Scaling adaptation of urban water with connected, decentralized systems

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March 28, 2023

1. Why urban water?
2. Three goals for water management
3. Three strategies for adaptation

   Identify water's interacting systems

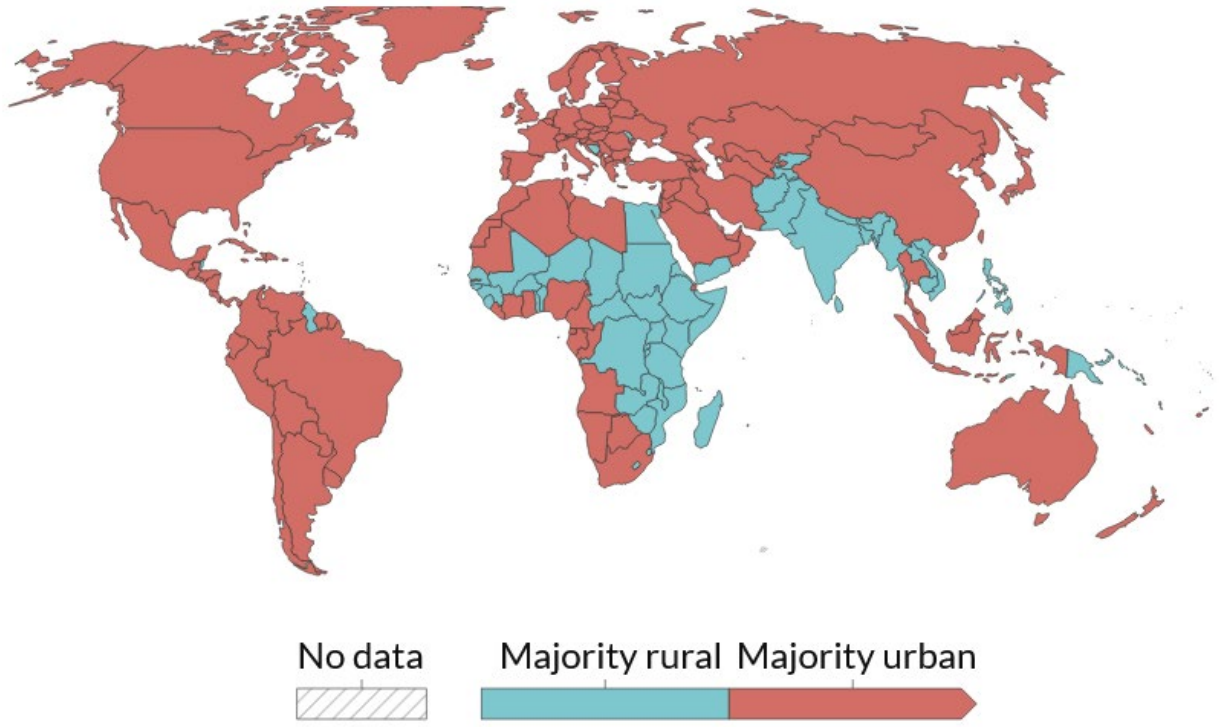
   Connect projects through systems

   Scale with decentralization

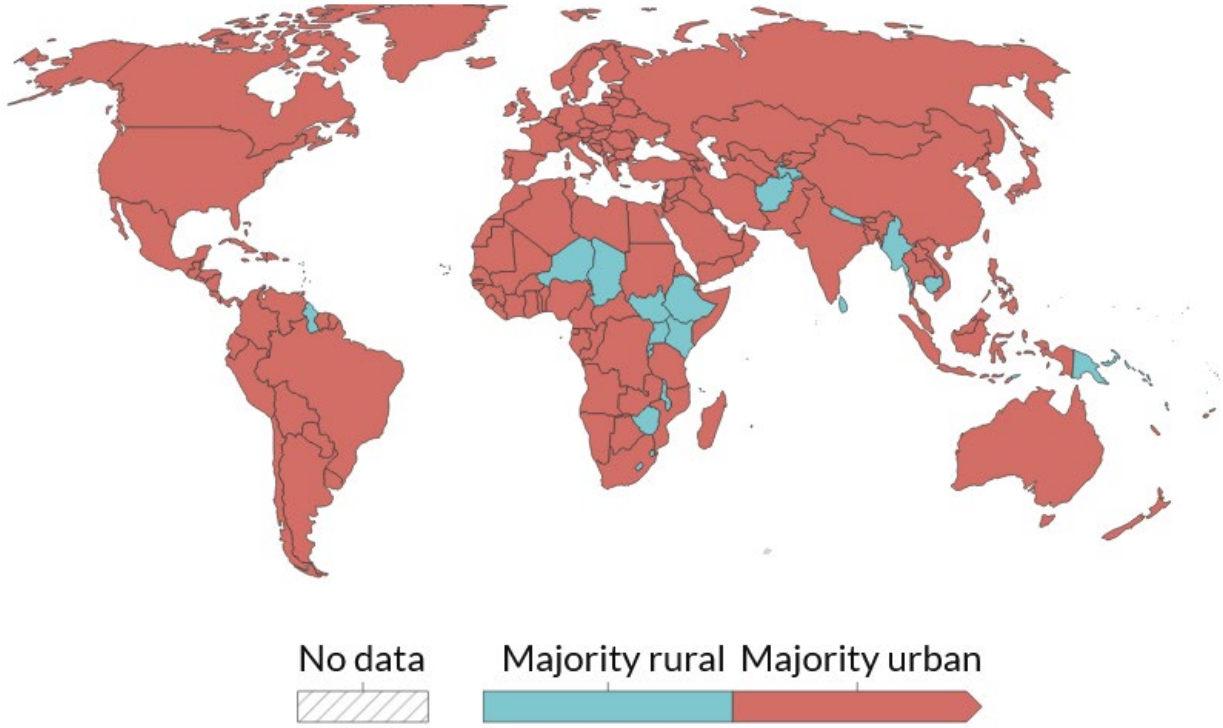
4. Can we measure how well adaptation is working?

Why urban water?

Every country is urbanizing, some are urbanizing rapidly



2020: 4 billion people in cities



2050: 7 billion people in cities

Source: https://ourworldindata.org/grapher/urban-vs-rural-majority

Water systems under pressure

- **Existing water infrastructure is under stress**
  - Systems are improperly sized and poorly maintained
  - Changing climate conditions add stress to already-stressed systems
  - Opportunity to improve existing infrastructure

- **New infrastructure is needed**
  - Necessary for health and productivity of urban residents and surrounding ecosystems
  - Opportunity to build 21st century systems, ready for population growth and climate change

Three goals for water management

Water management goals when adapting to climate change

1. **Accommodate greater variability in water supply and demand**
   - Many places in the world will experience less frequent, more intense storms (drought, flood)
   - More intense heat may increase water withdrawals
   - Exacerbated by landcover change: reducing permeability of surfaces

Water management goals when adapting to climate change

2. **Prepare for declining water quality**
   - Human activities and natural contributors are introducing contaminants
   - Increased heat may interact with contaminants, leading to non-linear degradation

Water management goals when adapting to climate change

3. **Ensure sustainable yield**
   - Each water system cannot extract more from source water than replaced
   - Not all water is the same: replacing high-quality water with more high-quality water
   - Many reports from UN Water on over extraction, "the end of water abundance"

Water management goals when adapting to climate change

1. Accommodate greater variability in water supply and demand
2. Prepare for declining water quality
3. Ensure sustainable yield

- To meet these goals, we need to build resilience and sustainability in water systems

