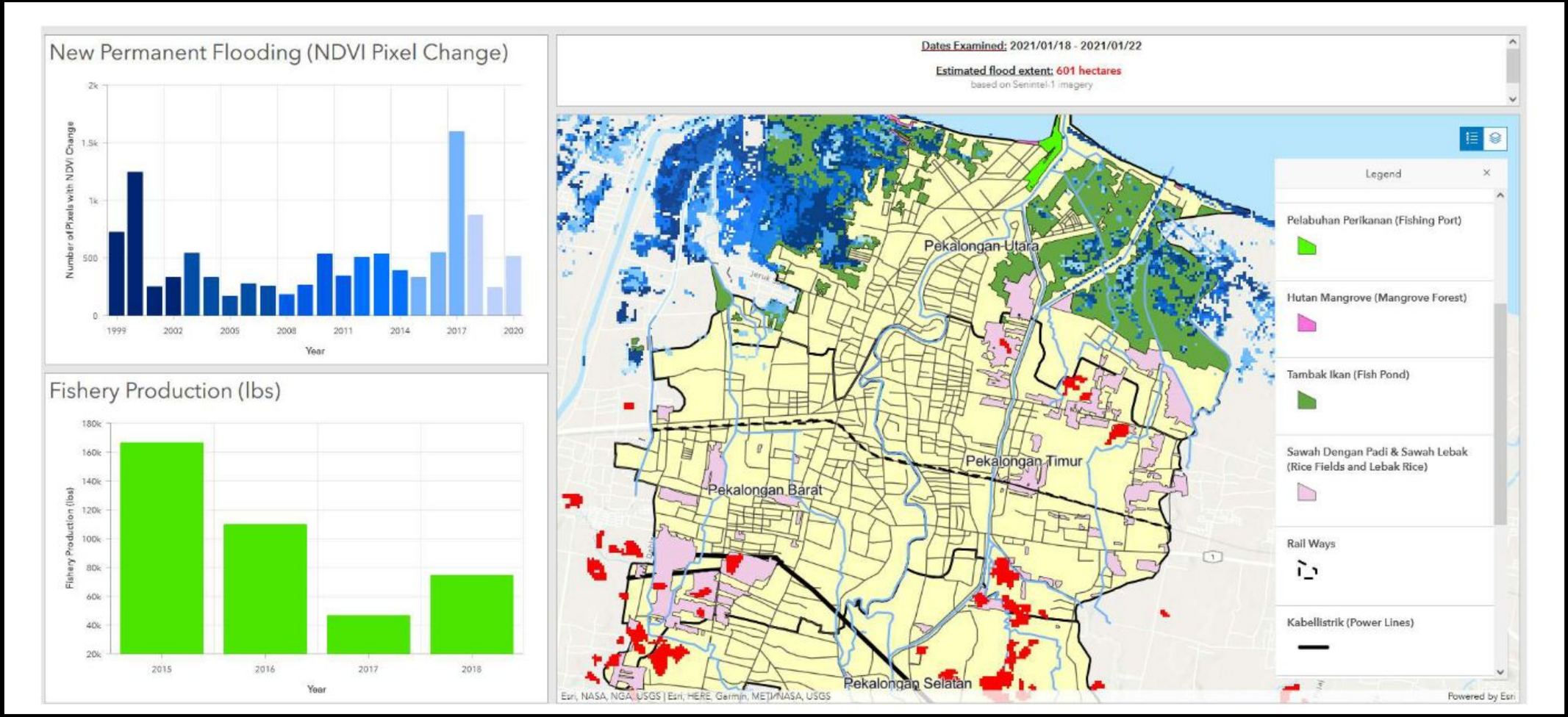
4) Interactive DSS - CS2 Pekalongan Flooding



Jack Reid

Graduate Student, MIT Media Lab
Space Enabled research group

5) Reuse & Capacity Building

- Building off the collaborative development process
- Tutorial sessions
- Direct code reuse
- Significant more work required

Jack Reid

Graduate Student, MIT Media Lab
Space Enabled research group

Intended Applications & User Types

- Geographics scale: Municipality to small province
- Temporal scale: Months to decades
- Potential Uses
  - Inform sustainable development policies
  - Educate on connections between EVDT domains
  - Facilitate comparison of remote sensing data products
  - Facilitate evaluation of new sensing technology architectures
  - Facilitate scientific research on ecosystem services and environmental impacts
  - Provide a basis for DSS effectiveness studies

Jack Reid

Graduate Student, MIT Media Lab
Space Enabled research group

Ongoing Efforts

- Develop a robust and reusable code base
- Put in place a solid development pipeline
- Expand participatory access
- Conduct critical evaluations of the framework and individual applications

