Impact of Fuel Supply Chain Disruptions on Energy Resilience: A case for Nuclear Energy

Guillaume L'Her, Mark Deinert

Energy Impact of Natural Hazards

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  - Hurricanes, seismic, landslides, floods, temperature extremes, …
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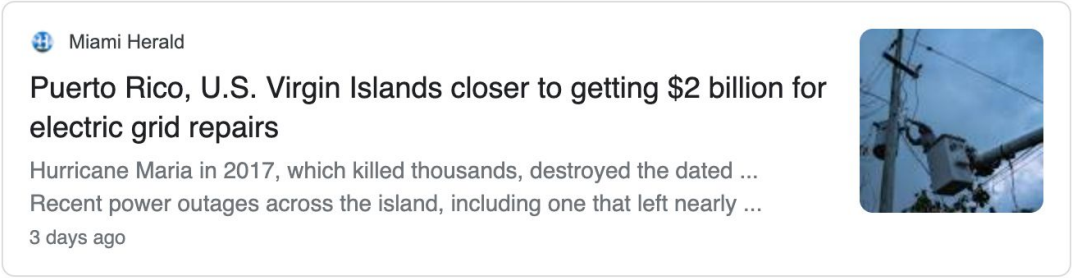

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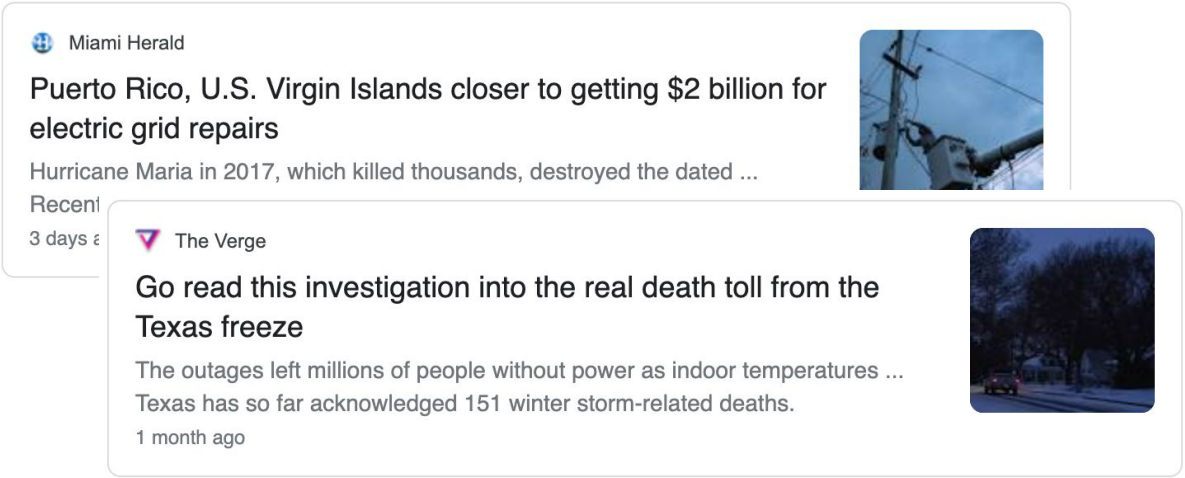

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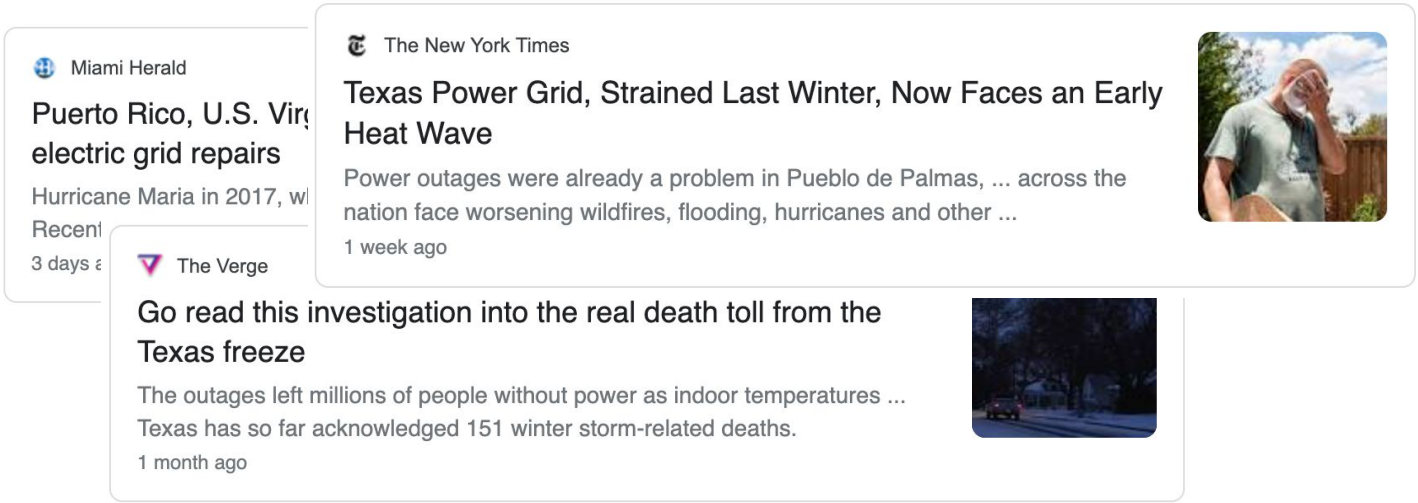

