

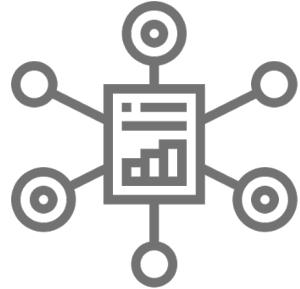
Lifelines, Losses, Livelihoods

A globally consistent model for Critical Infrastructure Failures & Basic Service Losses.

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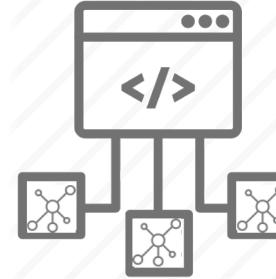
Conceptual Overview



Literature:
CI dependencies

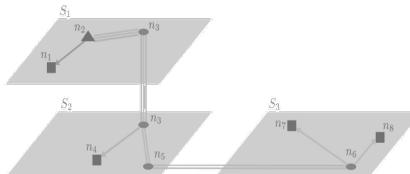


Data Collection:
Infrastructure Systems



Model build:
Infrastructure Networks

**Direct damages,
Failure Cascades,
Basic Service Losses**

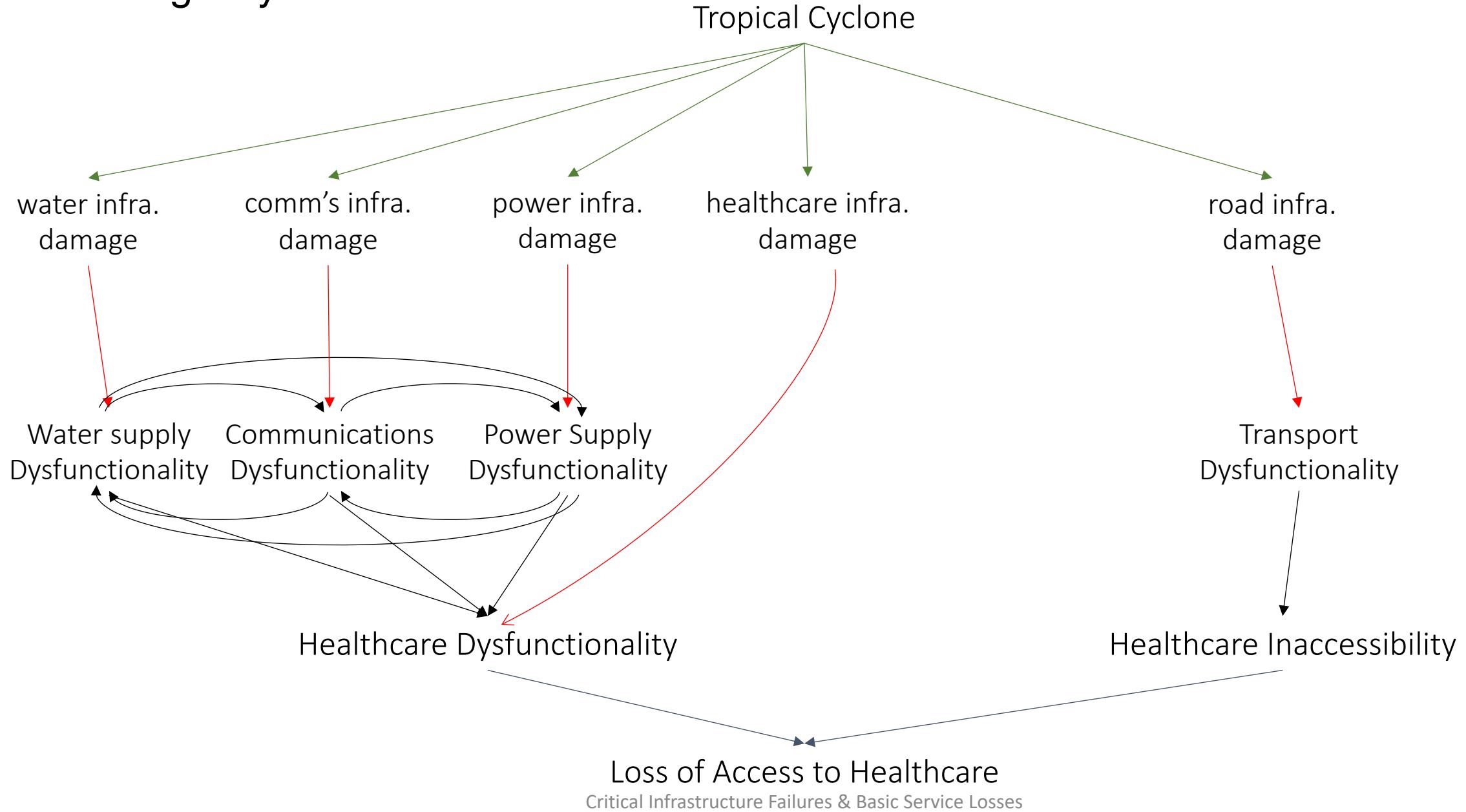