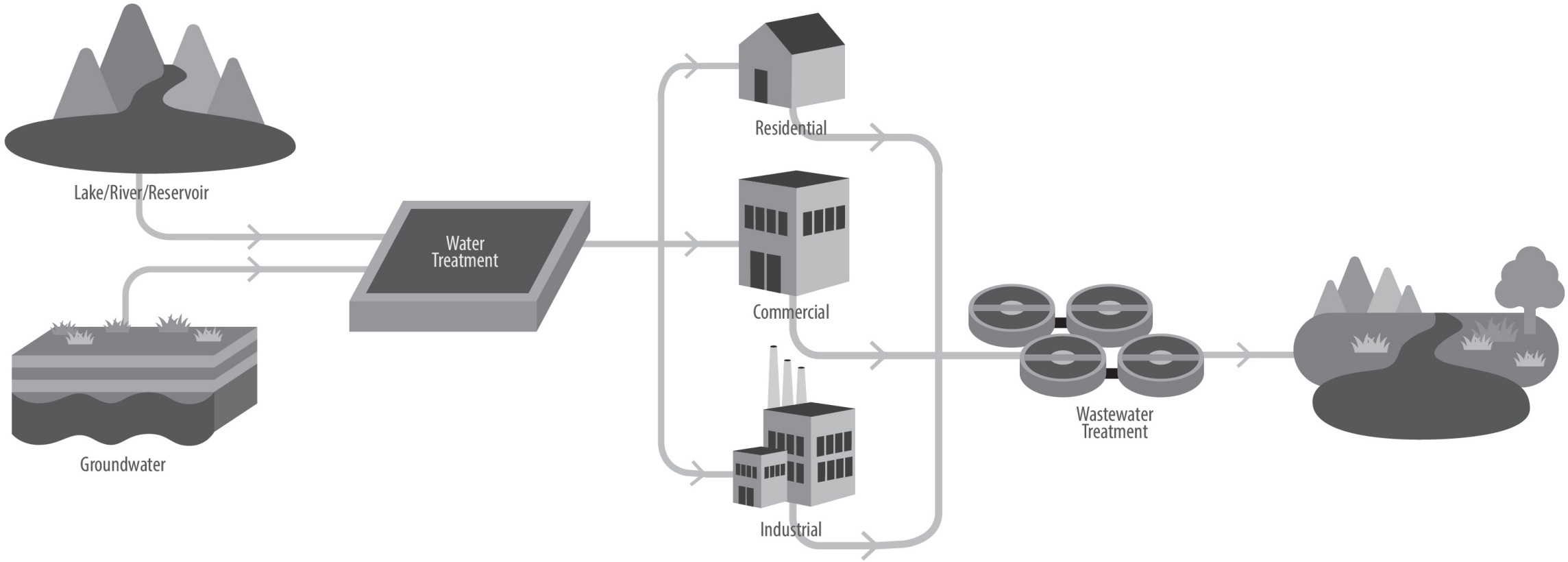
- Current methods of water management are most often:
  - Too prone to failure: cannot accommodate population growth and changing climate (changing locating and timing of water resources)
  - Too large and expensive: require high capacity and capital to execute

- How do we build more modular, flexible, affordable, and sustainable systems?

Three strategies for adaptation

1. Identify water's interacting systems

A linear understanding of urban water in common, but incomplete



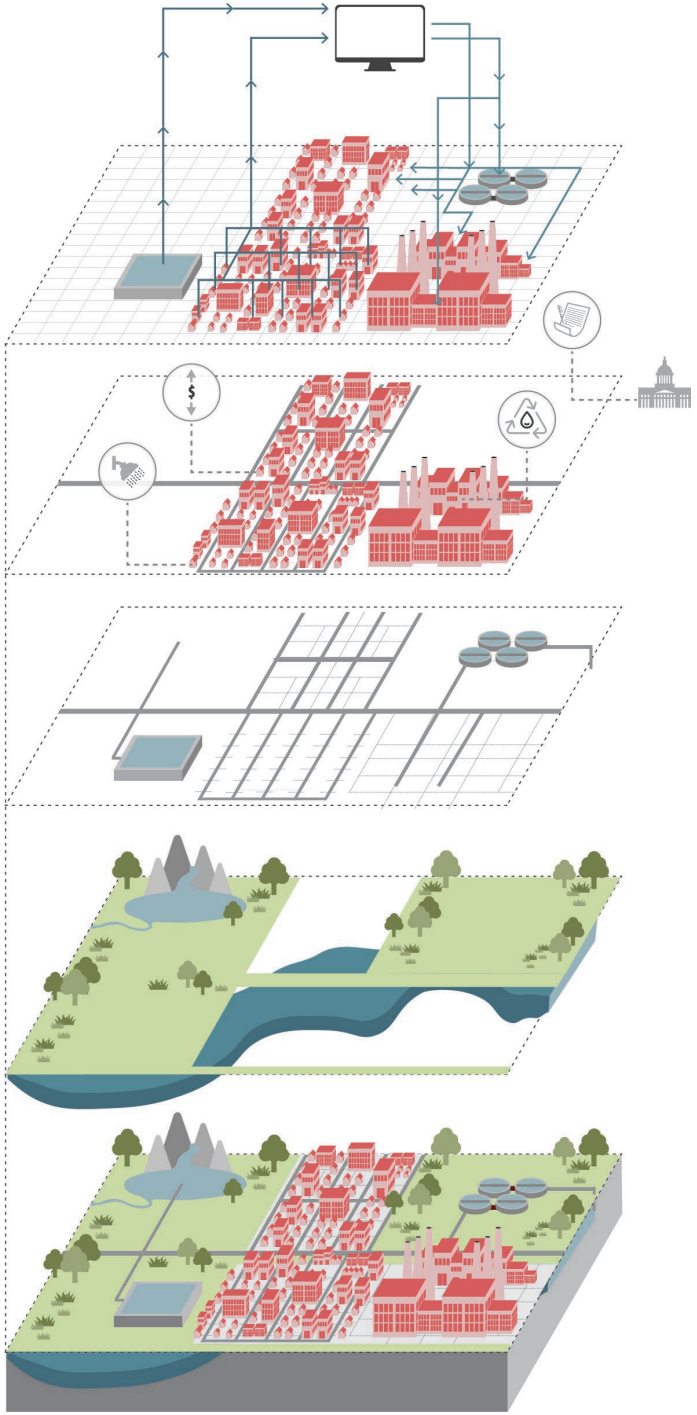
Drawn by Jing Cao and Larissa Whitney

Digital infrastructure

Social infrastructure

Physical infrastructure

Natural infrastructure



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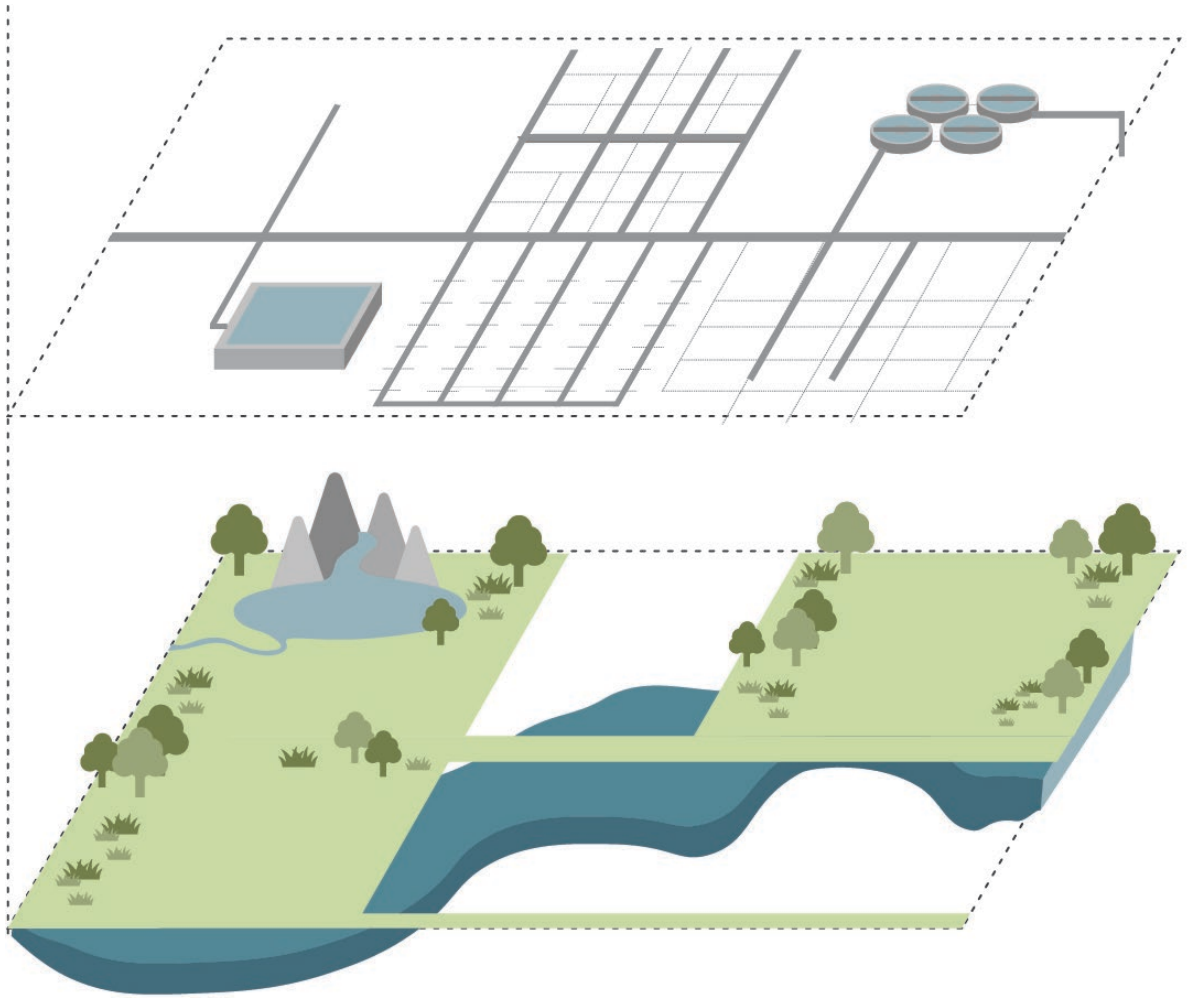
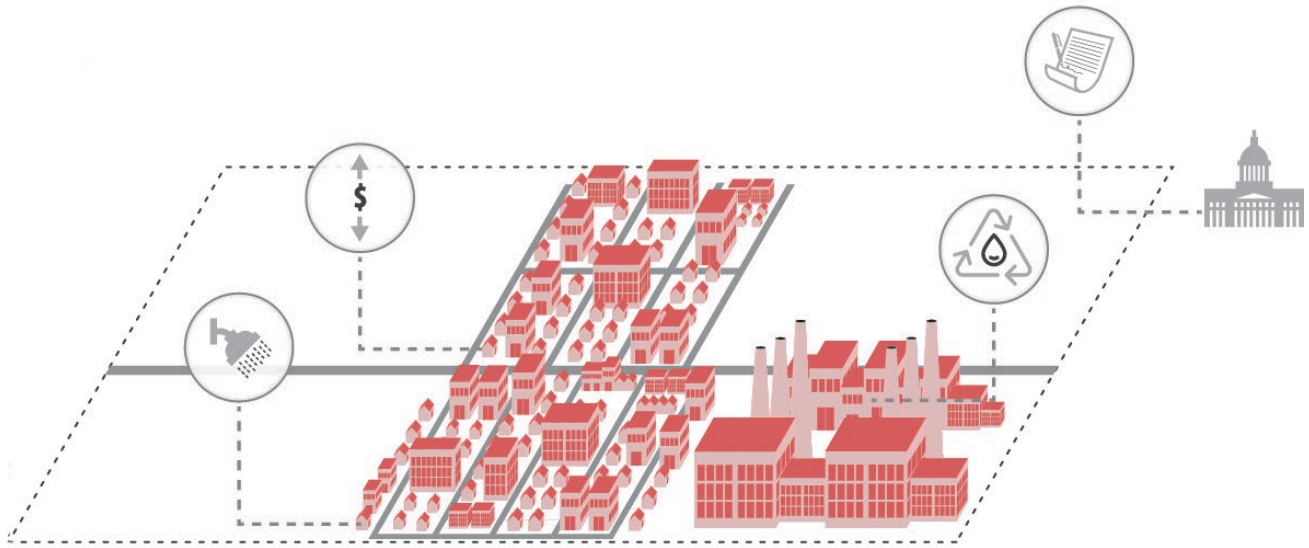
Water's physical and natural infrastructure