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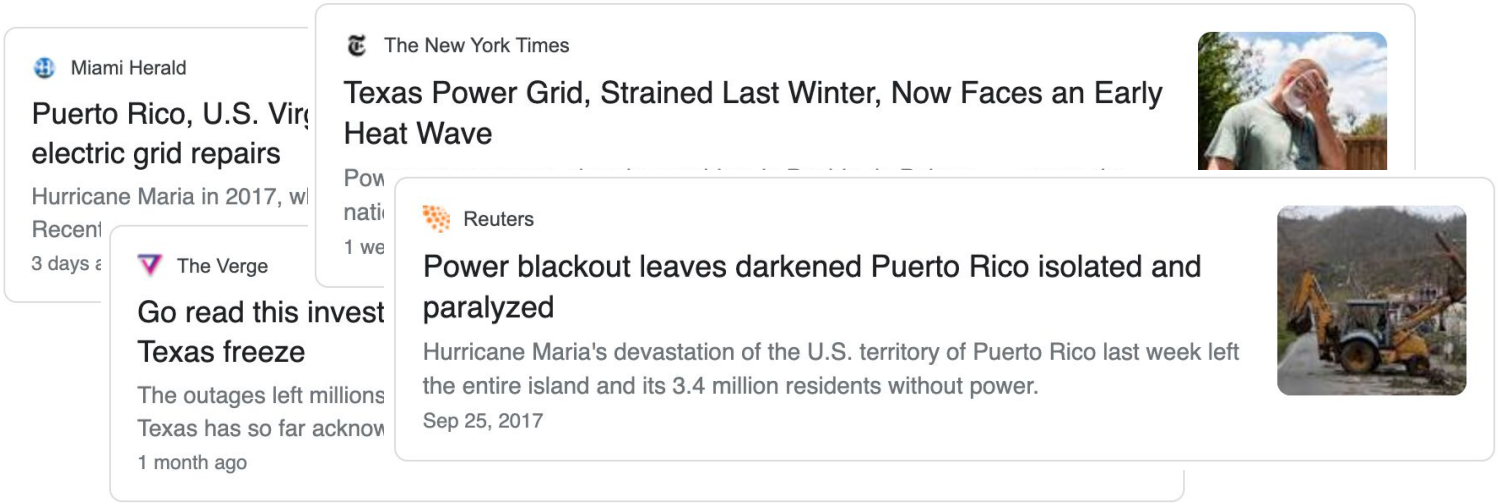

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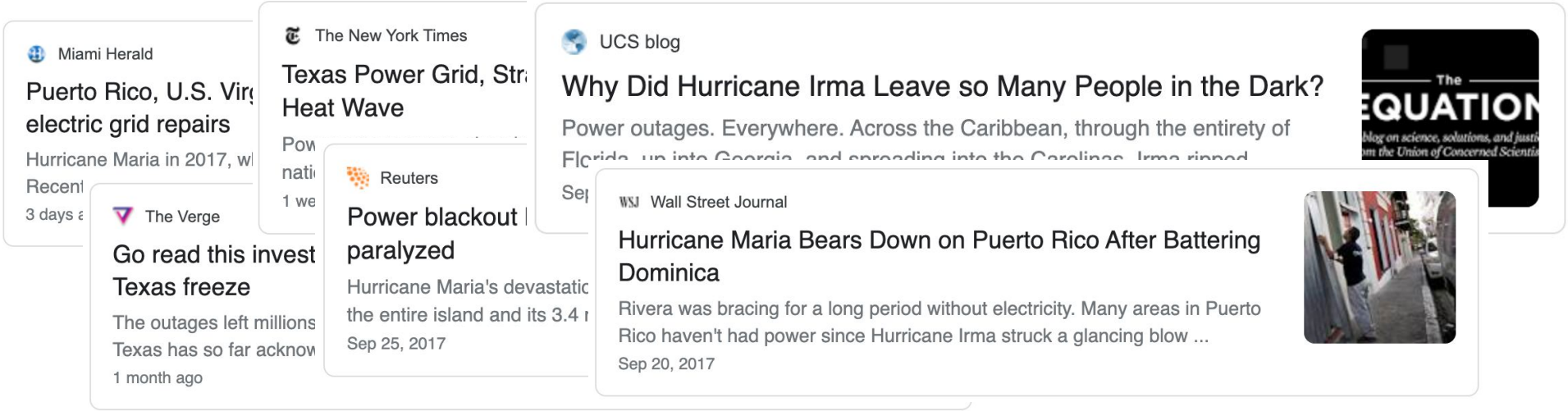

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Miami Herald

The New York Times

UCS blog

y People in the Dark?

n, through the entirety of

The EQUATION

Pacific Standard

Hurricane Maria Leaves the Caribbean in Shambles

The third in a string of cataclysmic hurricanes, Maria hit the islands just ... homes, dousing streets, and leaving the entire island without power.