from: Thacker *et al.* 2017

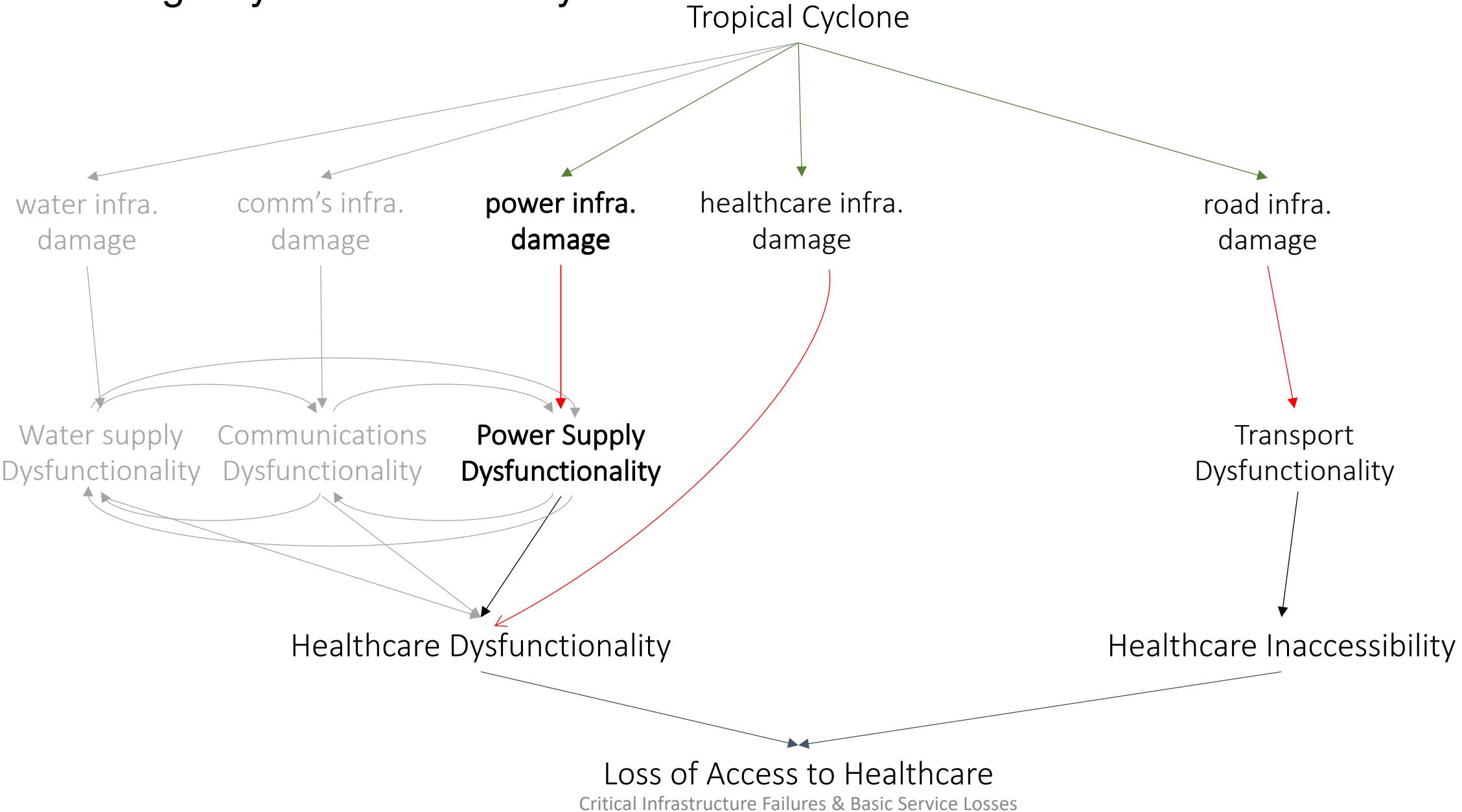
Hazard footprints



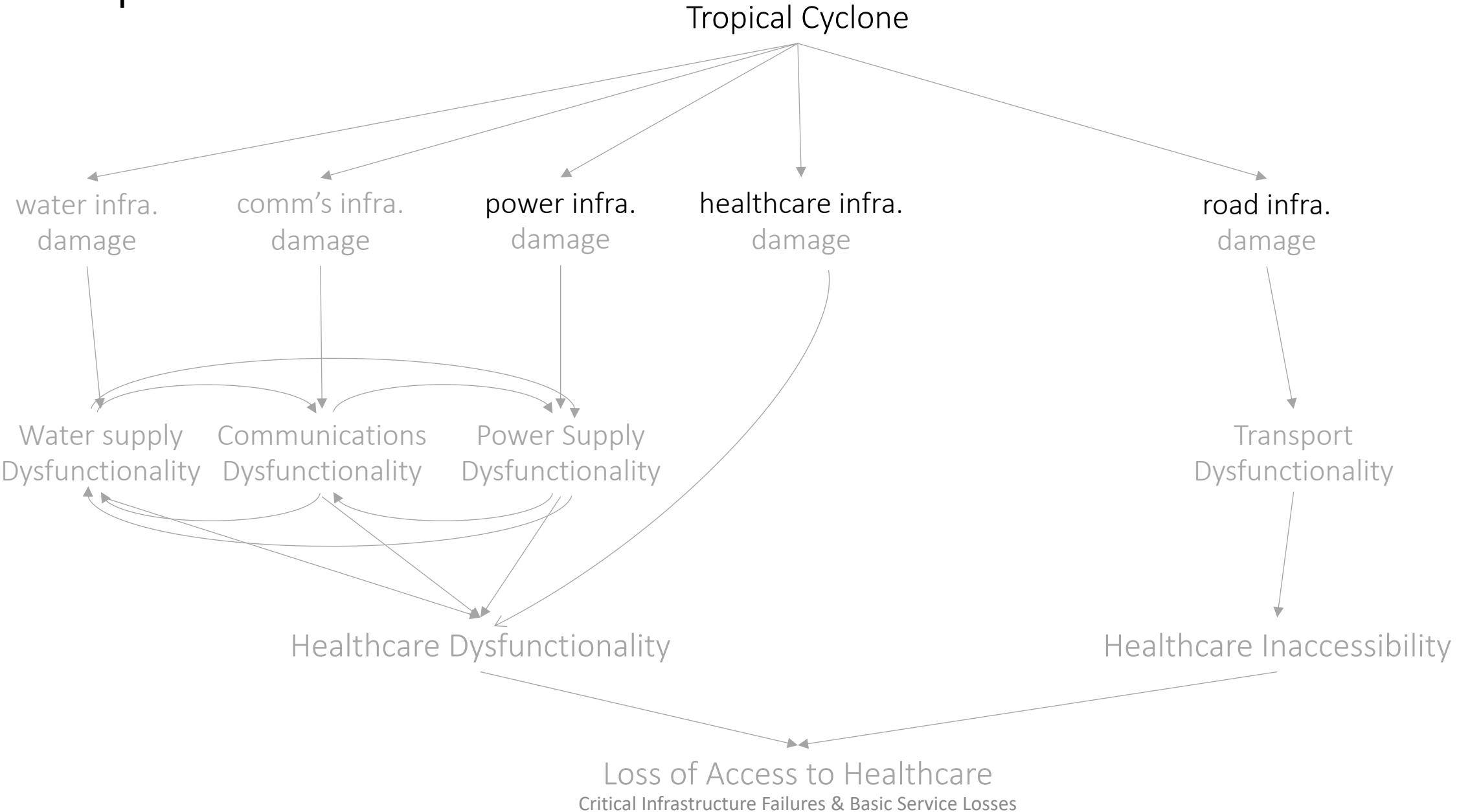
A long way



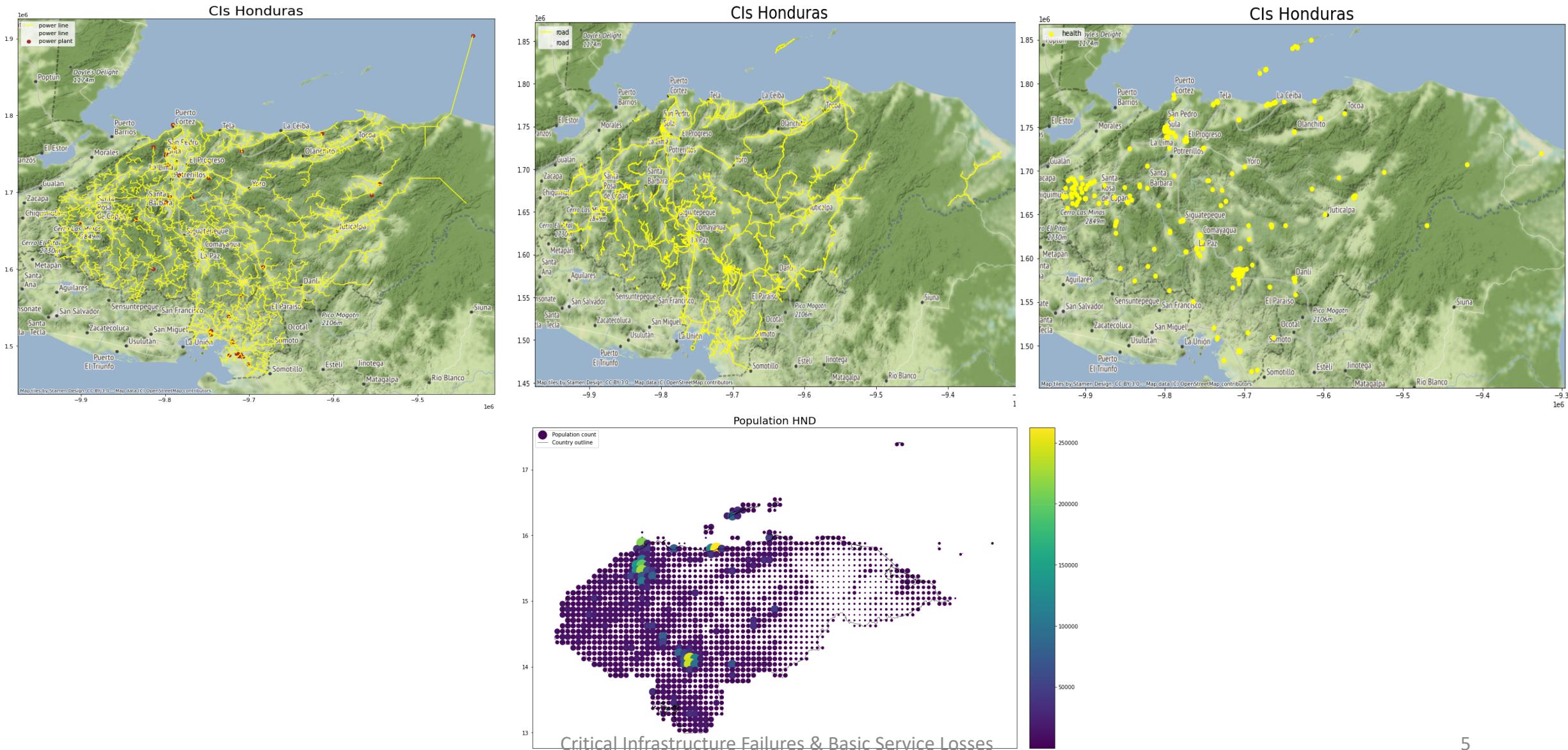