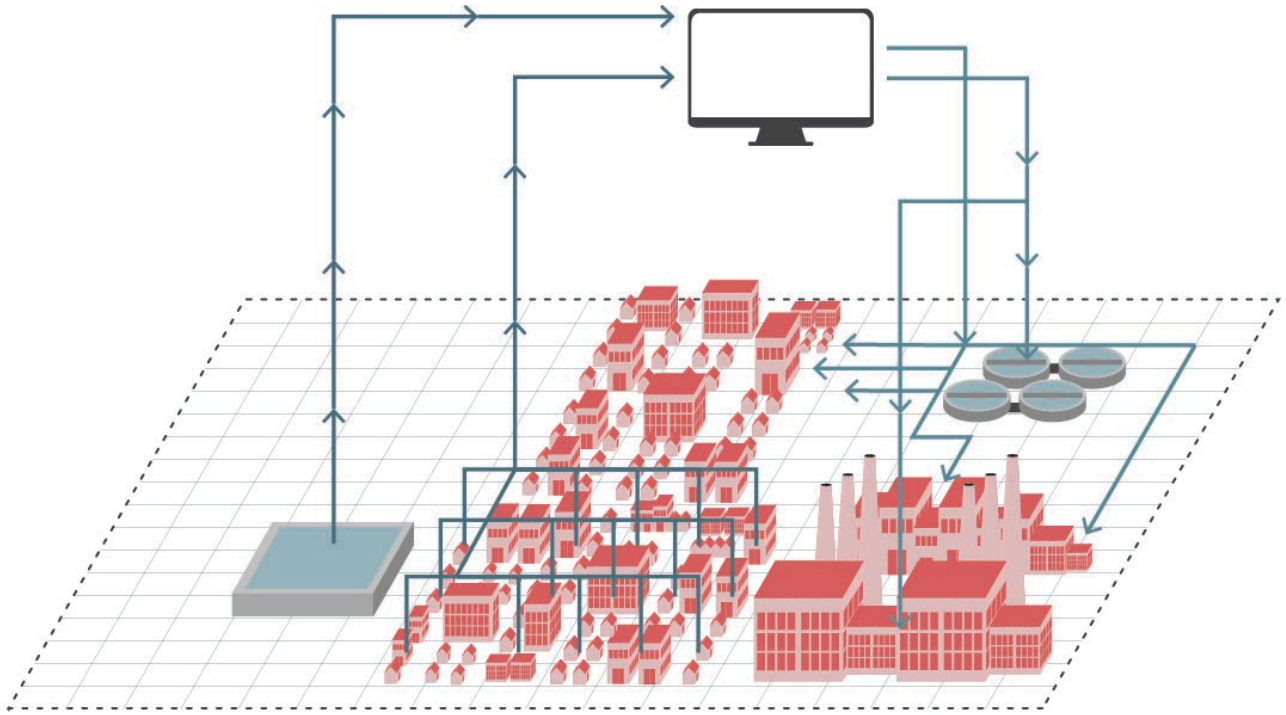
- **Physical**
  - Pipes
  - Treatment facilities
  - Pumps
  - Storage
- **Natural**
  - Groundwater
  - Surface water
  - Aquifer recharge zones

Water's social infrastructure



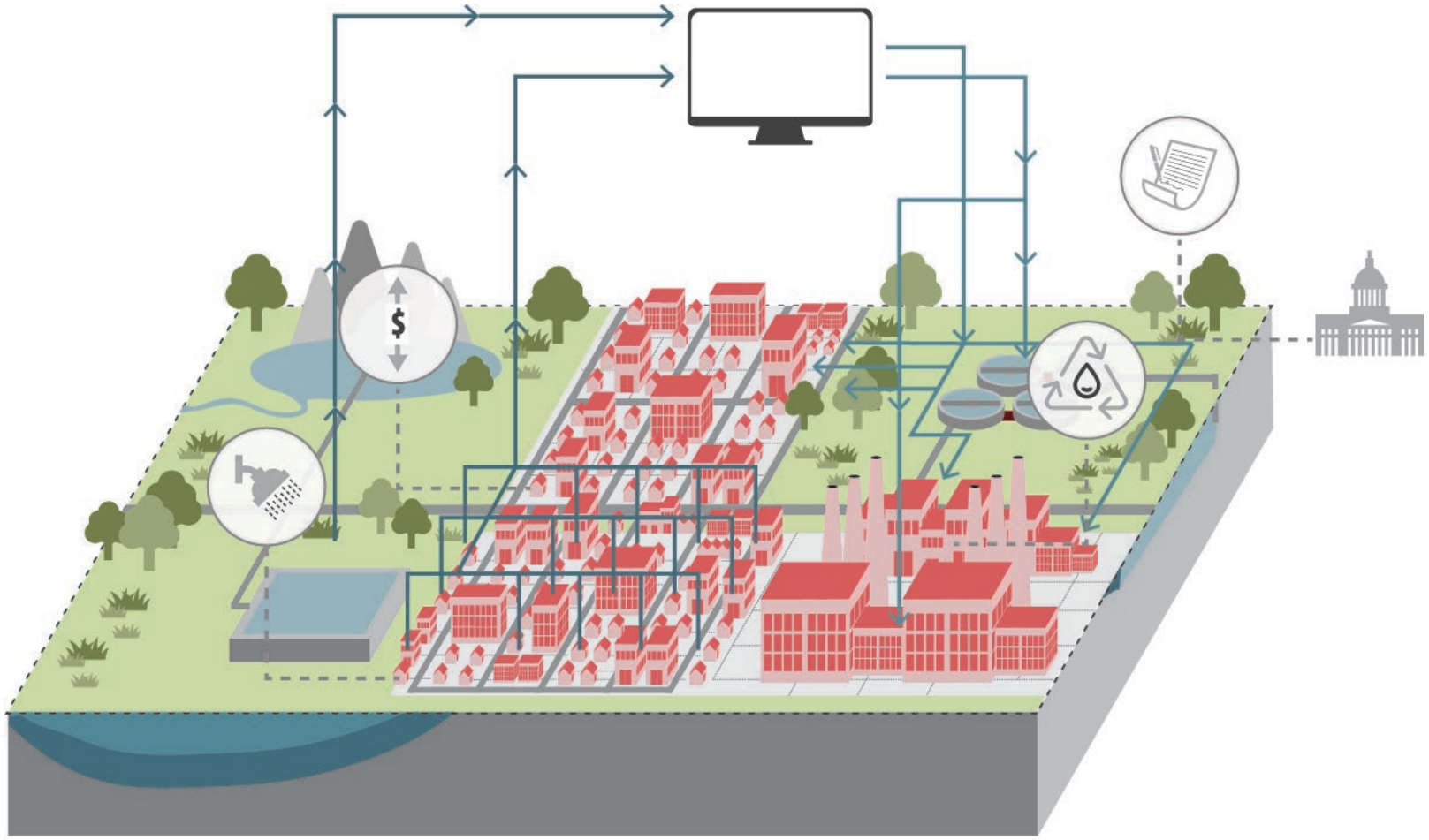
- National policies, regulations
- Local policies, regulations
- Pricing
- Behavioral norms and choices
  - Water re-use strategies
  - Water efficiency technologies