Sep 21, 2017

Rico After Battering

The outages left millions
Texas has so far acknow
1 month ago

Sep 25, 2017

Rico haven't had power since Hurricane Irma struck a glancing blow ...

Sep 20, 2017

Energy Impact of Natural Hazards

- Resilience:
  - Being able to absorb, and very quickly recover from, hazard events

- Most developing countries and at risk regions in developed countries do not have a resilient enough power infrastructure

- Three main avenues for resilience:
  - Impact on transmission lines
  - Impact on power plants
  - Impact on fuel supply chains

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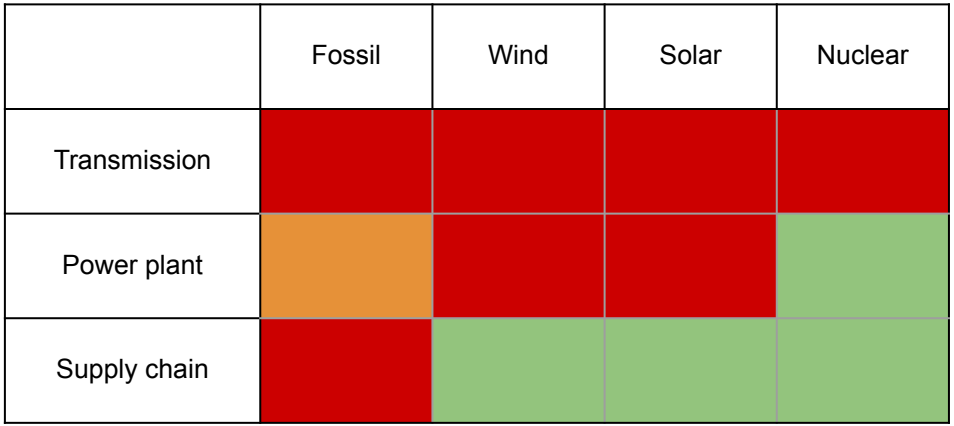
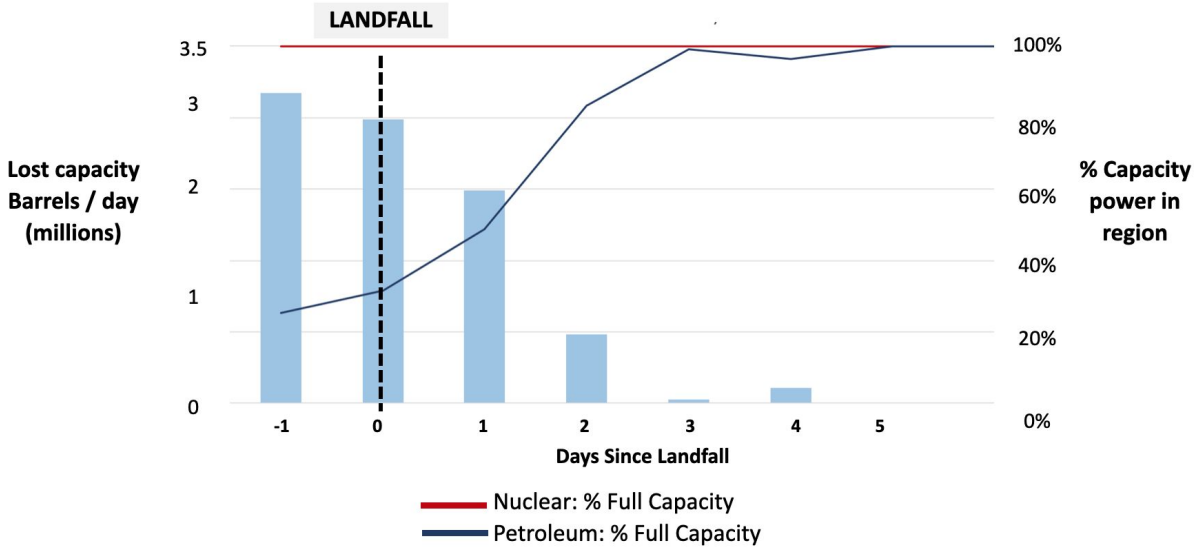


Context by example: Harvey

- Harvey hit Texas, USA on August 26, 2017
- Diverse energy sources allowing for anecdotal comparisons of impacts:
  - Oil/Gas shortages
  - High wind, no sun: renewables offline
  - Nuclear stayed online



Keeping climate change in mind

- Climate change will increase the frequency and severity of natural hazards

- Fossil fuels need to be replaced by carbon-free energy sources, notably:
  - Hydroelectricity
  - Wind
  - Solar
  - Nuclear

An Open ‘Green Energy’ Market

- Developing countries predominantly rely on fossil fuels
  - Imported fuel supply chain becomes a critical factor in the system resilience
  - Critical dependence on the road network

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- Nuclear energy is a clean and stable energy source
  - Designed to be resilient to external events
  - Remove the need for frequent refueling

Our Analysis

- Quantify the fossil fuel refueling risk
  - Stochastic method based on network analysis to assess the resilience of existing power infrastructure
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- Assess the SMR/MMR potential
  - Siting possibilities
  - Follow US Nuclear Regulatory Commission rules

