

# Three worldviews for complex systems

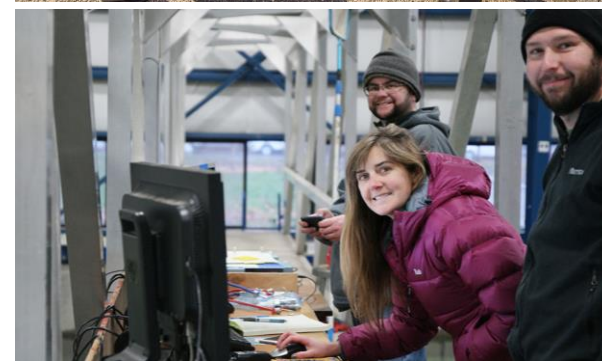
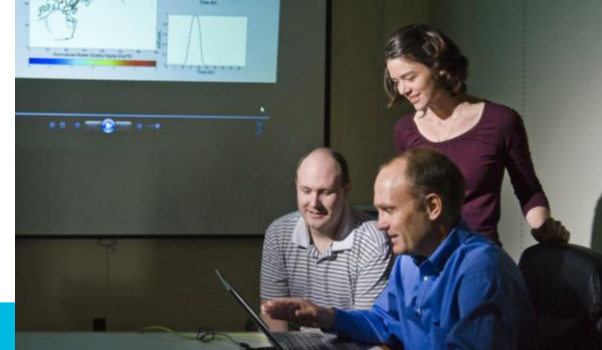
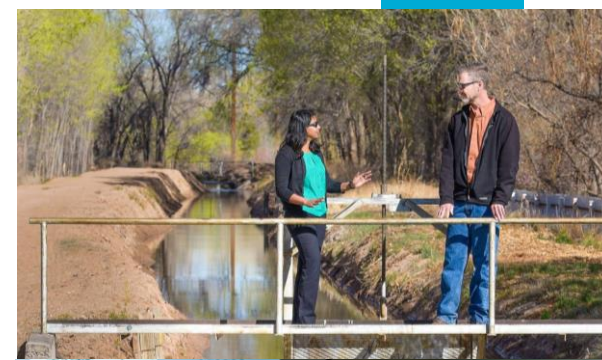
Thushara Gunda