Water's digital infrastructure



- Microsensors
- People as sensors (reporting on phones)
- Algorithms
  - Early warning systems
  - Predicting demand
- Automated controls
  - Water treatment
  - Water distribution by shared tap, pre-paid meters
  - Pressures in piped networks

Water's interacting systems



Digital infrastructure

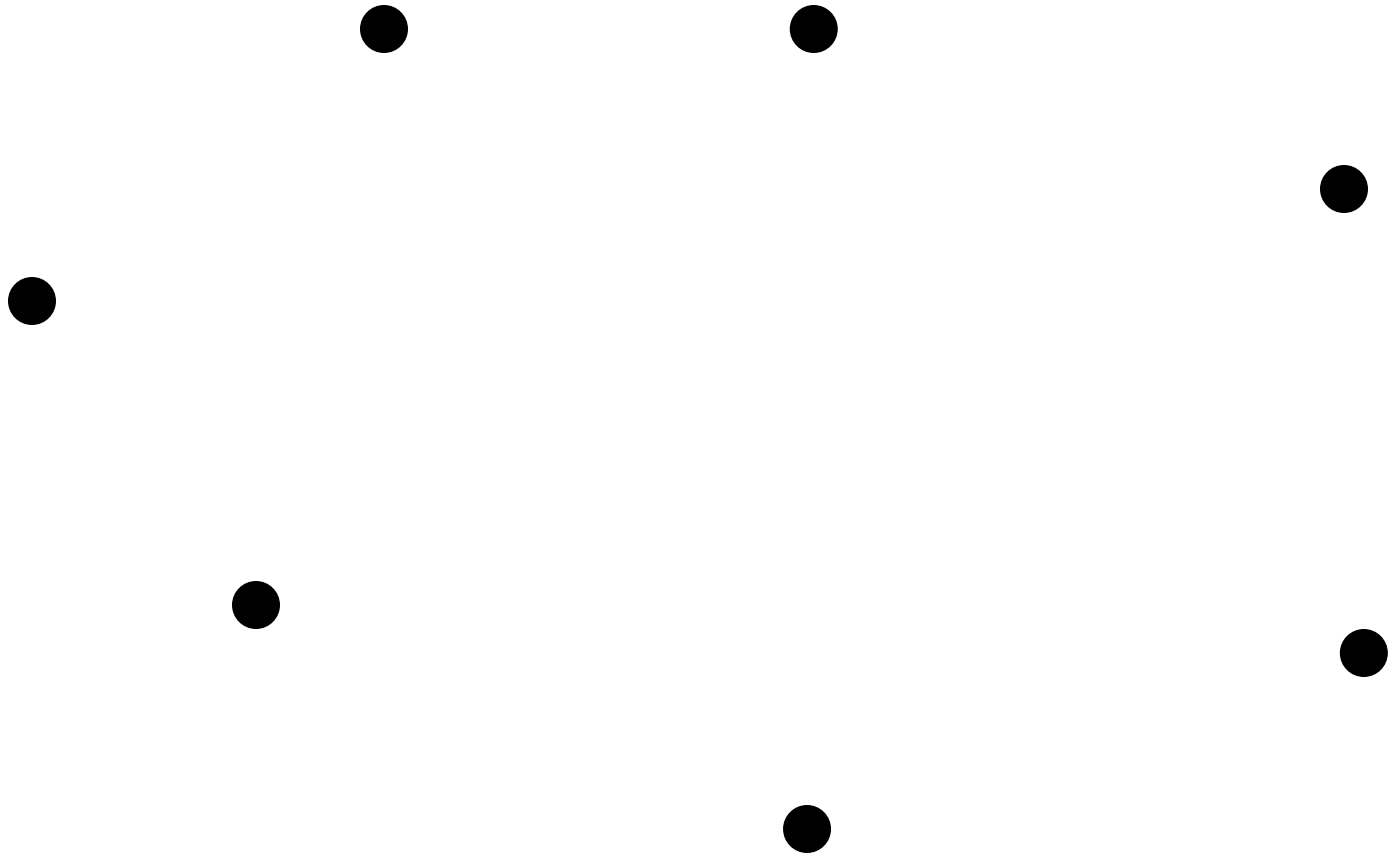
Social infrastructure

Physical infrastructure

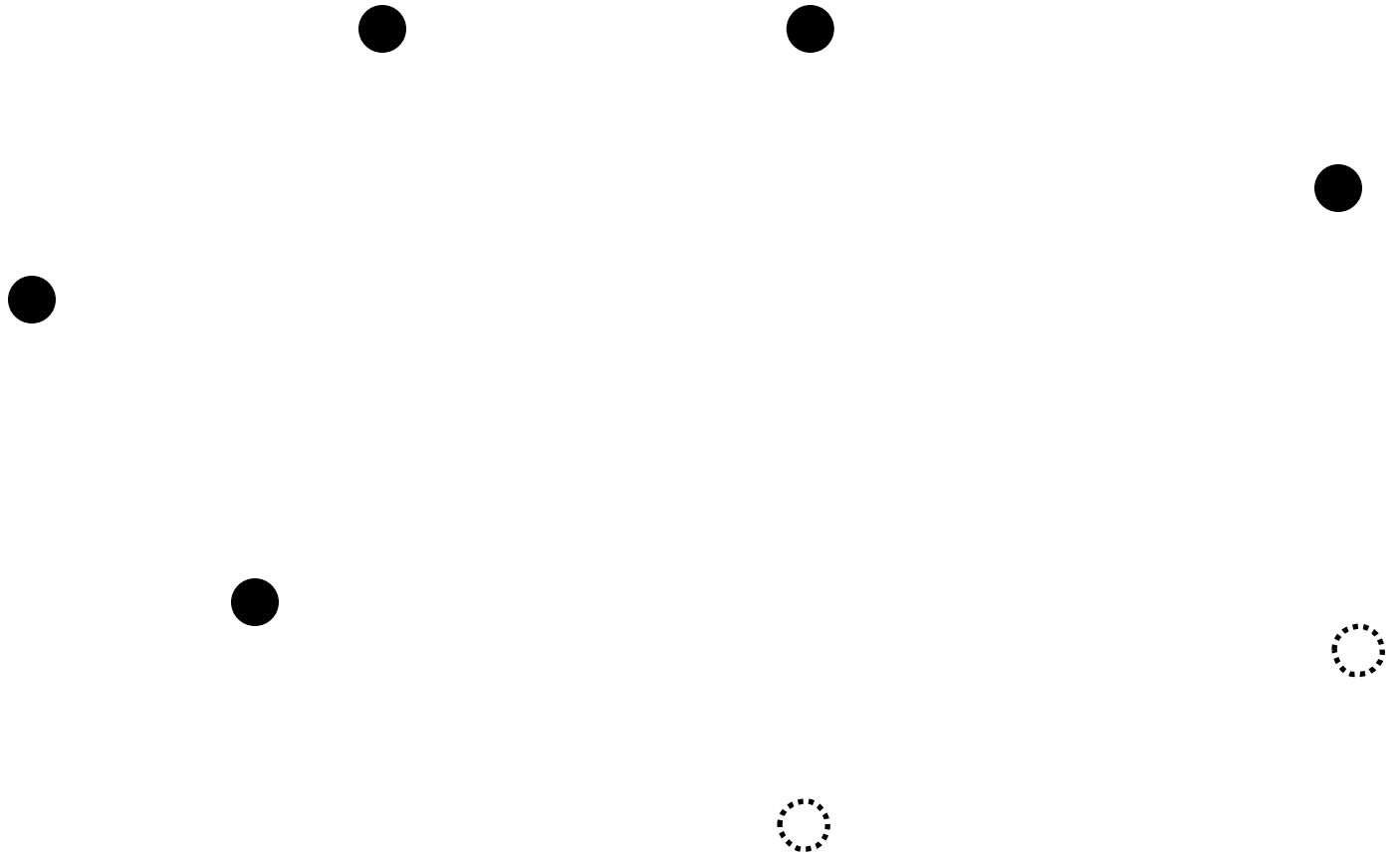
Natural infrastructure

2. Connect projects through systems

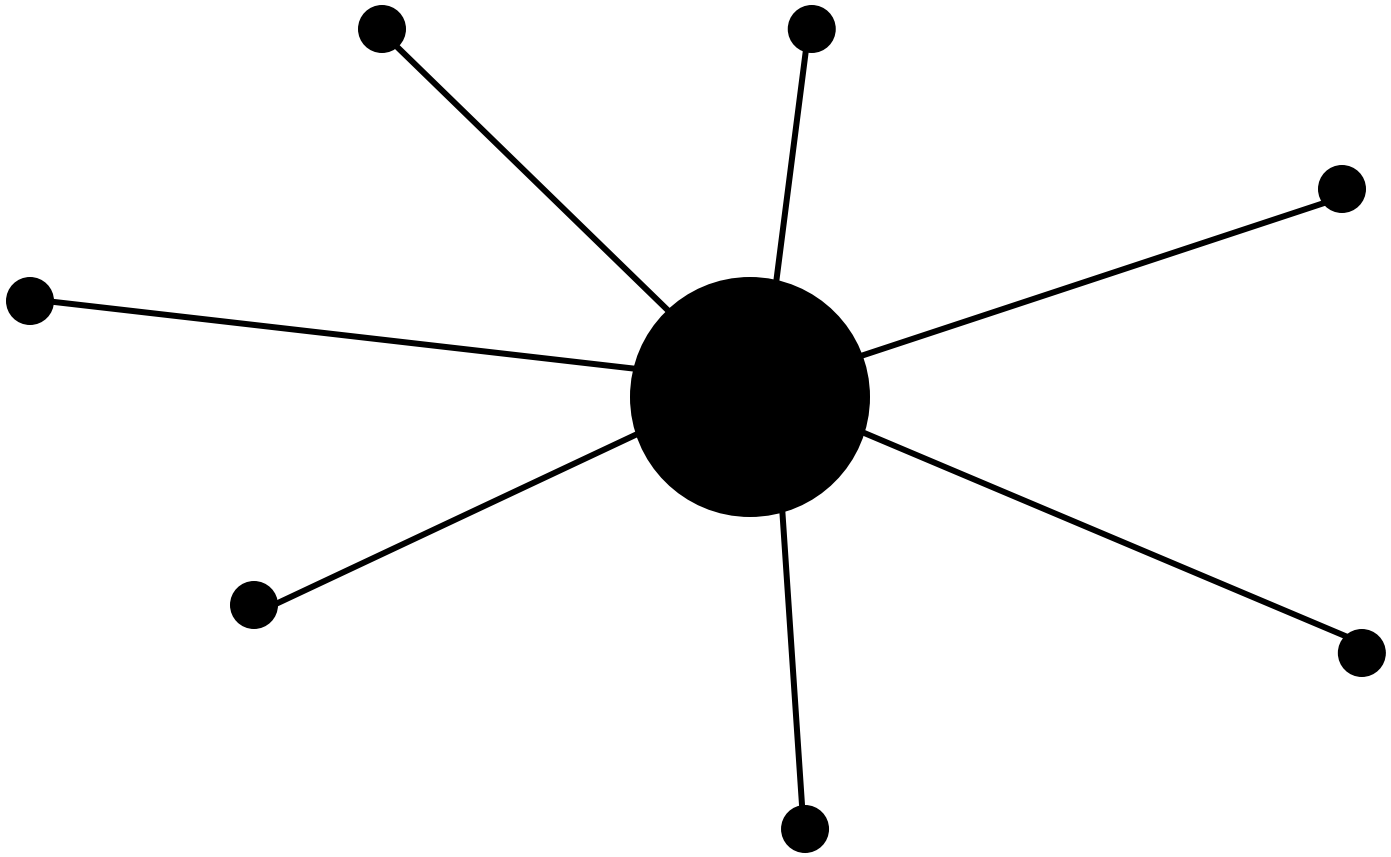
Water as systems: distributed



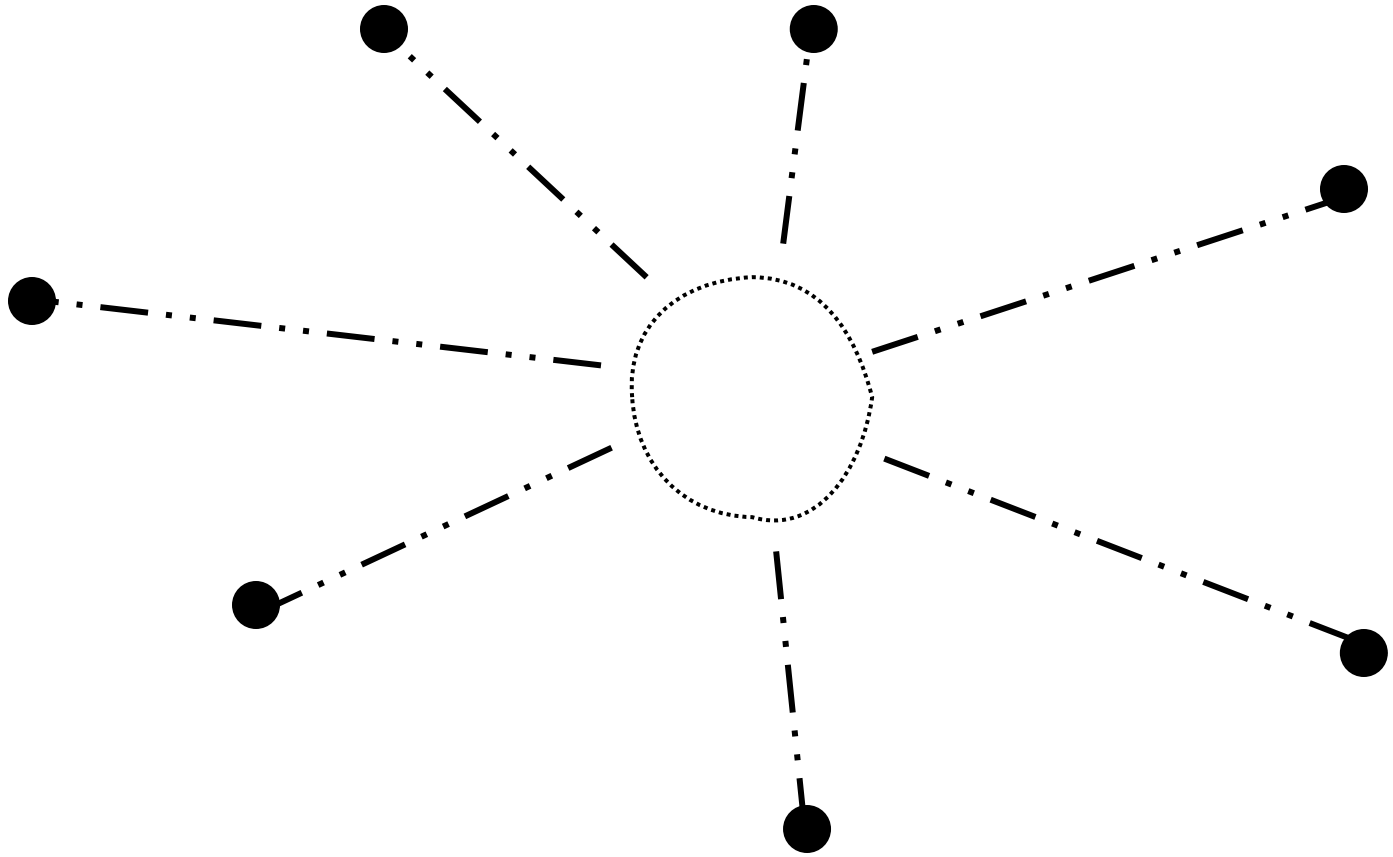
Distributed systems have a high probability of failure