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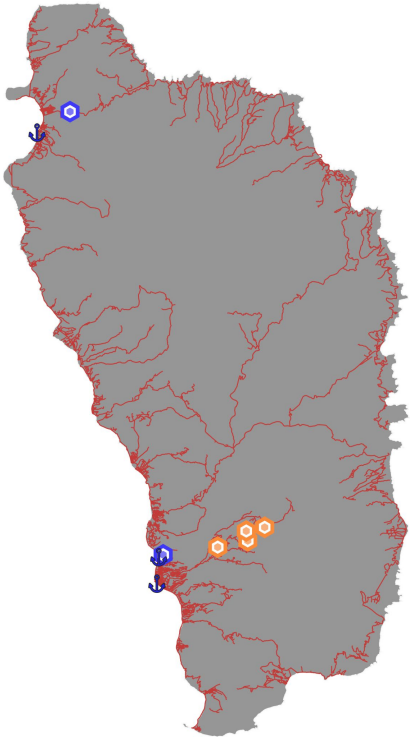
- Demonstrate on the Commonwealth of Dominica

Dominica

Existing Infrastructure In Dominica



Hydropower

Diesel plant

Seaport

2 Diesel plants:
- Fond Cole (south) → 13.3 MW
- Sugar Loaf (north) → 6.8 MW

Hydropower:
- Roseau river → 6.6 MW

3 Ports

Exposure Assessment and Informed Probabilities

*An example of road **exposure** to natural hazards*

Failure probabilities are obtained for each road segment

A: Road network

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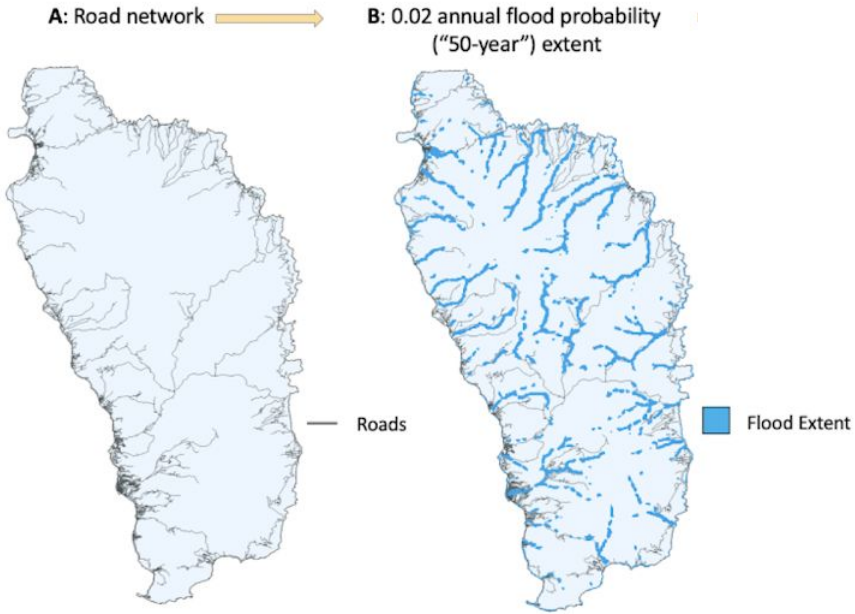

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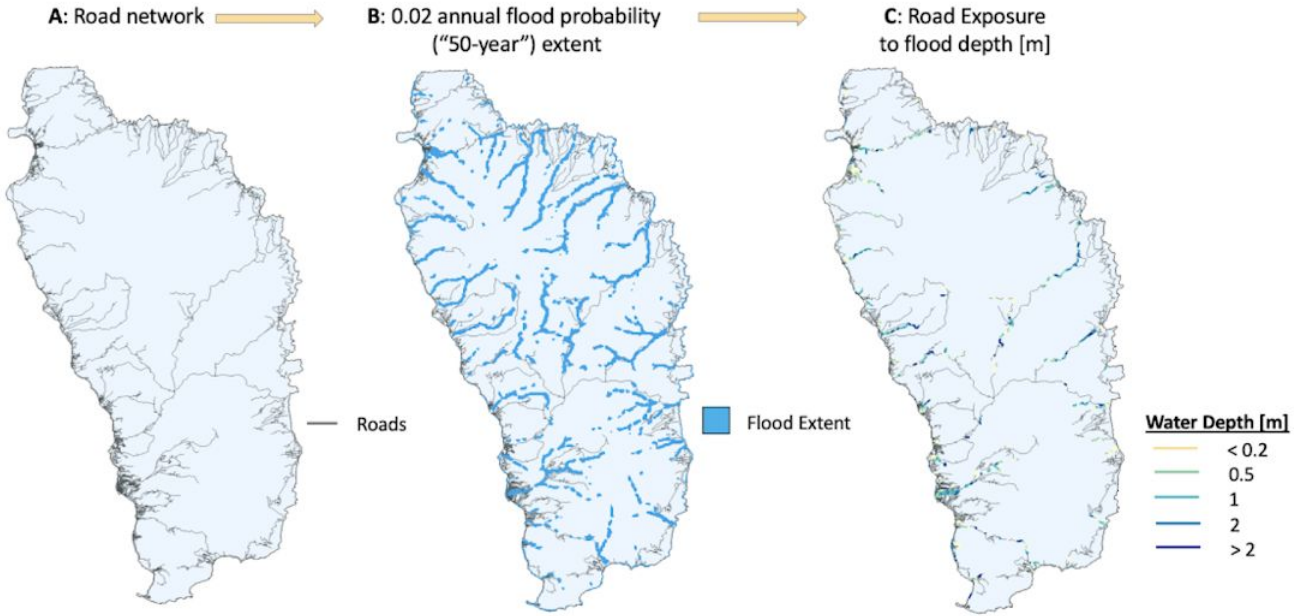