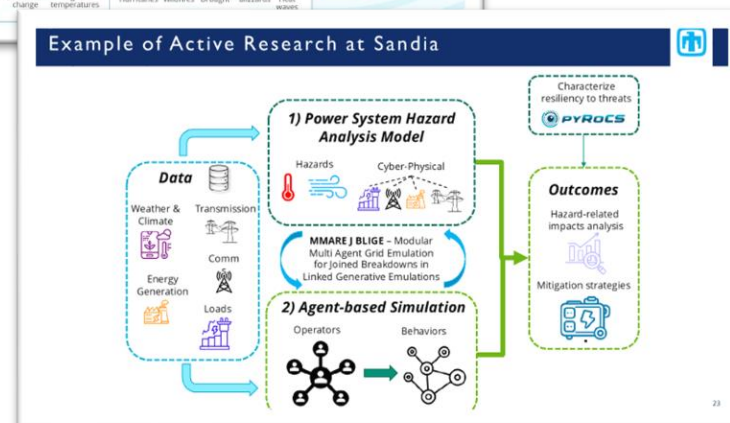
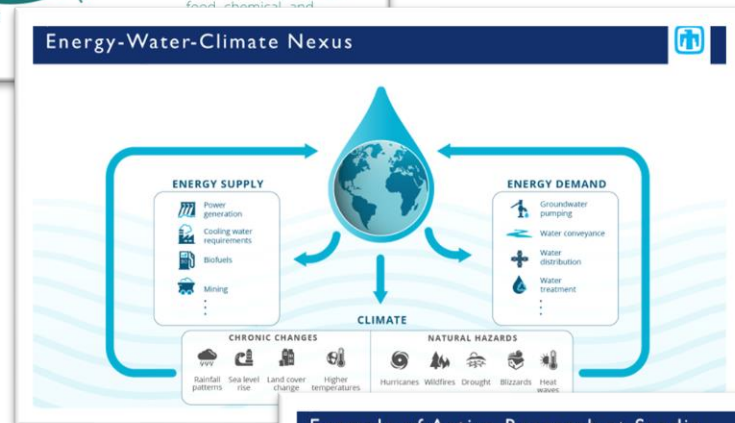
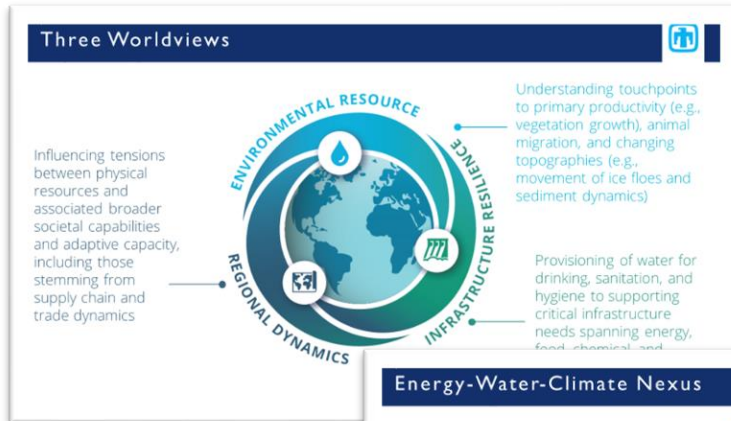
July 2024

 Sandia National Laboratories

 U.S. DEPARTMENT OF ENERGY  NNSA

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525. SAND2024-09663PE





## Background

## Case Study: Energy

## Challenges & Opportunities



- Refers to impacts of the climate crisis on peace and security (emphasis on fragile and conflict-affected settings)
  - Exacerbation of existing insecurities (e.g., food, water, and livelihoods)
  - Aggravation or prolonging of existing conflict
- Occurs through increased competition over natural resources, social disruptions, and/or displacement
- Can disrupt or impede climate action (e.g., destruction of assets or delays in implementation of mitigation and adaptation)





How are social dynamics influencing system states (supply chains, tensions between users, adaptation behaviors, ...)?

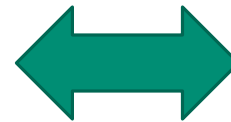


What aspects of the natural system are changing (precipitation patterns, changing ice floes, animal migration, ...)?

How are the current and planned systems able to withstand or recover from changing system states (drinking water, energy production, manufacturing, ...)?



**disease** hazard impacts food security/access  
compound events **mission readiness**  
**water availability** governance infrastructure  
cascading failures **arctic** adaptive capacity  
**drought** resource driven conflict contaminants  
**community well-being** water quality  
**scarcity** extreme weather rising sea levels  
cloud seeding **floods** agriculture  
population dynamics multi-sector dynamics  
**energy and carbon transitions** weaponization  
migration hydropower/pumped hydro ecosystems



- Multiple climate security concerns are influenced by complex dynamics associated with the three worldviews