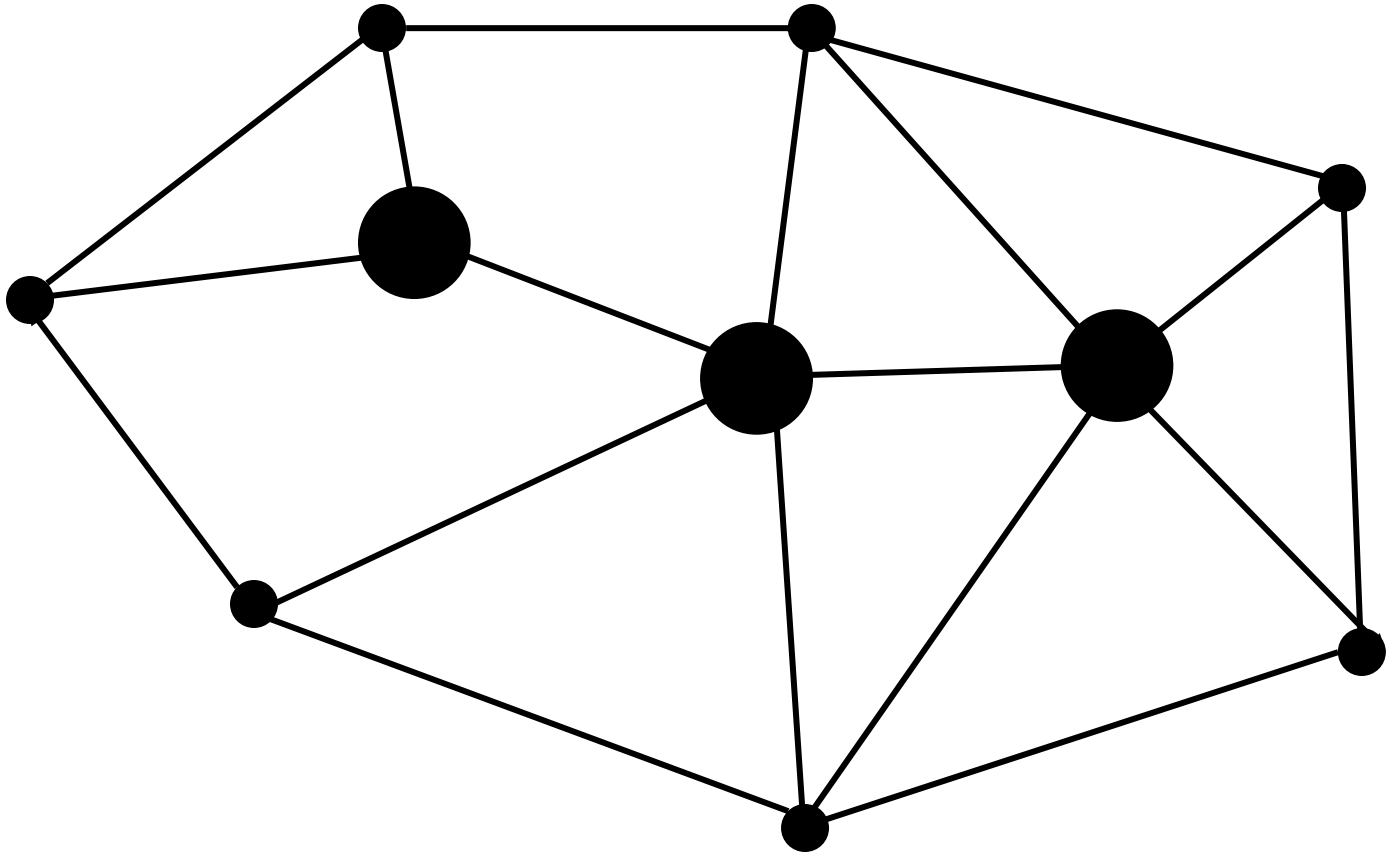
Water as systems: centralized



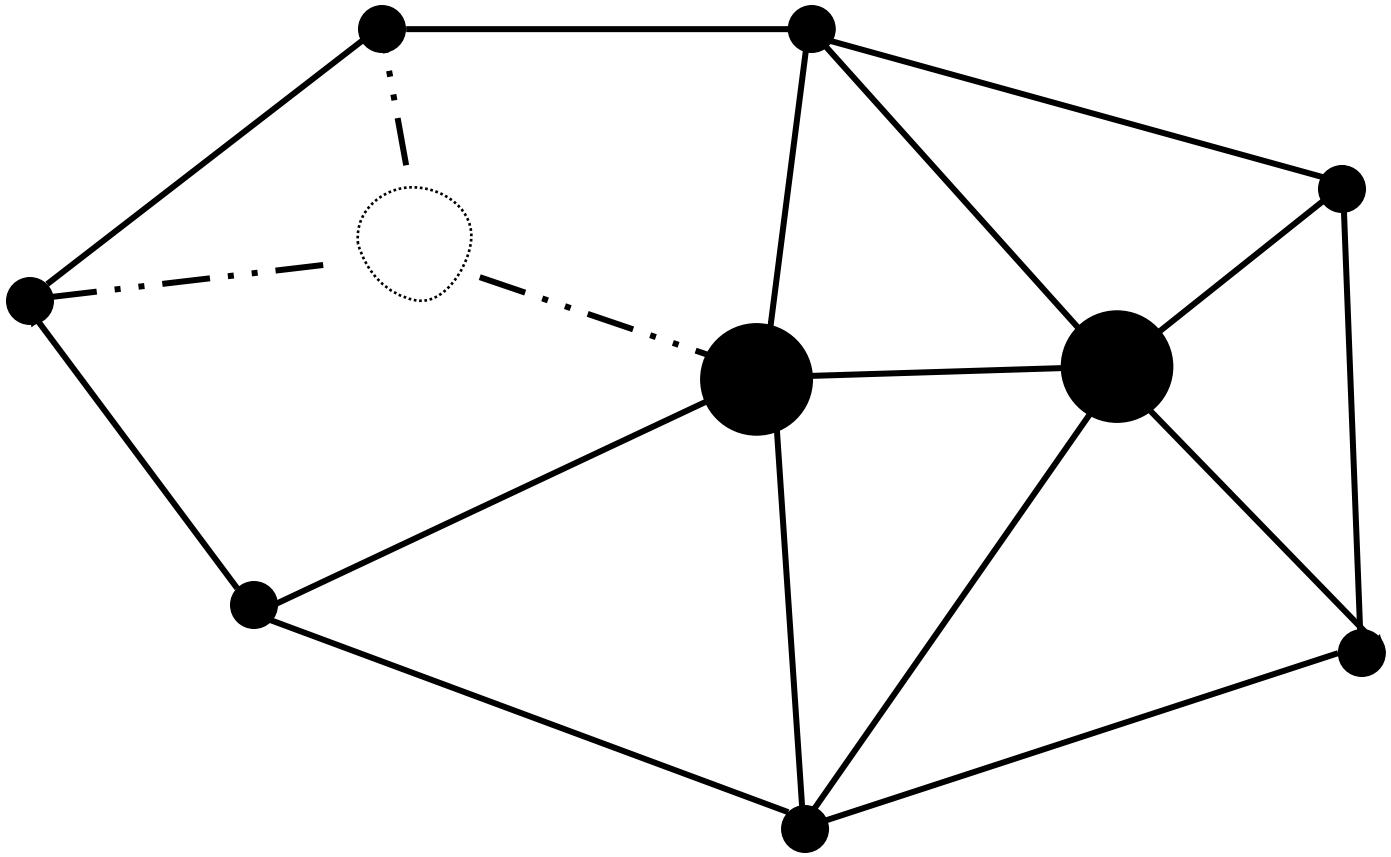
Centralized systems have a lower probability of failure, but high consequence



Water as systems: decentralized



Decentralized systems are designed to accommodate failure



Comparing distributed, centralized, and decentralized approaches

- **Distributed, disconnected projects are vulnerable**
  - Low cost
  - High probability of failure
  - Moderate consequence of failure

- **Centralized infrastructures lack flexibility and redundancy**
  - Expensive
  - Low probability of failure initially, but will increase over time
  - High consequence of failure

- **Decentralized, connected infrastructures can build resilience**
  - Moderate cost
  - Medium probability of failure
  - Low consequence of failure

The future is decentralized!

Note: This is now a common expression, but I learned it from Charles Hawkinson's TEDx talk

- How do we build these decentralized networks?

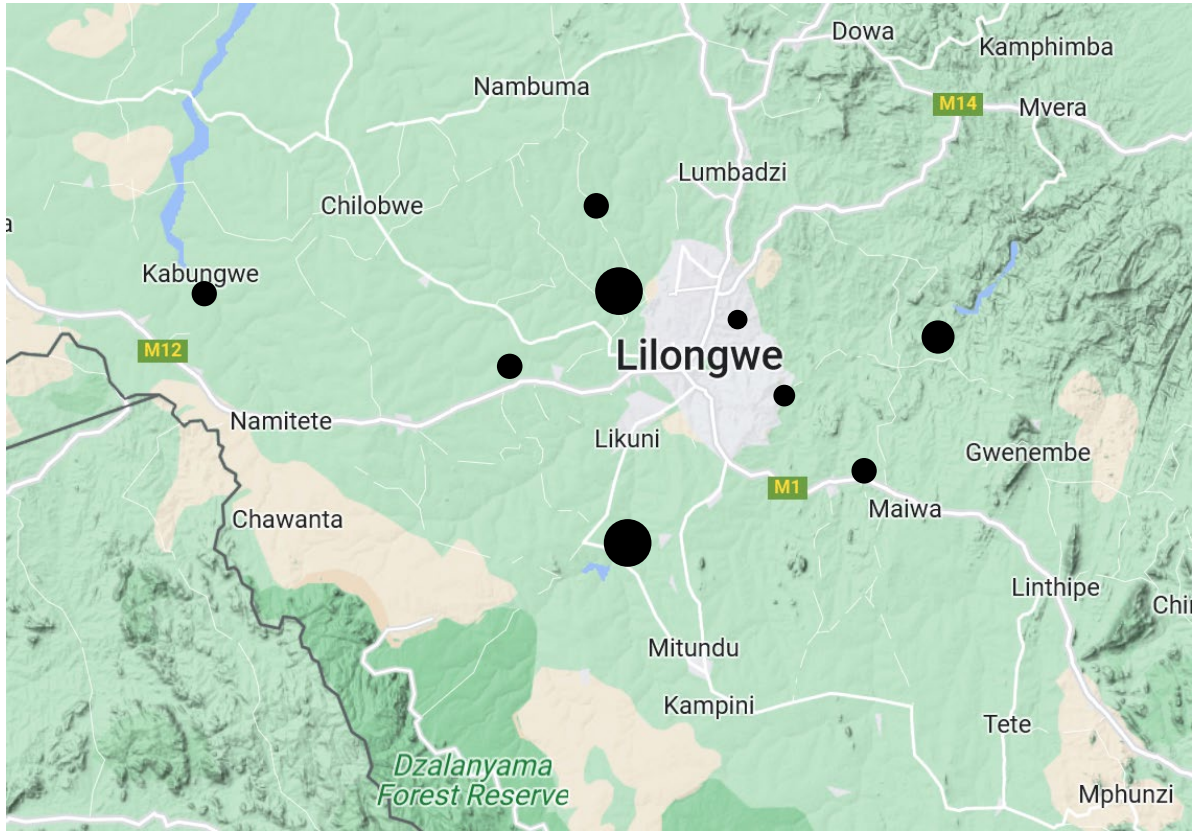
- Connect projects and water suppliers through systems: natural, physical, social, and digital

3. Scale with decentralization

Decentralized, connected projects within the city

What to connect?