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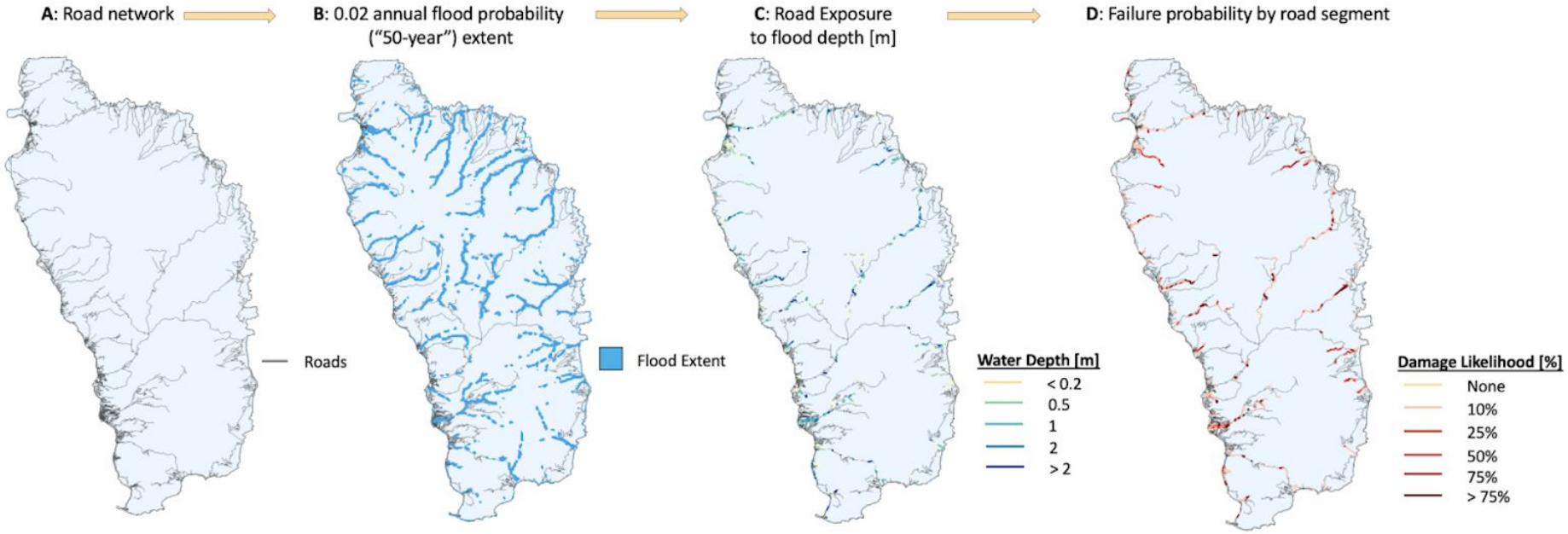

Exposure Assessment and Informed Probabilities

Monte Carlo analysis:

- *1000 simulations*
- *The network is disrupted according to the road segment failure likelihood in a 50-yr flooding situation.*
- *Supply chain impact is obtained (in terms of time)*