Jack Reid

Graduate Student, MIT Media Lab
Space Enabled research group

Project Page:

https://www.media.mit.edu/events/evdt-community-meeting-june-2022/

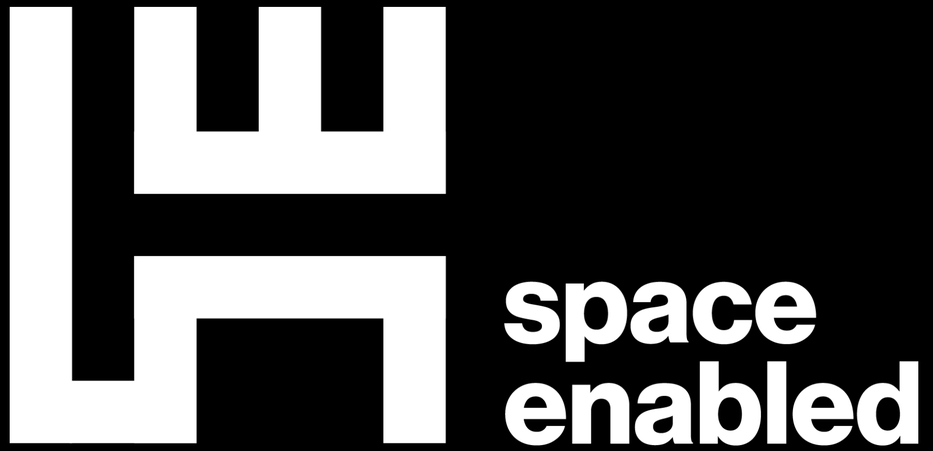
Contact Information:

jackreid@mit.edu

https://twitter.com/Jack_B_Reid

Acknowledgements:

All of our collaborators



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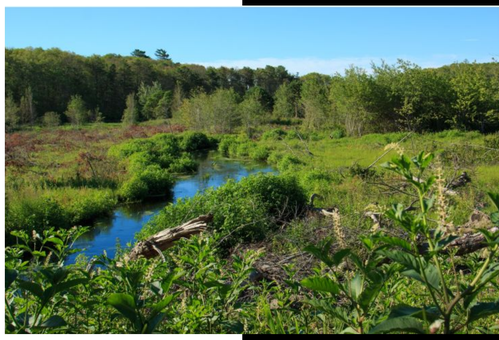
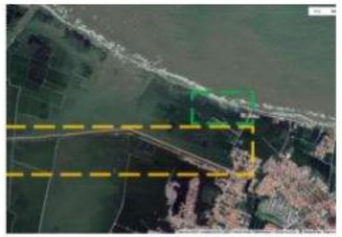


CS2: Pekalongan Coastal Flooding and Subsidence

Satellite remote sensing data, local ground and aerial data, and existing climate model results

Socioeconomic data from local communities such as land use change, loss of economic activity, and property damage

Policy Constraints & Opportunities such as funding and coordination across agencies and government levels



Environment: *Remote sensing analyses of flooding and mangroves, hydrological modeling of flood inundation*

Environmental dynamics

Vulnerability: *Integrated visualizations of environmental and socioeconomic data, vulnerability index modeling*

Environmental dynamics and estimates of socio economic impact

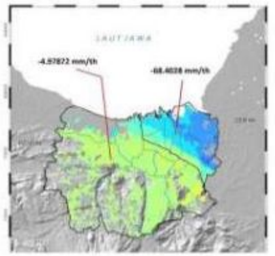
Decision-making: *Evaluation of different flood mitigation interventions and policies via risk index modeling*

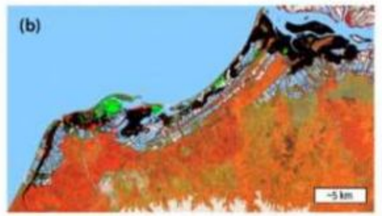
Policy actions related to coastal resilience such as mangrove planting or seawalls

Technology: *Observation and Warning System Design Model*

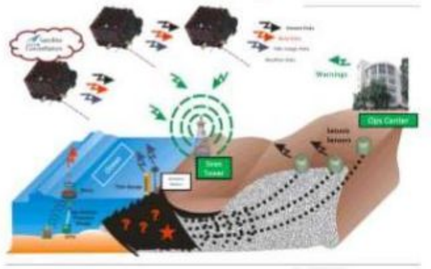
Capabilities for improved flood and mangrove monitoring as well as flood risk warnings