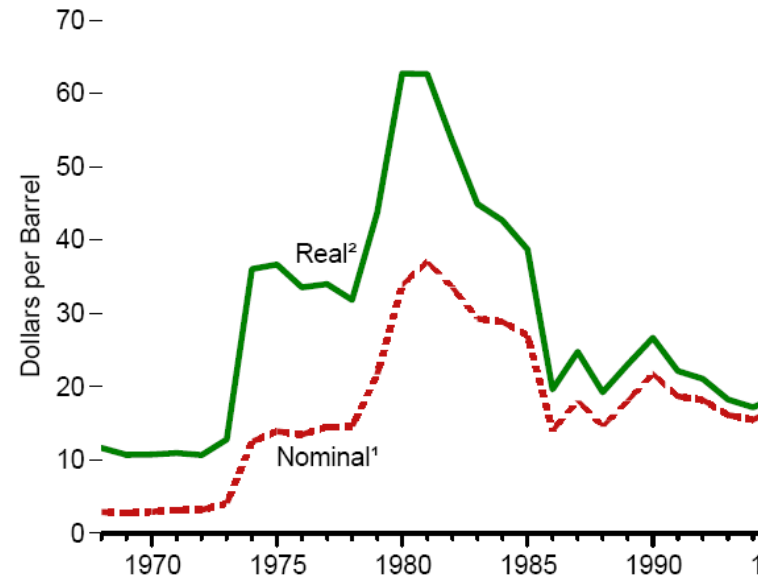
# Case Study: Energy



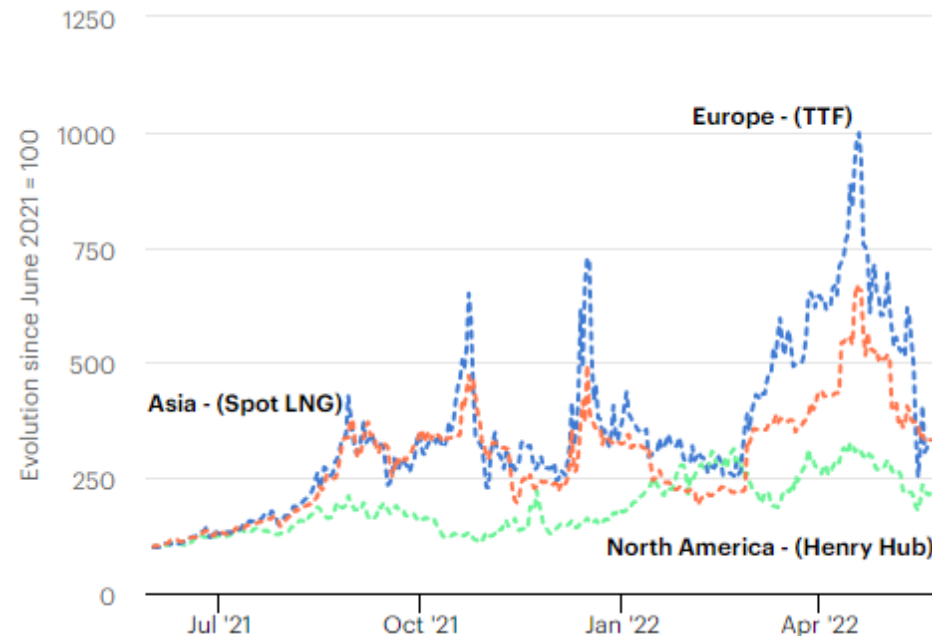
# Energy is a Security Priority



## Imported Costs



Source: [EIA, 2007](#)



Source: [IEA, 2022](#)

- Decreases in local petroleum production in the 1970s drew attention to importance of energy sector to economic growth
- Global dynamics continue to influence prices (e.g., European and Asian gas price increases from Russia's invasion of Ukraine)
- Energy is continuously traded across regions (shipments of fuel or electricity through transmission networks)



## Wild Weather Cuts Power, Sparks Bushfires in Australia

By Reuters | Feb. 13, 2024, at 6:14 p.m.

Save Comment f t r ...



REUTERS

Source: [Reuters, 2023](#)

## Oroville Dam Spillway Failure: Nearly 190,000 Ordered to Evacuate

Mandatory evacuations remained in effect on Monday afternoon for nearly 190,000 people in Northern California after a spillway serving the country's tallest dam suffered significant erosion.