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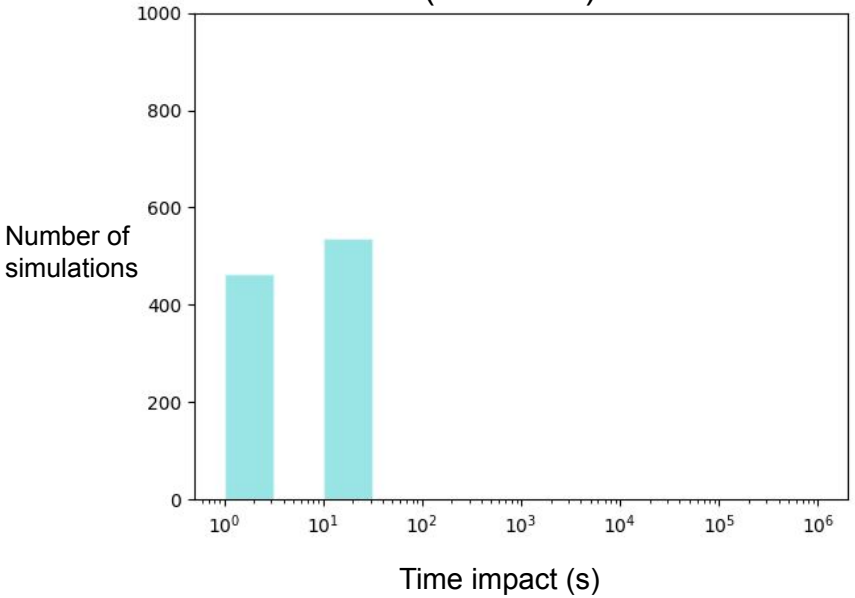
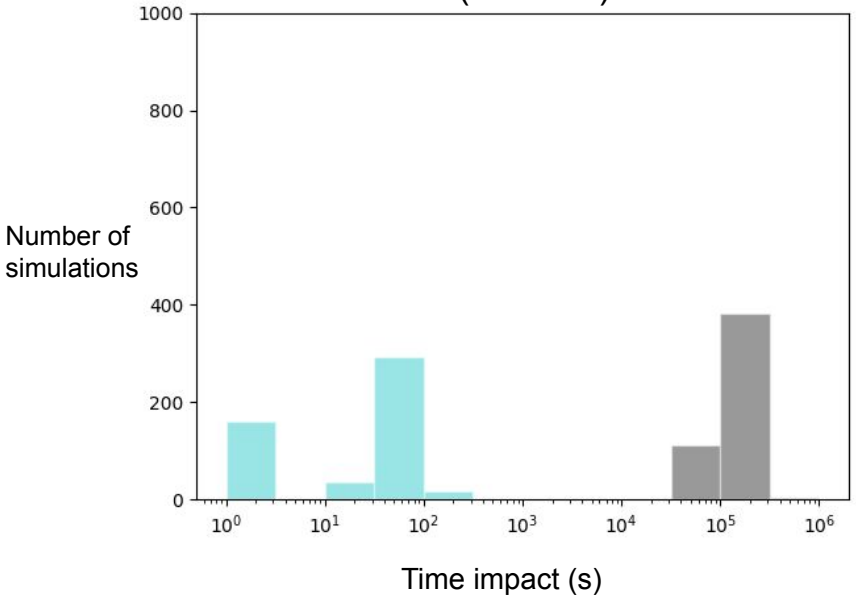
(13.3 MW)



Sugar Loaf
(6.8 MW)



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Stranded asset!

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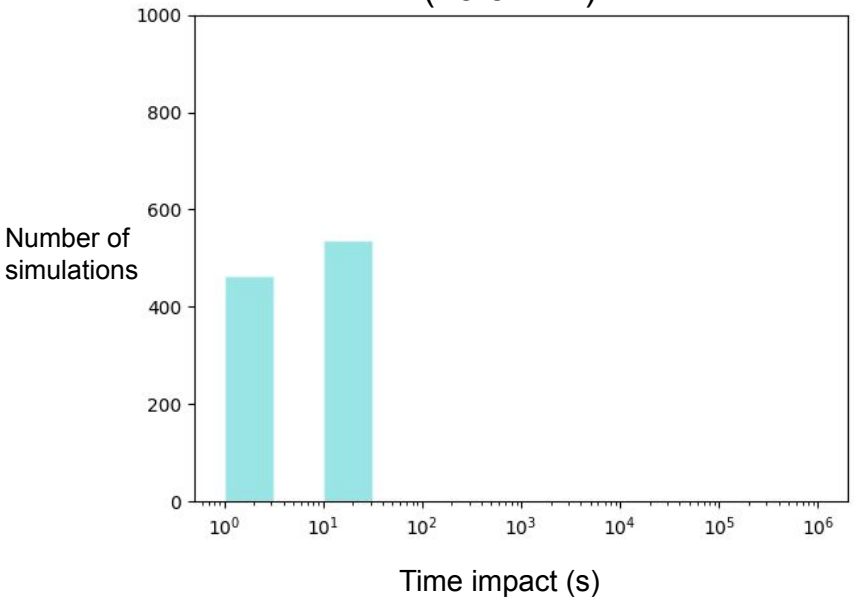

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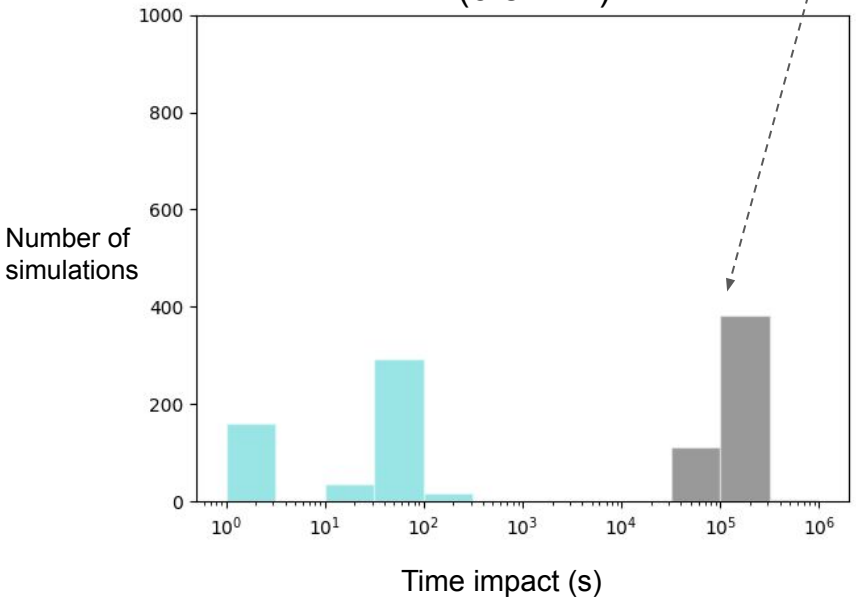