Data gaps identified for flooding and mangrove monitoring

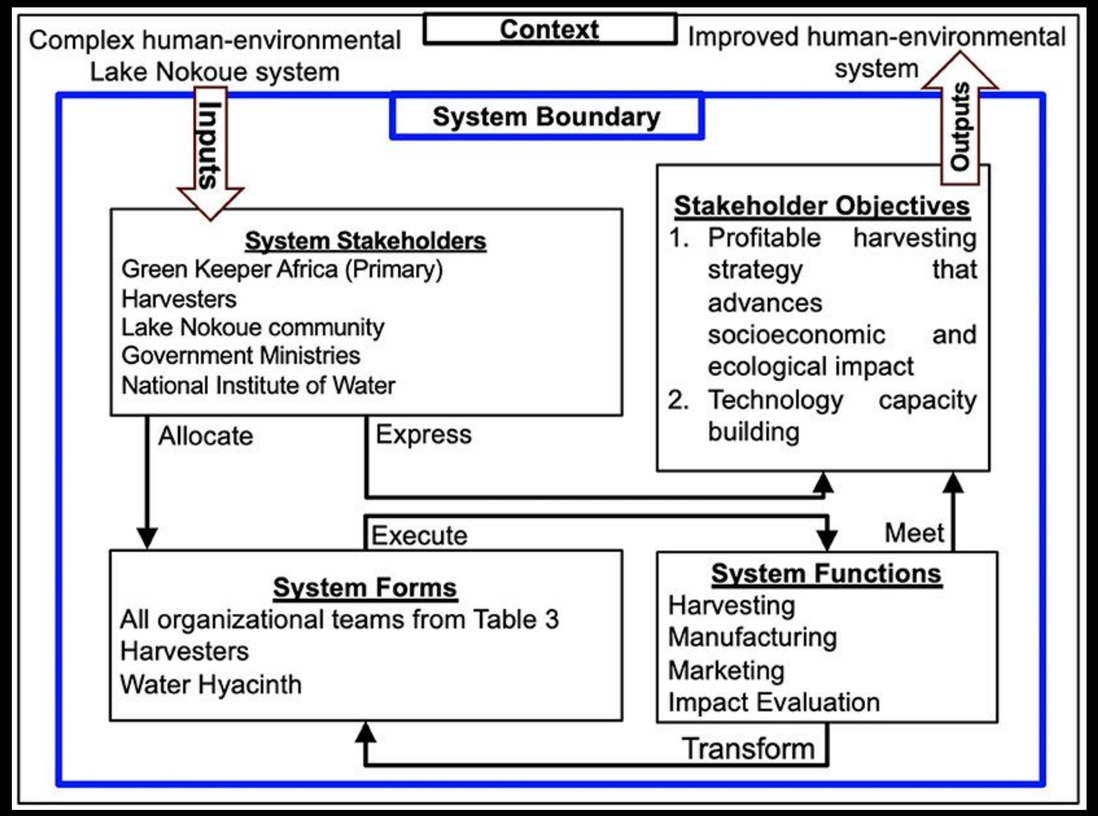




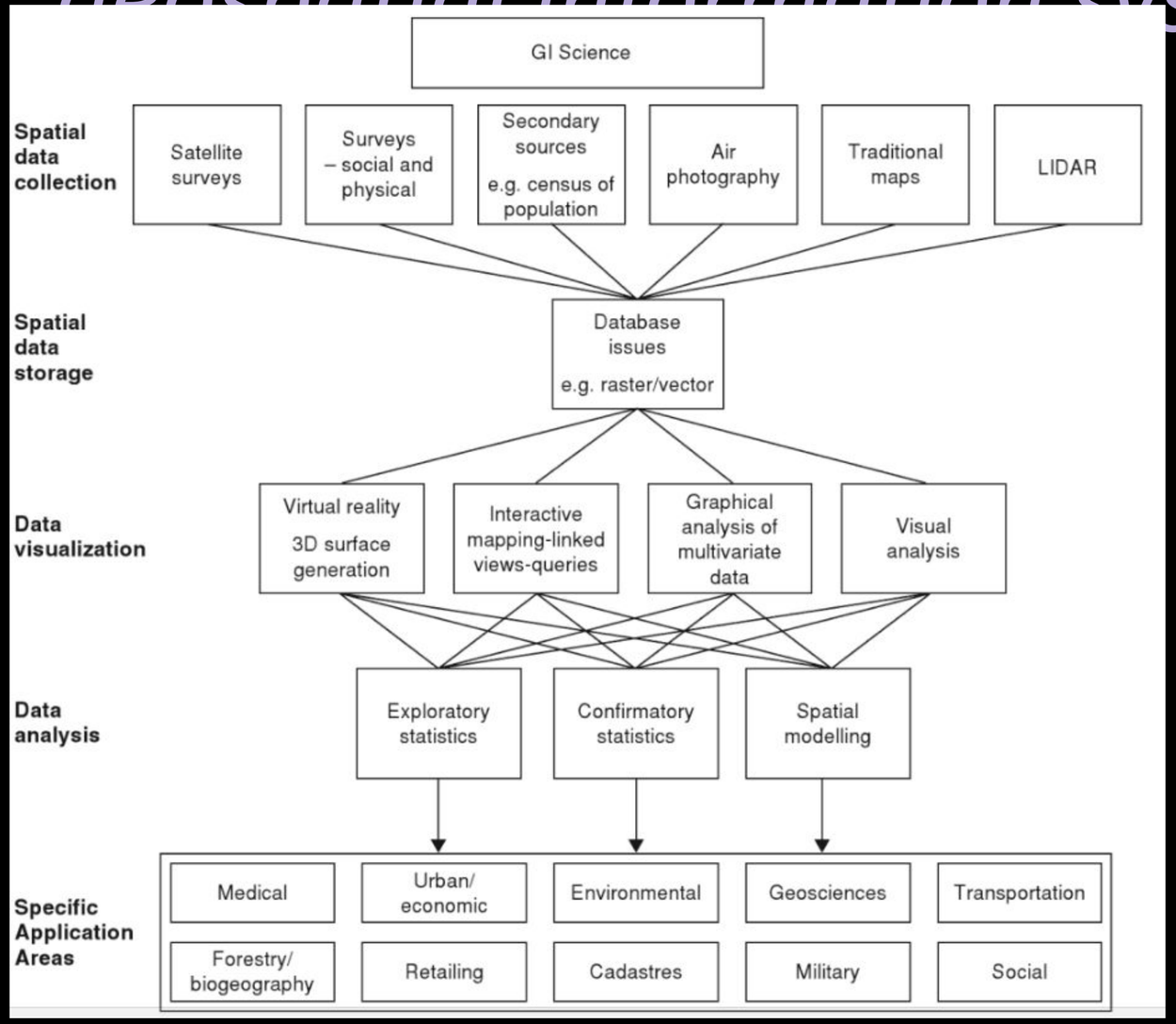
Mangrove Extent Change 2000-2016



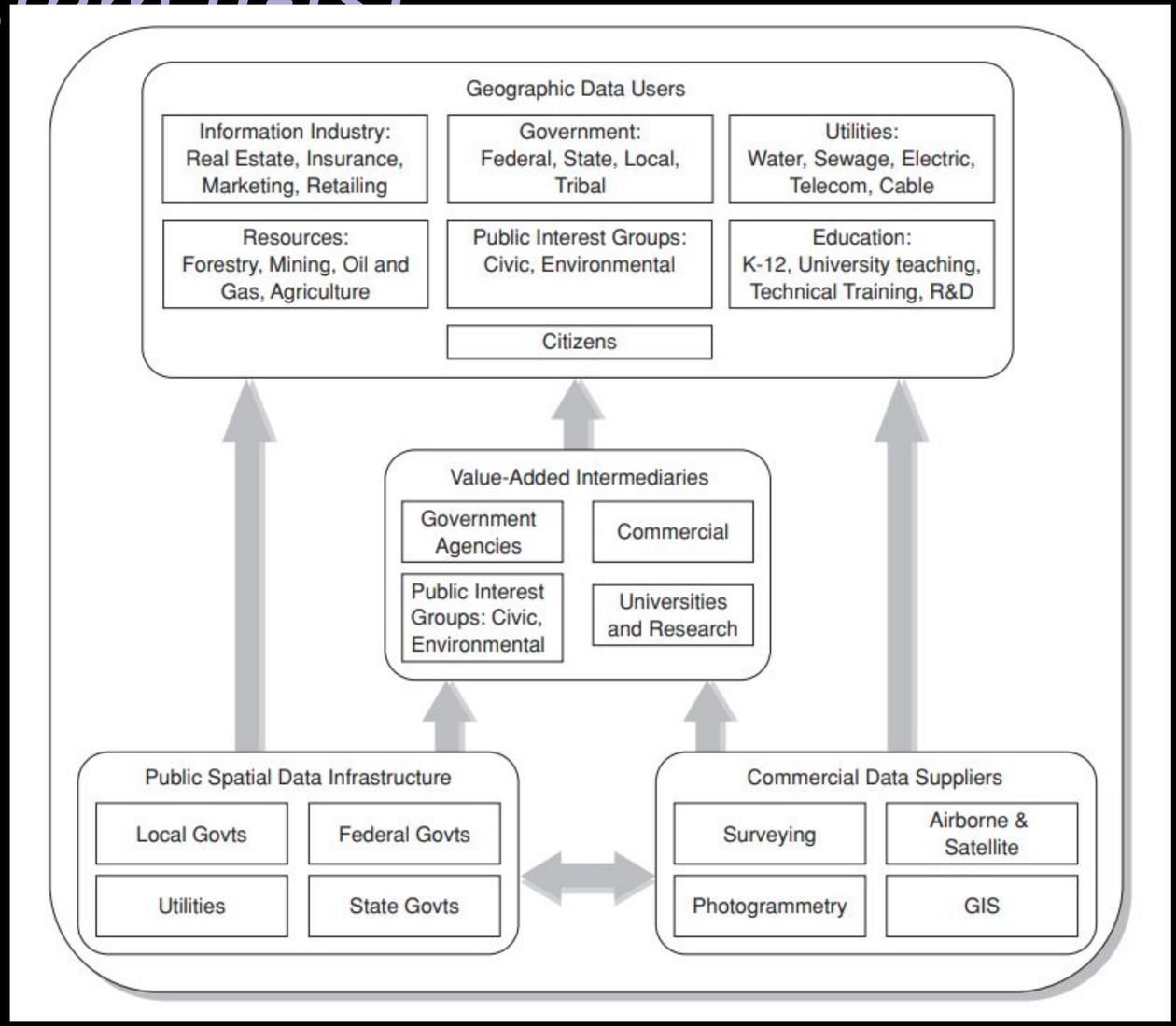
CS3: Invasive Plant Management on Lake Nokoué



geospatial information system (GIS)



Fotheringham, A. Stewart, and John P. Wilson. "Geographic Information Science: An Introduction." *The Handbook of Geographic Information Science*, John Wiley & Sons, Ltd, 2007, pp. 1–7.

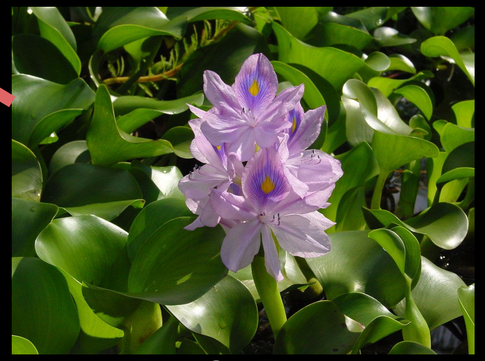


Cowen, David J. "The Availability of Geographic Data: The Current Technical and Institutional Environment." *The Handbook of Geographic Information* Science, John Wiley & Sons, Ltd, 2007, pp. 11–34.