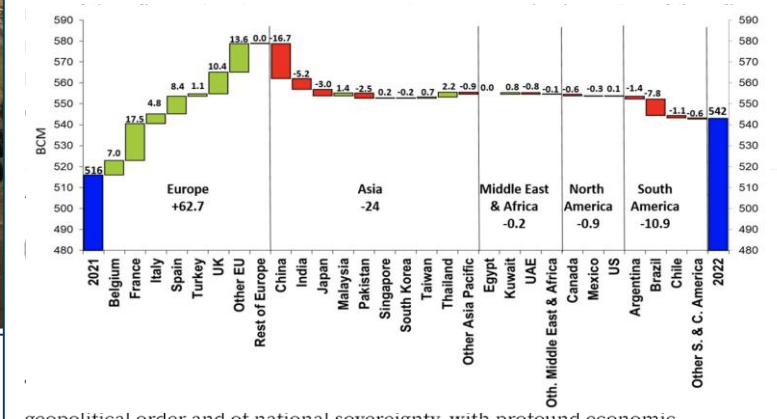


Source: [Stelloh et al., 2017](#)

## The European energy crisis and the consequences for the global natural gas market

Simone Emiliozzi, Fabrizio Ferriani, Andrea Gazzani / 11 Jan 2024

The 2022 Russian invasion of Ukraine severely disrupted European gas markets. Energy costs rose steeply, global natural gas flows were significantly reoriented, and policymakers' focus shifted towards energy security. This column examines how the conflict has reshaped the natural gas market, with an emphasis on the



Source: [Emiliozzi, 2024](#)





World ▾ Business ▾ Markets ▾ Sustainability ▾ Legal ▾ Breakingviews ▾ Technology ▾ Investigations

Boards, Policy & Regulation | Sustainable Markets | Regulatory Oversight | Governance | Grid & Infrastructure

## Climate change-related droughts dent progress on energy emissions - report

By Reuters  
October 5, 2023 4:40 AM MDT · Updated 9 months ago



The Baihetan hydropower plant is seen in operation on the border between Qiaojia county of Yunnan province and Ningnan county of Sichuan province, China June 28, 2021. Picture taken with a drone. cnsphoto via REUTERS [Purchase Licensing Rights](#)

Source: [Reuters, 2023](#)

## Scientists develop technology to produce green hydrogen from seawater

IIT-Madras researchers have developed components for an alkaline water electrolyser that can use seawater directly to make green hydrogen. This is proposed as an alternative to the use of freshwater that is currently the key input for green hydrogen production.



Source: [Sinha, 2023](#)

BUSINESS | GERMANY

## Tesla in Germany: Locals vote against factory expansion plan

02/20/2024

Residents of Grünheide near Berlin have voted against expansion plans for the large Tesla facility there. But the vote is not binding and local authorities can still decide. Turnout was high, though, indicating interest.



Source: [DW, 2024](#)