A long way – covered today



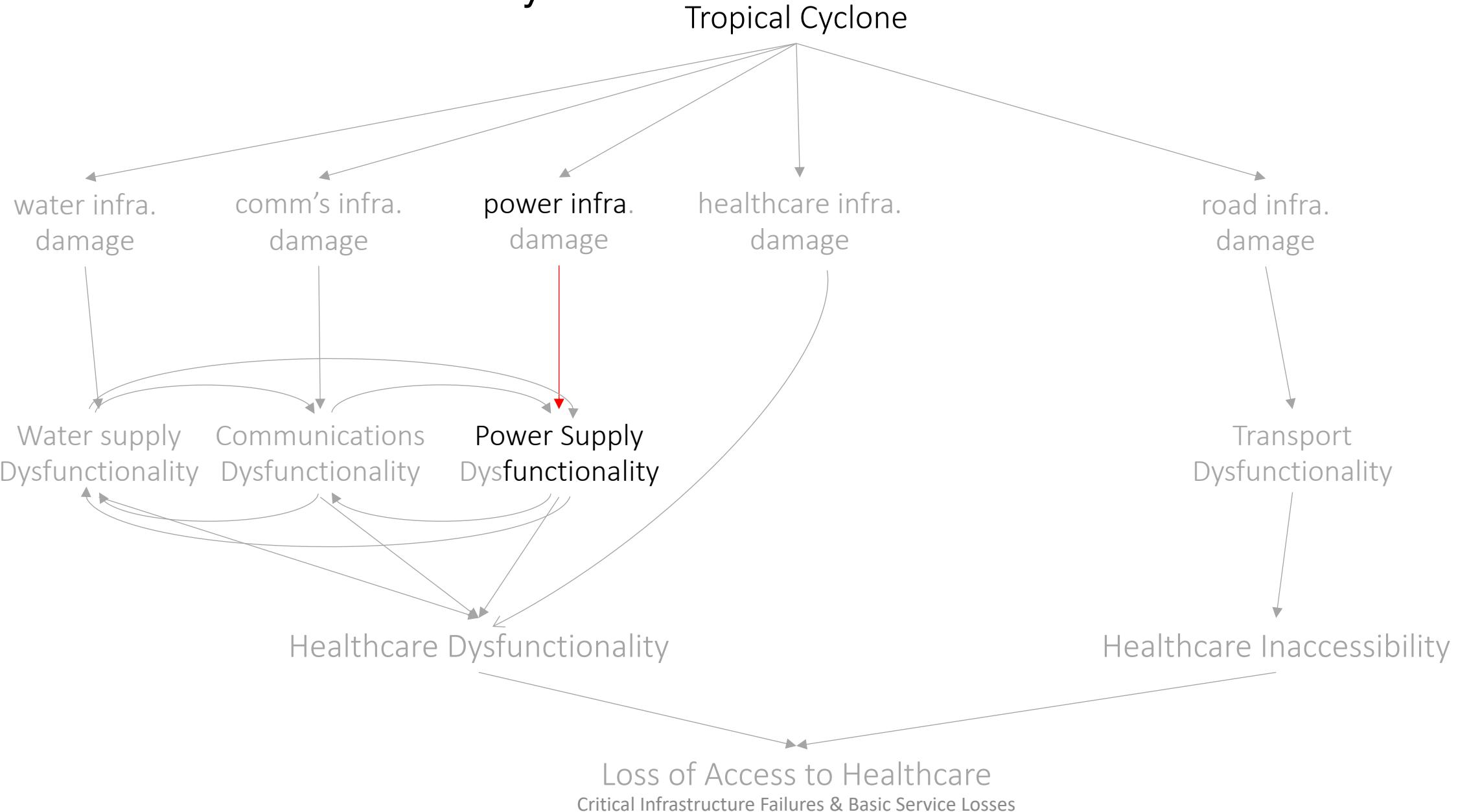
Exposure



Exposure



Infrastructure functionality

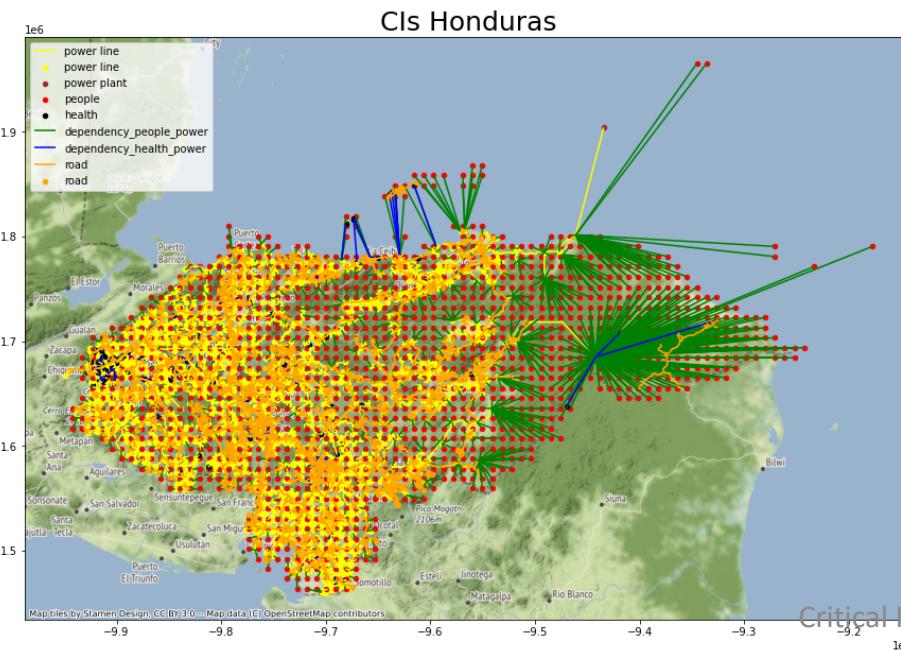