Market Opportunity For Nuclear Energy

- 20 MW of fossil fuel power to transition
  - 6.8 MW at high risk of supply disruptions
- Another 6.6 MW at high flooding risk (run-of-the-river hydro plants)

- Between 6.8 and 26.6 MW market on this developing island nation

Local Potential of Nuclear Energy

- The potential of Small Modular Reactor (SMR) is assessed locally
  - Using NRC siting regulations, find siting locations of interest to show viability

- Use Geospatial Information System analysis
  - Combine all relevant map data layers to reveal suitable nuclear siting locations

Consideration of NRC Equivalent Siting Rules for SMR

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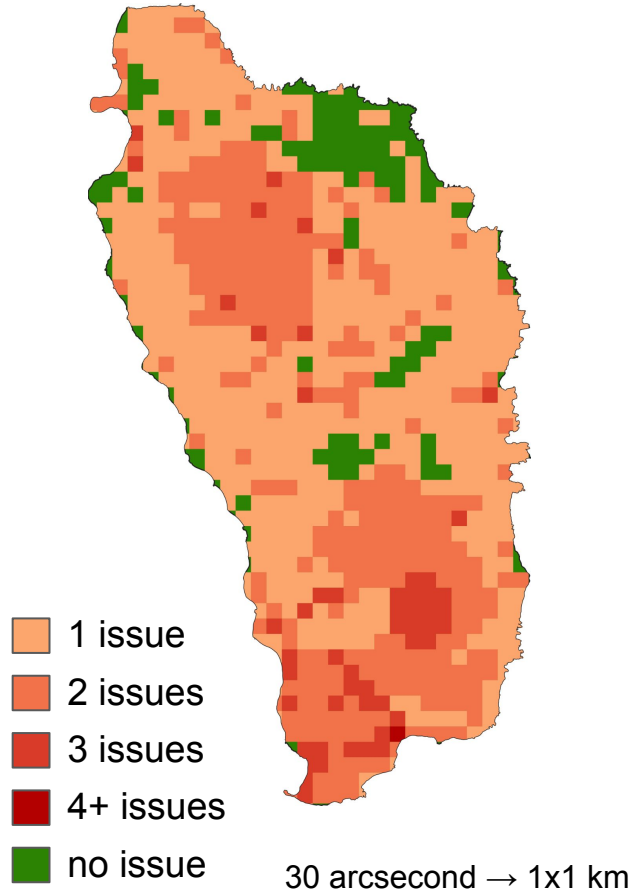
- Land within a volcanic high risk area is excluded.

Siting Potential for Small Modular Reactor



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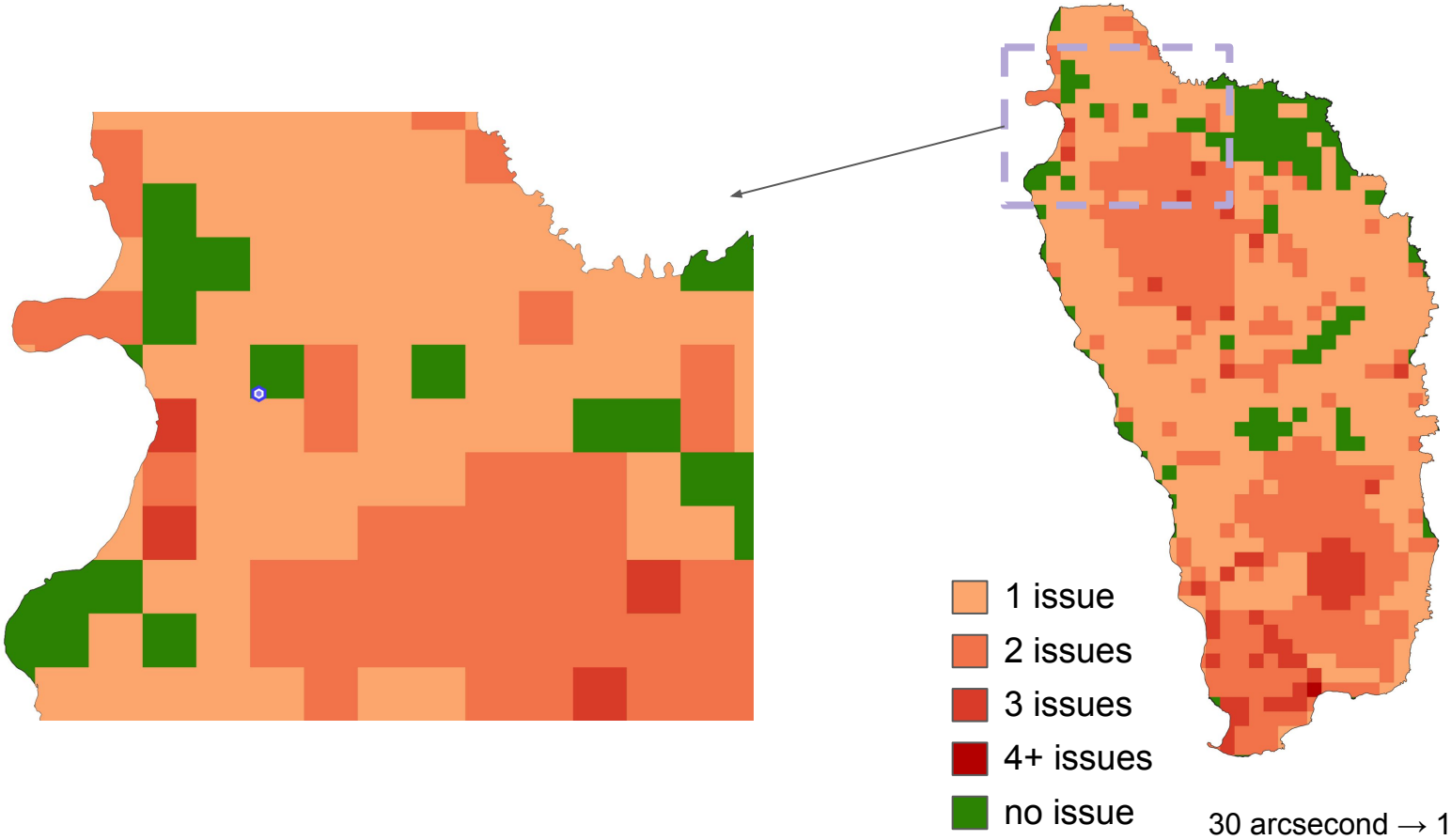