## ENVIRONMENTAL RESOURCE WORLDVIEW

Sea level rise

Extreme events

Water scarcity

Mobilization of  
contaminants

Drought-induced  
power disruptions

Infrastructure  
damage

Reduced efficiency  
during operations

Supply chain and power  
delivery disruptions

Conflict

Aid & support

Technology development

Trade markets

Water treatment

Disease breakouts

Changes in  
behavioral profiles

Increased demand on  
local water resources  
for global needs



## INFRASTRUCTURE RESILIENCE WORLDVIEW

## REGIONAL DYNAMICS WORLDVIEW



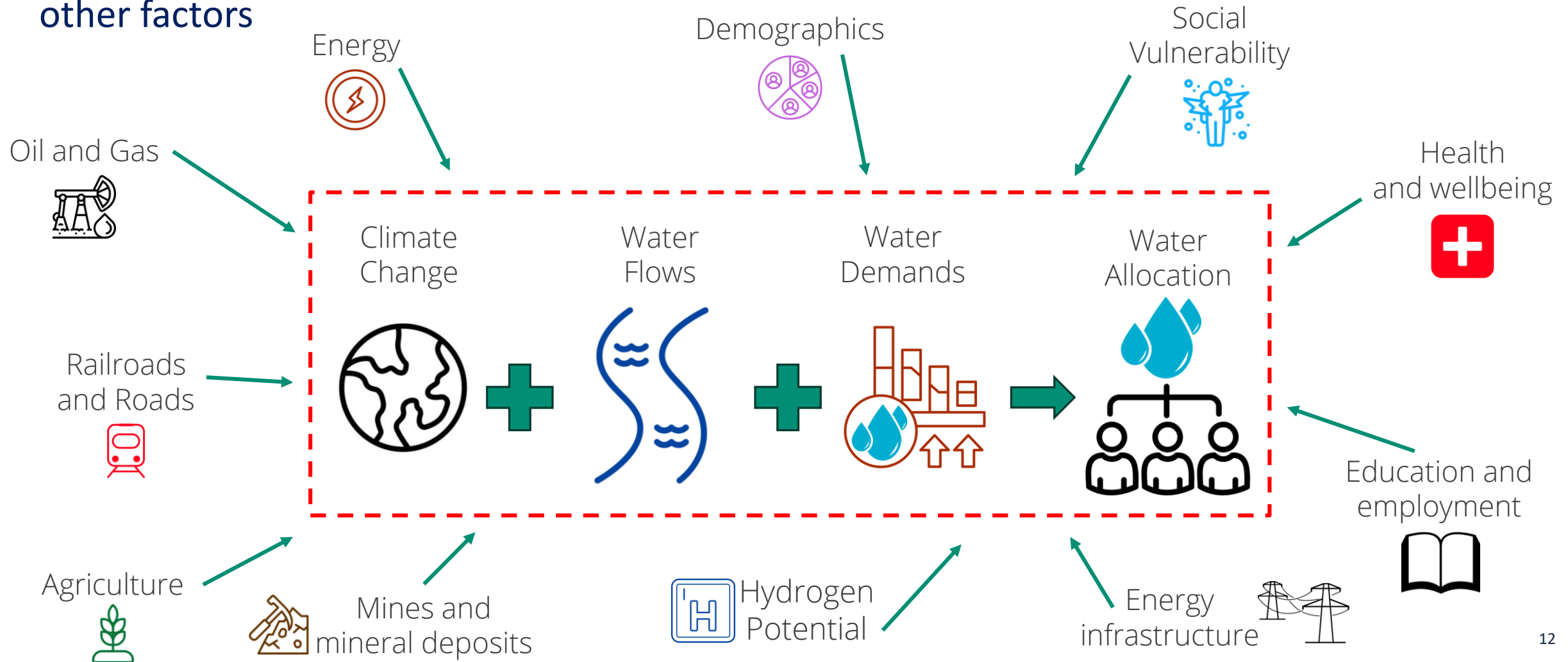


# Challenges and Opportunities

# A Systems of Systems Approach



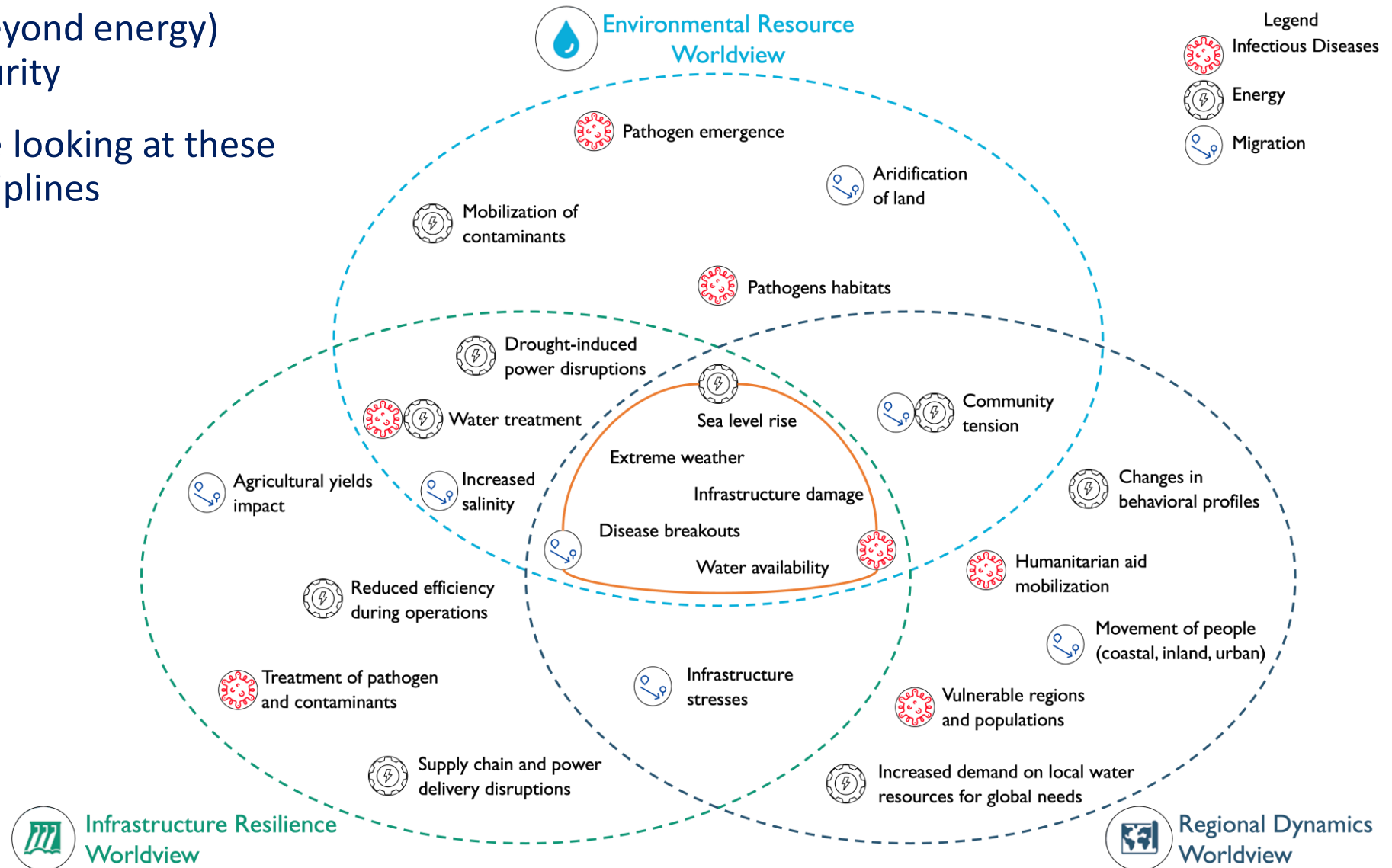
- Recognize sociotechnical nature of current climate security challenge
- Climate impacts are influenced by various other factors, which in turn are influenced by other factors