Some Pre-Pandemic EVDT Applications

Mining in Ghana

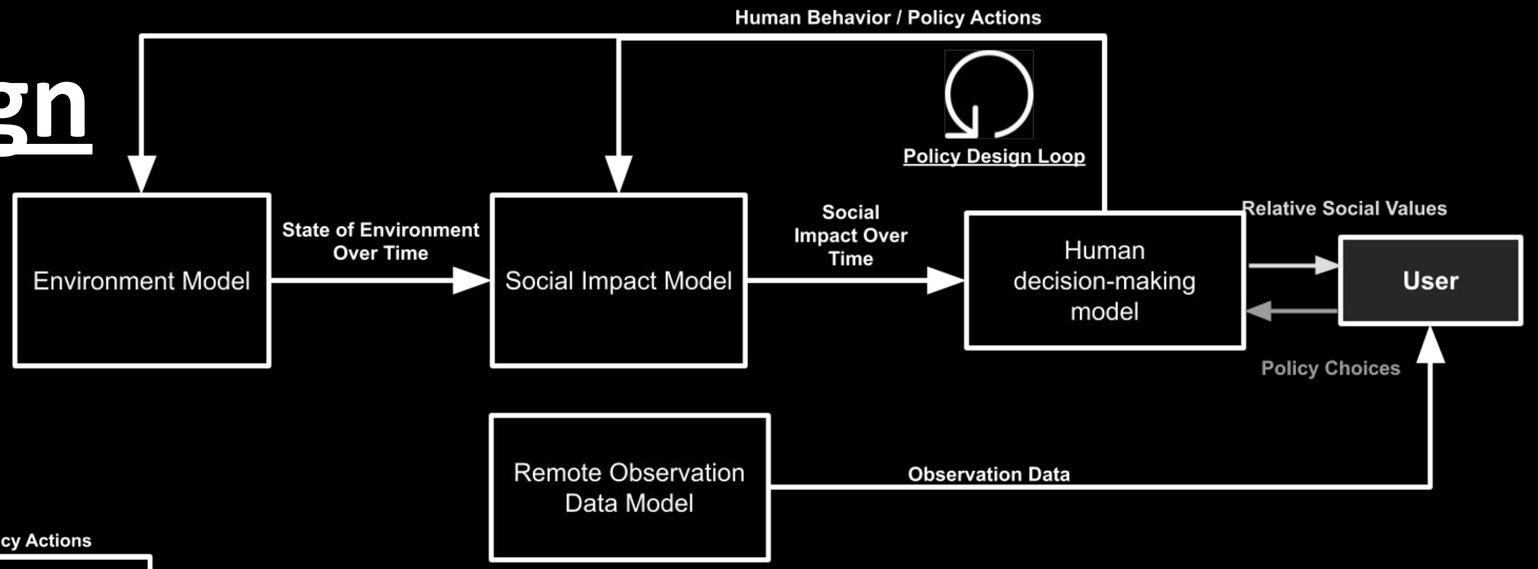
Mangroves in Rio de Janeiro

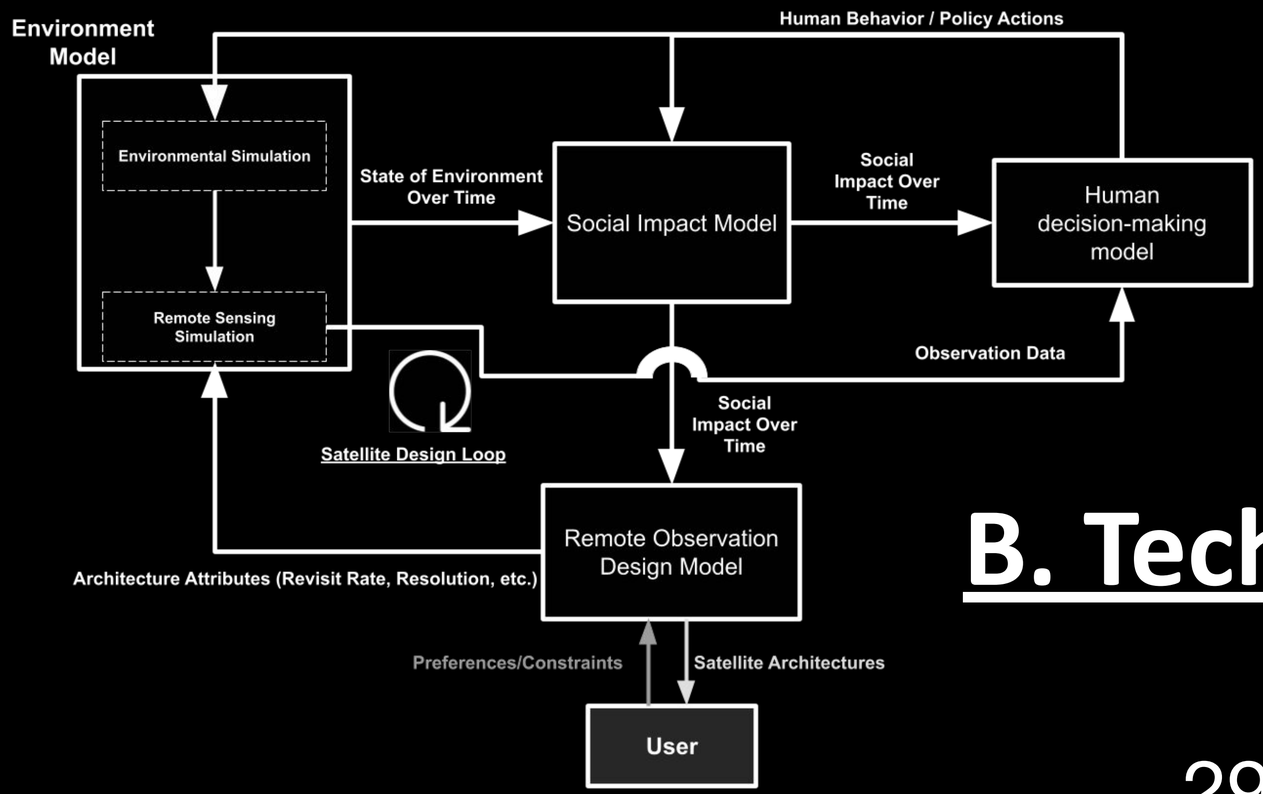


Water Hyacinth in Benin

Map adapted from the Nations Online Project.