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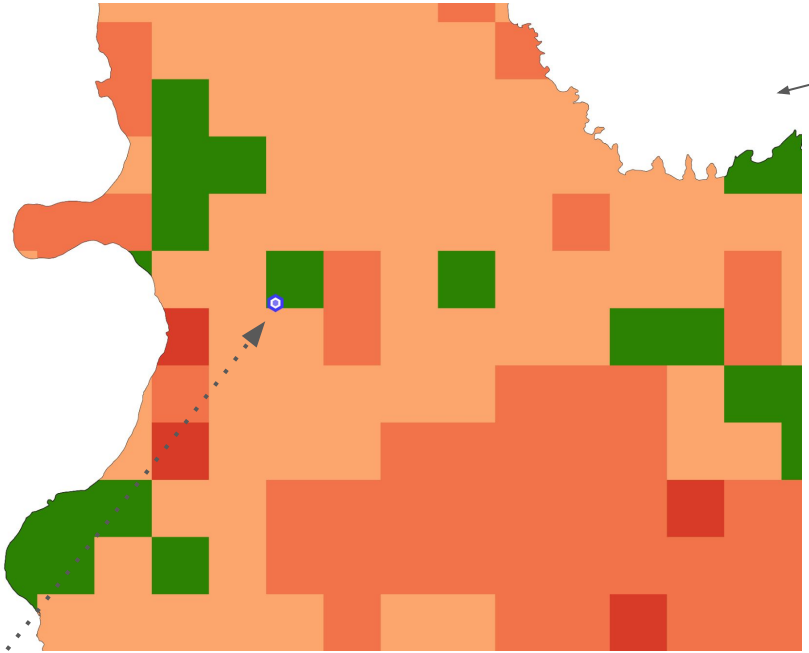

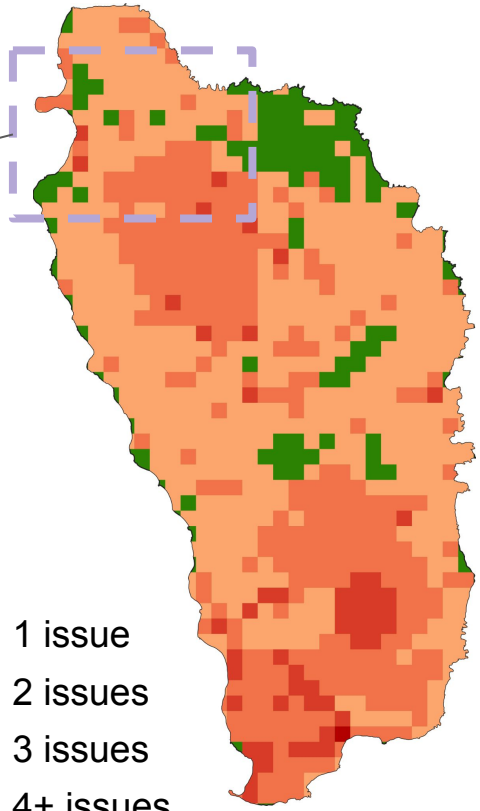

1 issue
2 issues
3 issues
4+ issues
no issue

30 arcsecond → 1x1 km

Sugar Loaf power plant site infrastructure could even be reused for a small modular reactor

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  - Responsible (clean, and plays well with renewable energy microgrids)
- Emerging grids: SMR and MMR market
  - Adapted to small grids in development
  - Scalable
  - Suitable locations exist