# Co-Occurring Climate Security Concerns



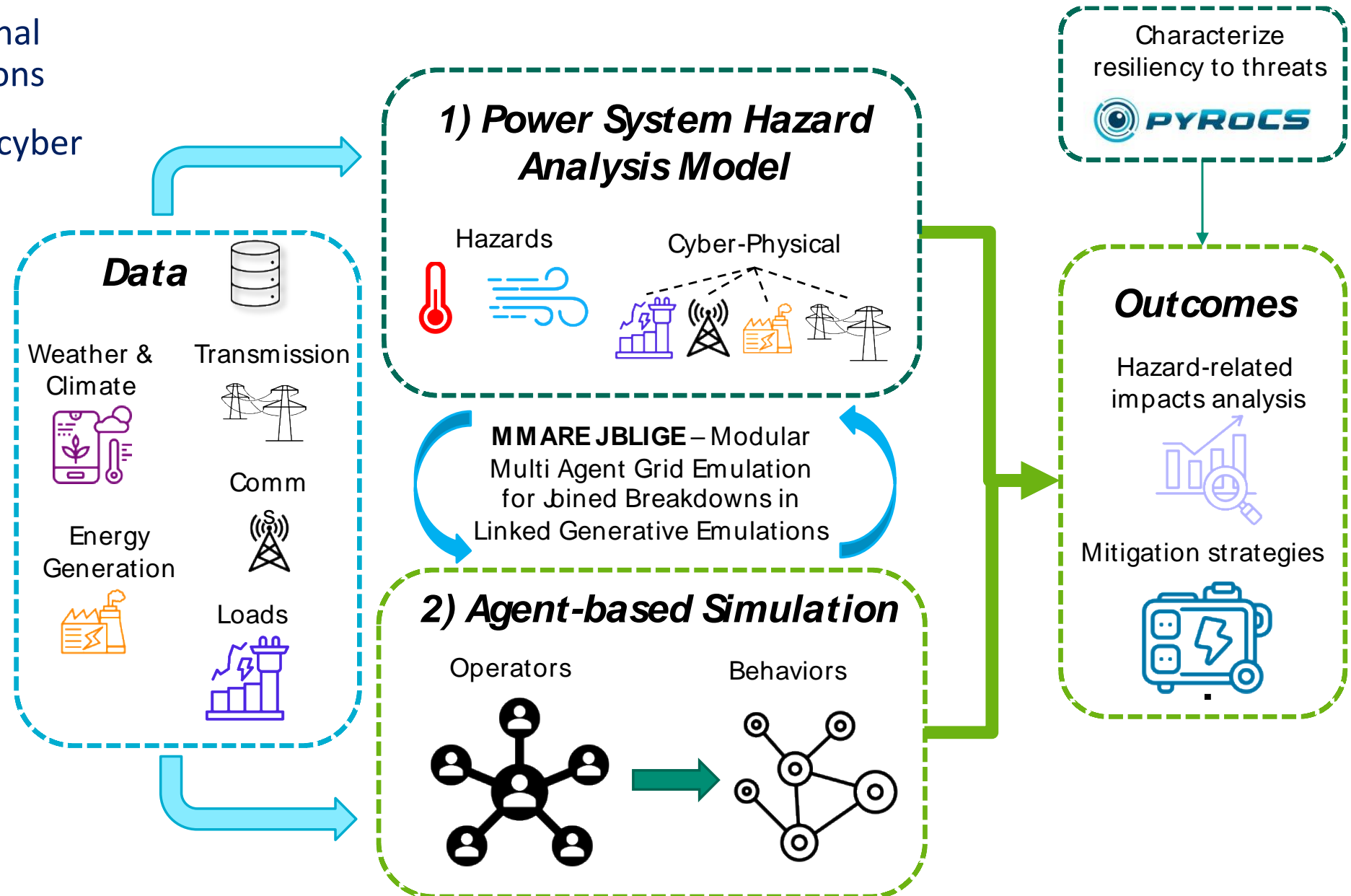
- Various concerns (beyond energy) exist for climate security
- Worldviews facilitate looking at these concerns across disciplines



# Systems Approach for Evaluating Hazards



- Consider operational and response actions
- Actively integrate cyber dimensions



# Acknowledgements



Multi-disciplinary team with expertise in various domains relevant to climate security



**Thushara Gunda**



**Kevin Stamber**



**Nicole Jackson**



**Natalie Prittinen**



**Anthony Falzarano**



**Priya Hora**



**YeongAe Heo**



**Robert Taylor**

Not pictured: Joshua Dise

Happy to answer any questions!

Email: [tgunda@sandia.gov](mailto:tgunda@sandia.gov)