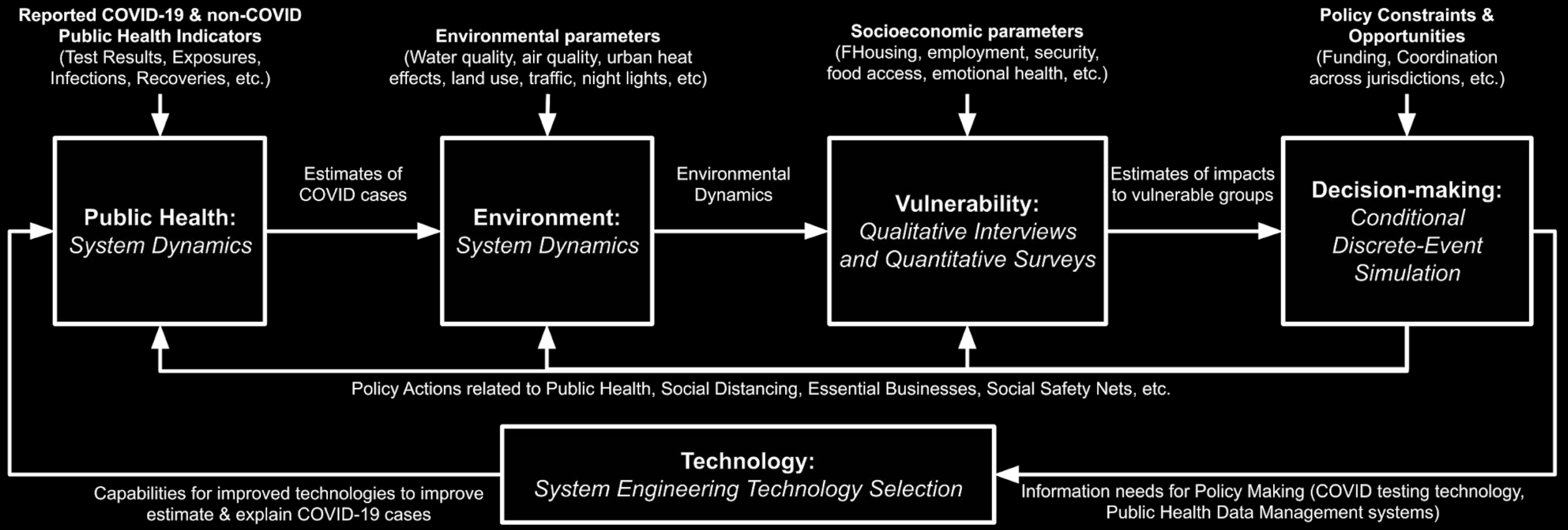
A. Policy Design



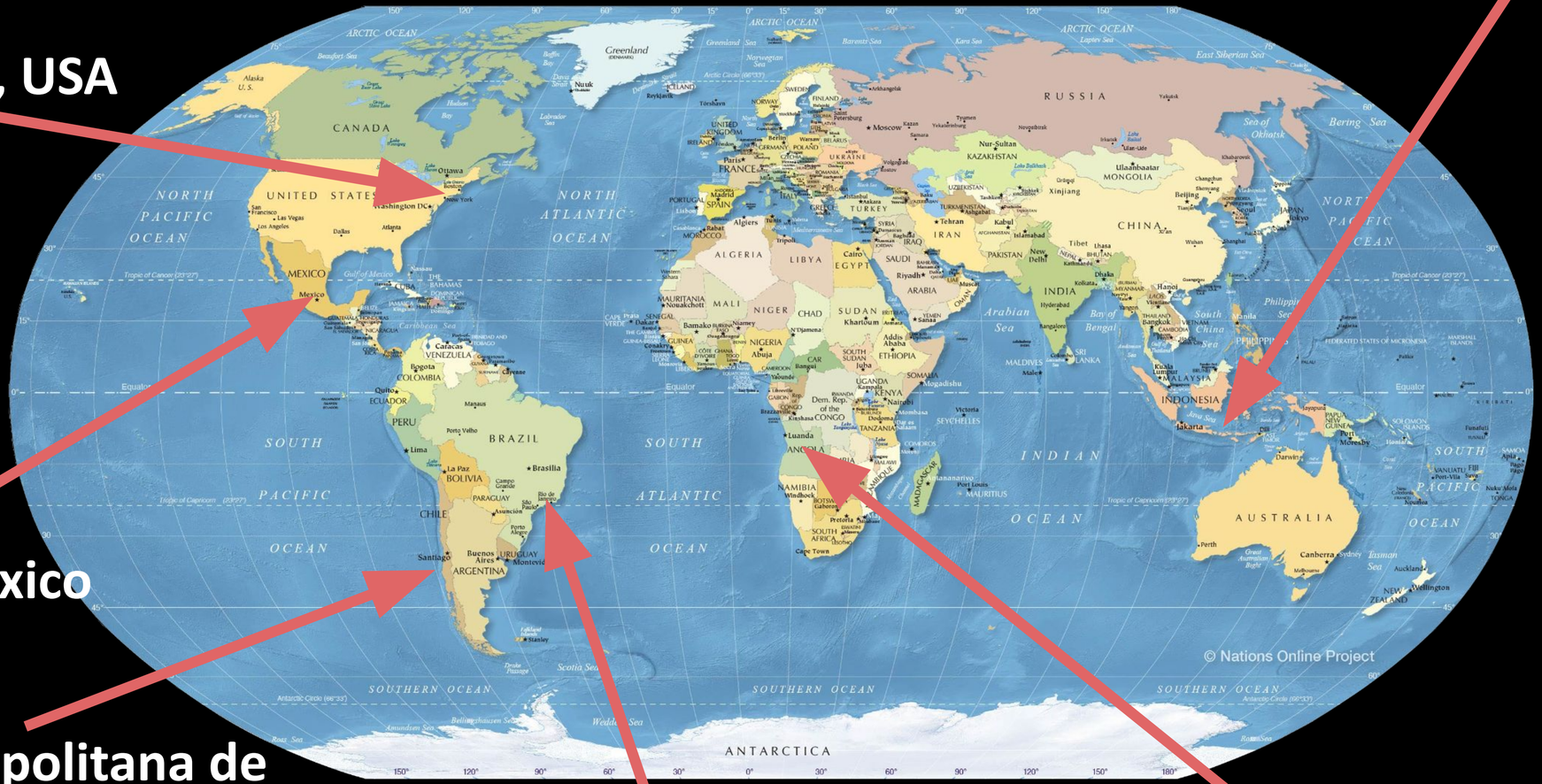


B. Technology Design

Vida Decision Support System



Vida DSS International Network



Java & Sulawesi, Indonesia

Boston, USA

Querétaro, México

Región Metropolitana de Santiago, Chile

Rio de Janeiro, Brasil

Luanda, Angola

Map adapted from the Nations Online Project.