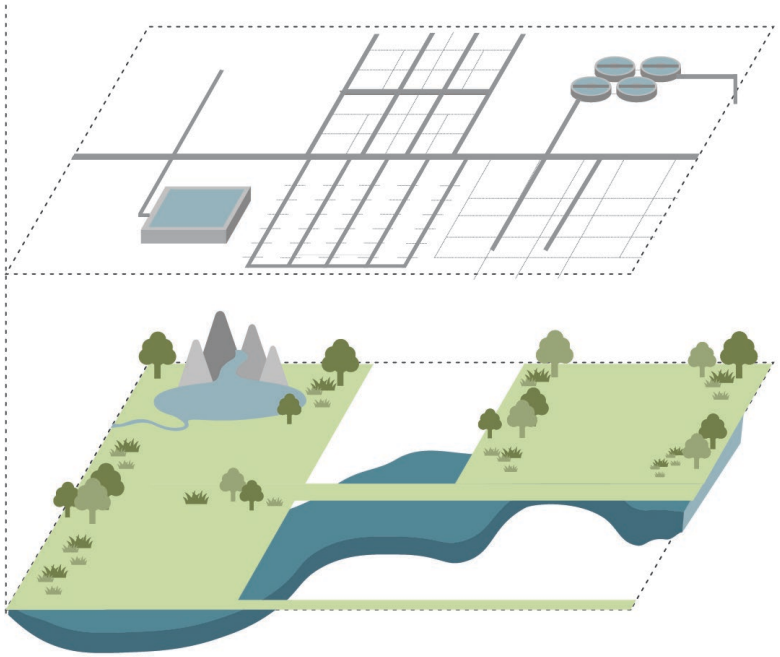
- Wells
- Surface water intakes
- Dams, reservoirs
- Other flood management infrastructure
- Aquifer recharge zones
- Drinking water treatment facilities
- Wastewater treatment facilities
- Water reuse facilities
- Non-potable water sources
- What else?
  - Water conservation campaigns
  - Stormwater drainage maintenance staff



Note: hypothetical resources and facilities for illustrative purposes

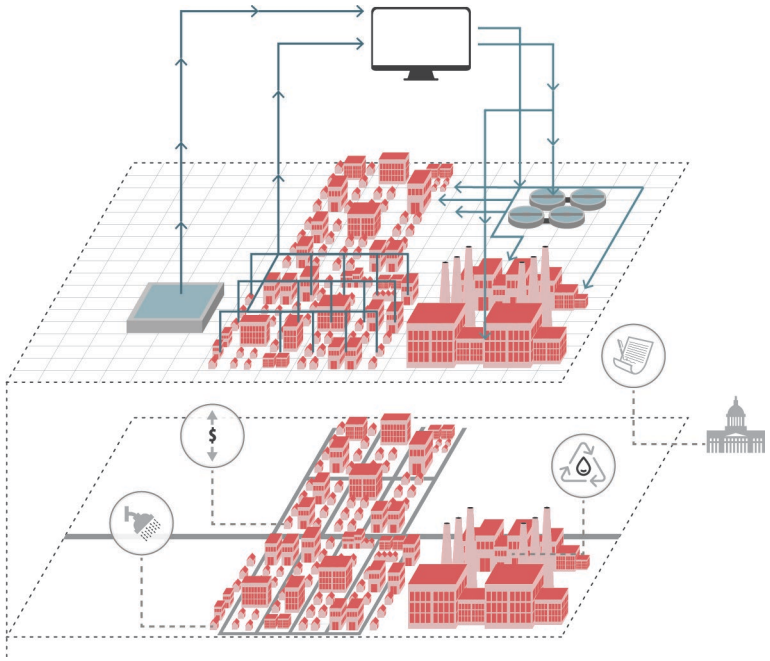
Turning distributed projects into a connected, decentralized system

- **Connect through physical infrastructure**
  - Pipes, aqueducts
  - Shared treatment facilities
- **Connect through natural infrastructure**
  - Share groundwater
  - Share surface water
  - Share land management



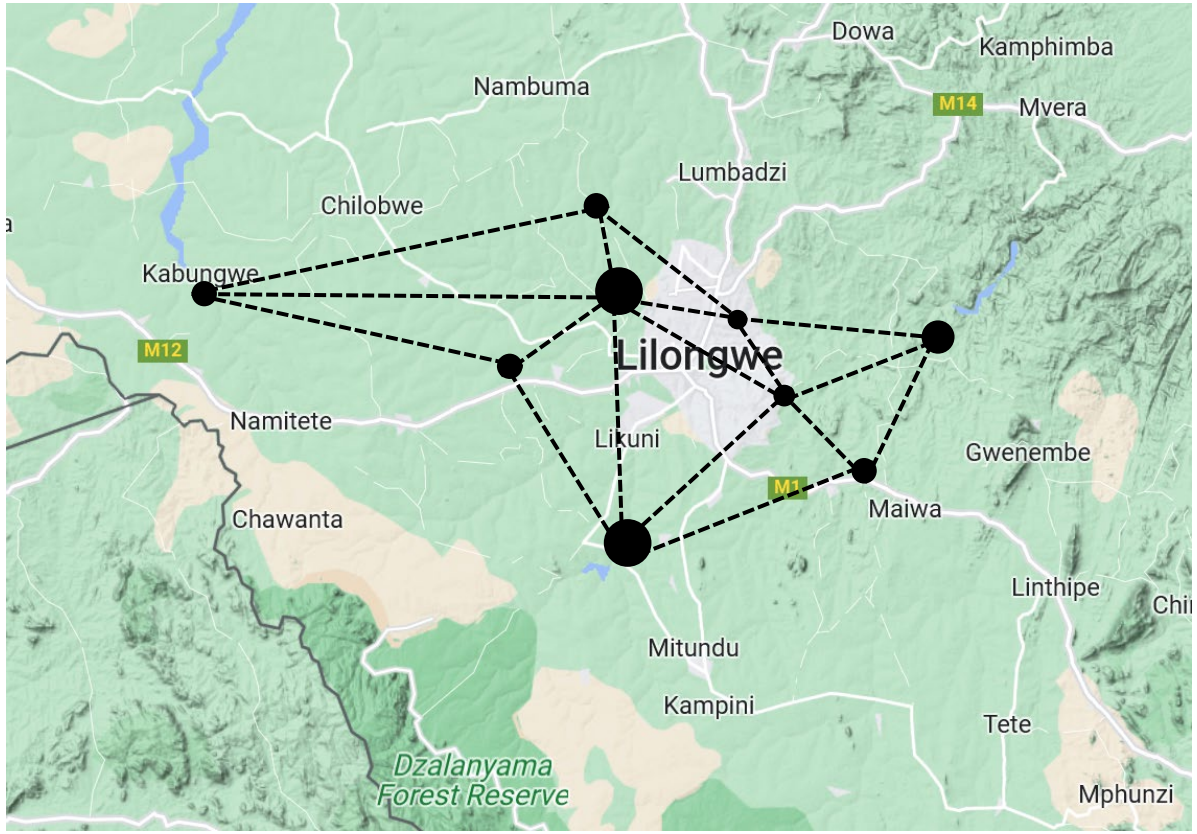
Turning distributed projects into a connected, decentralized system

- **Connect through digital infrastructure**
  - Monitor water quality
  - Report maintenance status
  - Coordinate billing
- **Connect through social infrastructure**
  - Share technical staff
  - Procure products together (e.g., water meters)
  - Create joint policies for managing flood, drought
  - Create a watershed management plan



Decentralized, connected projects within the city

- **Connect through systems**
  - Natural, physical, social, digital
- **Build resilience and sustainability**
- **Over time, add new projects and create new connections to adapt the system**



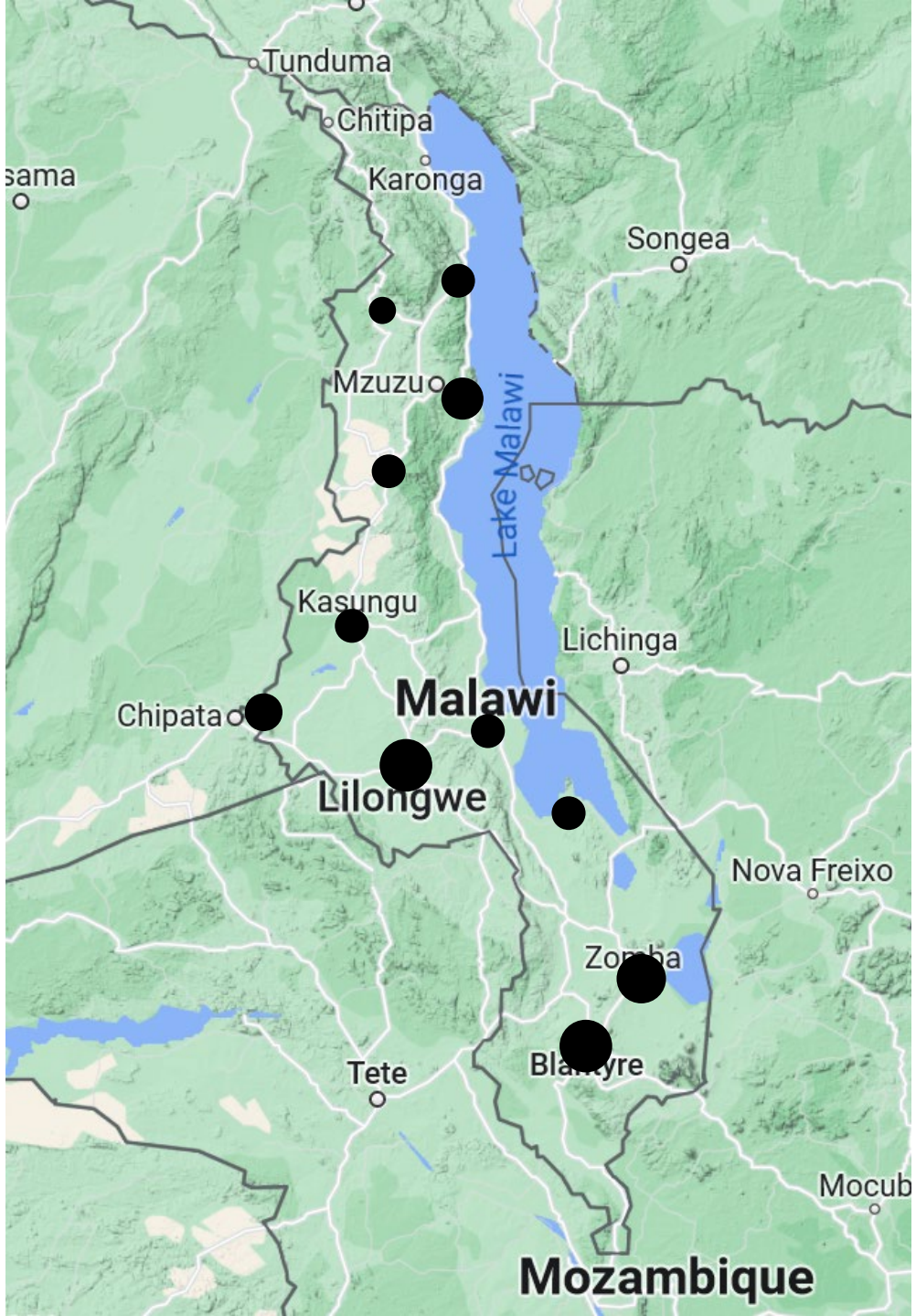
Note: hypothetical resources and facilities for illustrative purposes

Decentralized, connected projects among cities

- **How to connect?**
  1. Digital
  2. Social
  3. Physical
  4. Natural

- **Many different possible connections, different patterns for a decentralized system**

- **More connections builds more resilience, creates more capacity**



Decentralized, connected projects among cities

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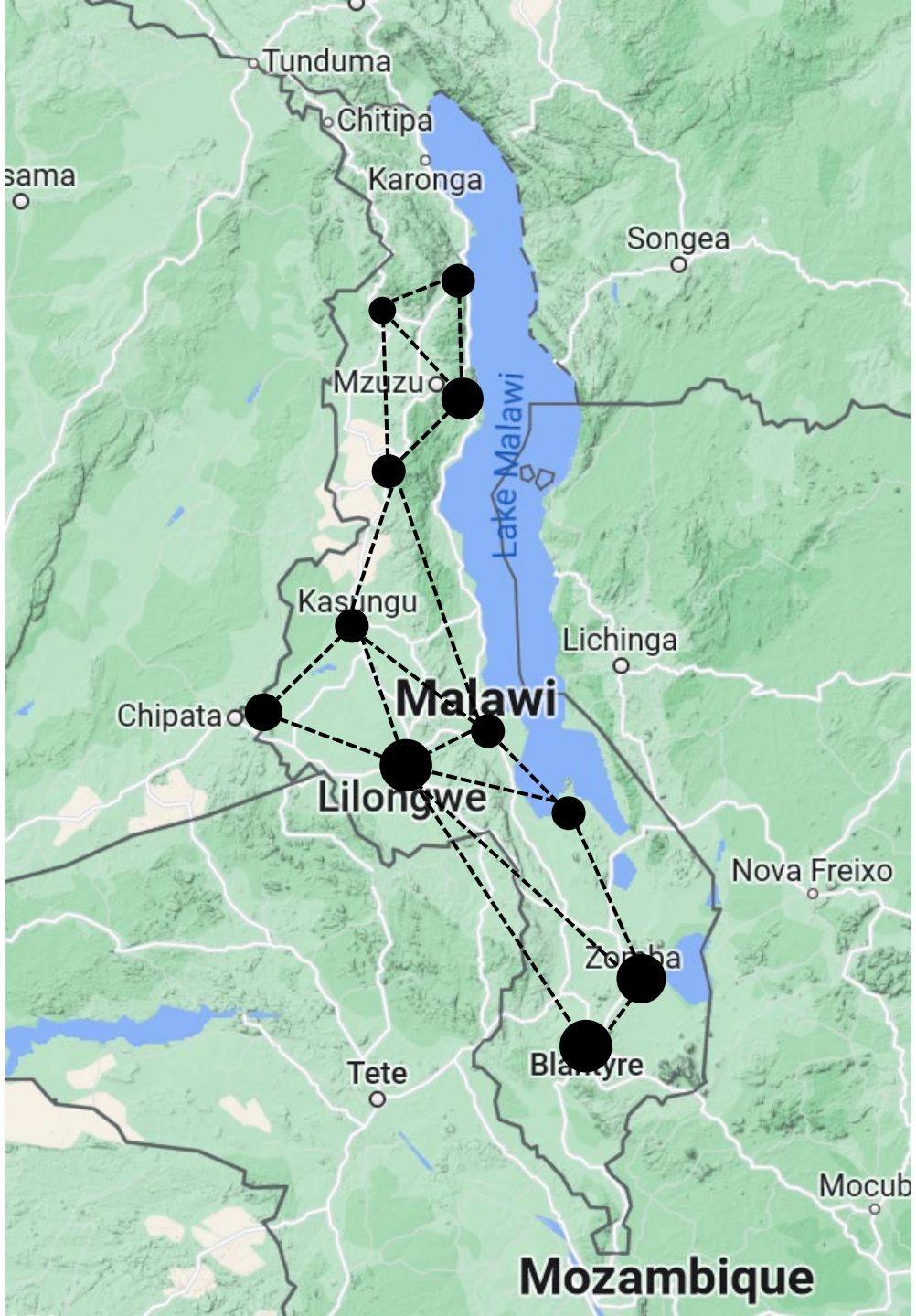

Connected, decentralized water systems make it possible to…

- Avoid projects that require huge capacity and huge capital outlays
- Magnify impact of smaller projects by making them part of a connected system
- Build resilience by preparing for failure and ensuring quick recovery
- Add projects/places, change connections, and adapt the system over time, as population and climate change

Take-away: three goals and three strategies for resilient, sustainable water systems

GOALS

1. Accommodate greater variability in water supply and demand
2. Prepare for declining water quality
3. Ensure sustainable yield

STRATEGIES

1. Identify water's interacting systems
2. Connect projects through systems
3. Scale with decentralization

How do we know adaptation is working?

Measuring impacts of adaptation actions

- In addition to water systems, what other systems must adapt to climate change?
- Can we use passively collected data products, like earth observations, to identify adaptation?
- What are the right indicators for evaluating adaptation over time?

GEO4NAPS

Leo C. Zulu, Michigan State University, MI, USA

Allison Lassiter, University of Pennsylvania, PA, USA

Sosten Chiotha, Leadership for Environment and Development, Southern and Eastern Africa, Zomba, Malawi

David Stevens, Independent Scientist, Geneva, Switzerland

Tristan Grupp, University of Pennsylvania, PA, USA

- Session 3.3.2., co-hosted with GEO, Wednesday 14:00-15:30
- We will ask: what do you think are best indicators for measuring adaptation outcomes?

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