Brasil

México

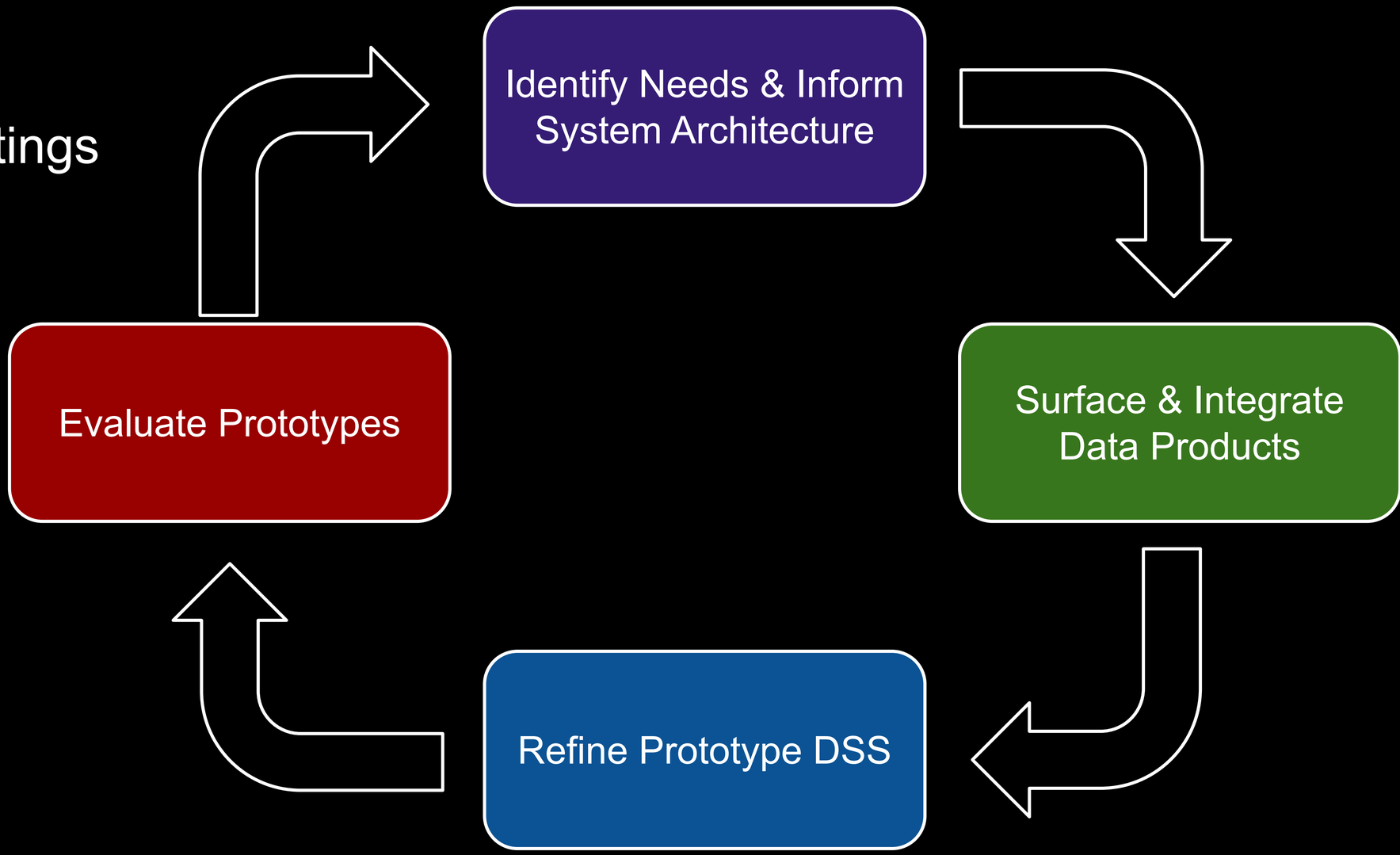
Indonesia

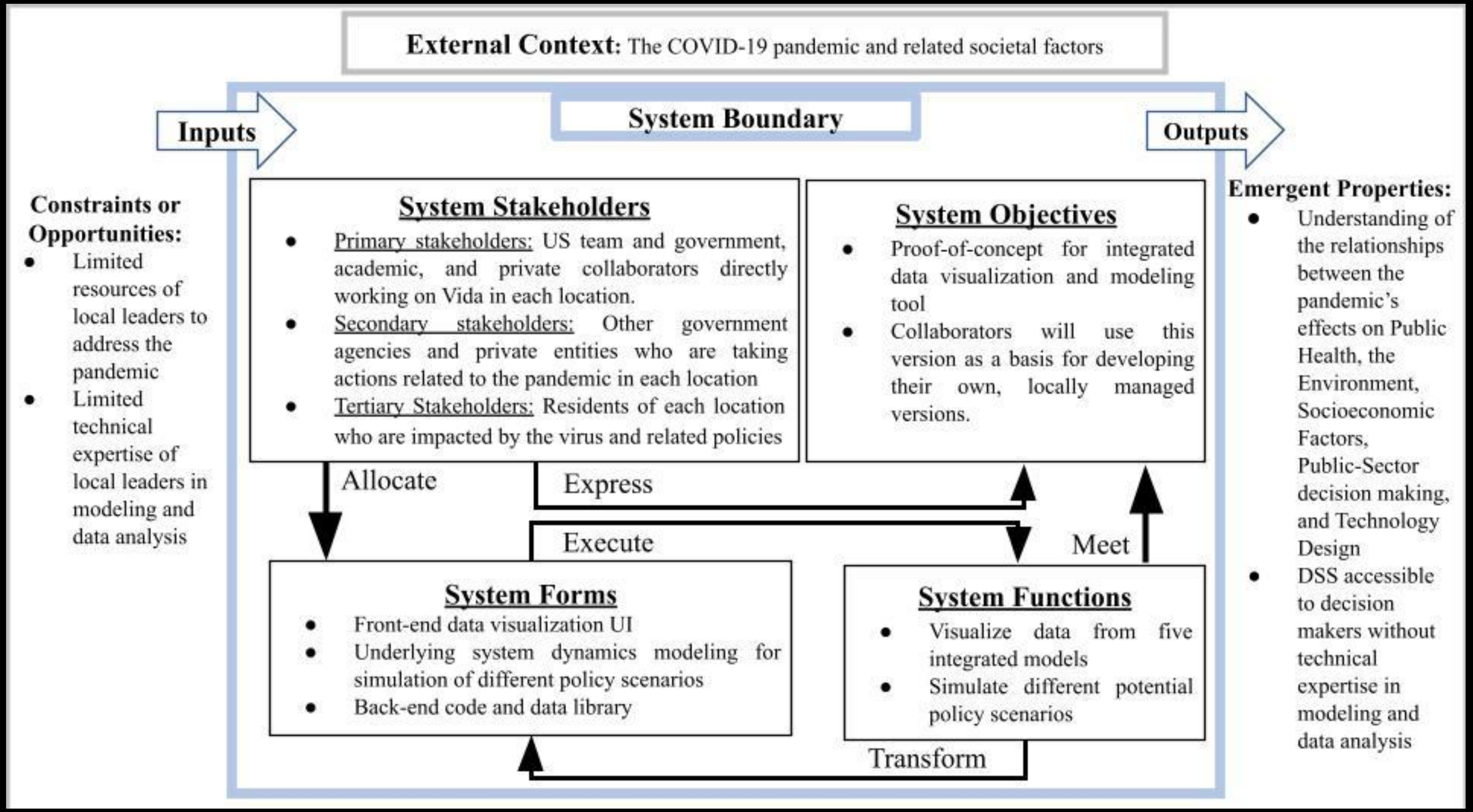
Chile

Angola

Stakeholder Involvement

- Weekly/Biweekly 1-on-1 meetings
- Monthly full network meetings
- Online collaboration
  - Data Repositories
  - Github
  - Browser-based DSS




External Context: The COVID-19 pandemic and related societal factors
Inputs
System Boundary
Outputs
Constraints or Opportunities:
Limited resources of local leaders to address the pandemic
Limited technical expertise of local leaders in modeling and data analysis
System Stakeholders
Primary stakeholders: US team and government, academic, and private collaborators directly working on Vida in each location.
Secondary stakeholders: Other government agencies and private entities who are taking actions related to the pandemic in each location
Tertiary Stakeholders: Residents of each location who are impacted by the virus and related policies
System Objectives
Proof-of-concept for integrated data visualization and modeling tool
Collaborators will use this version as a basis for developing their own, locally managed versions.
Allocate
Express
Execute
Meet
System Forms
Front-end data visualization UI
Underlying system dynamics modeling for simulation of different policy scenarios
Back-end code and data library
System Functions
Visualize data from five integrated models
Simulate different potential policy scenarios
Transform
Emergent Properties:
Understanding of the relationships between the pandemic's effects on Public Health, the Environment, Socioeconomic Factors, Public-Sector decision making, and Technology Design
DSS accessible to decision makers without technical expertise in modeling and data analysis