Exposure Network & Infrastructure Functionality

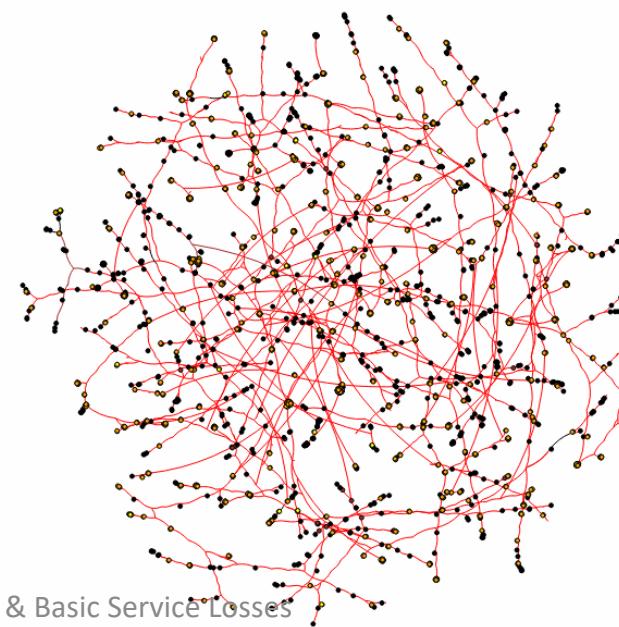
5 sub-networks (People, power lines, power plants, roads, health facilities) with 6 dependencies:

- People ($10 \times 10\text{km}$) → closest node in power line network [*PL demand*]
- Power plants → closest node in power line network [*PL supply*]
- Health facility → closest node in PL demand
- People → closest node in road network
- Health facility → closest node in road network
- People → all health facilities $< 100\text{km}$ road distance

39'260 edges, 8'177 nodes (fully connected)

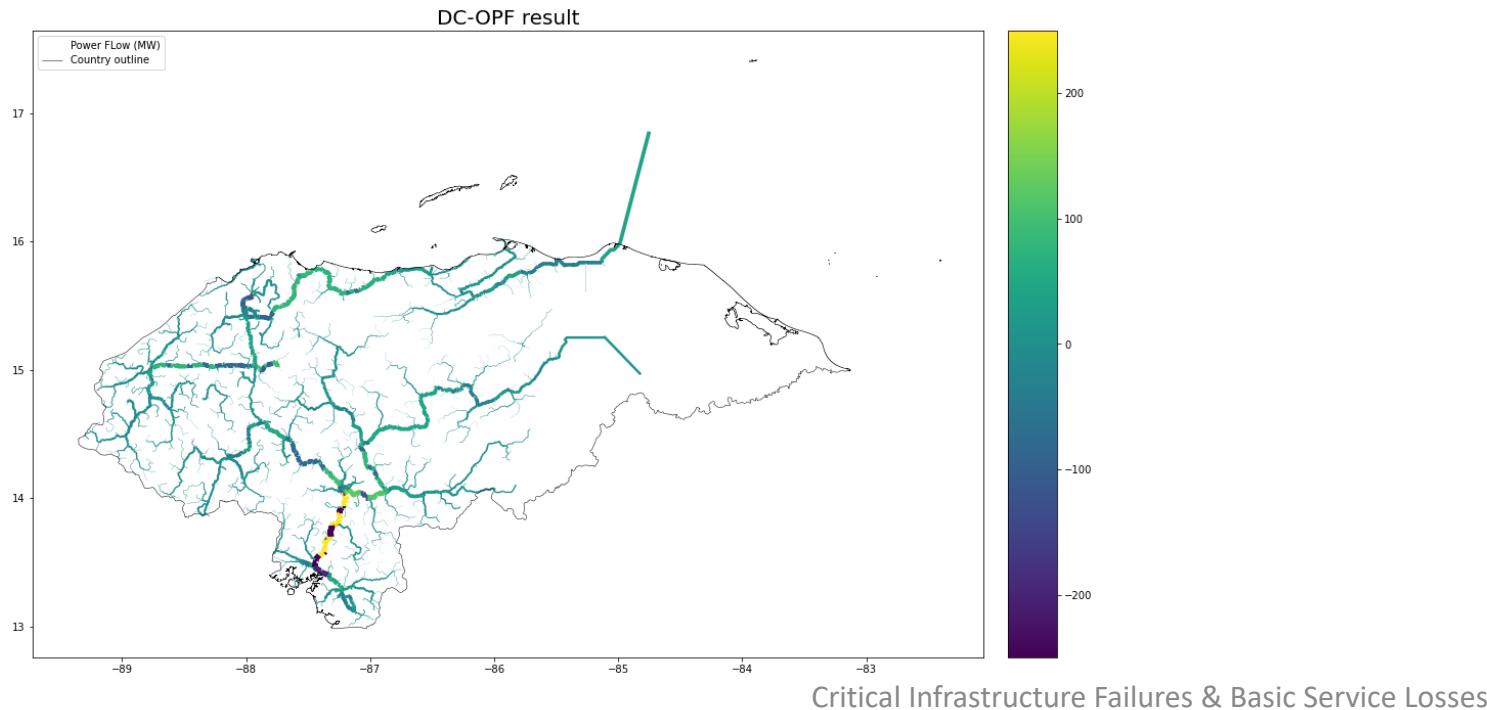


Critical Infrastructure Failures & Basic Service Losses

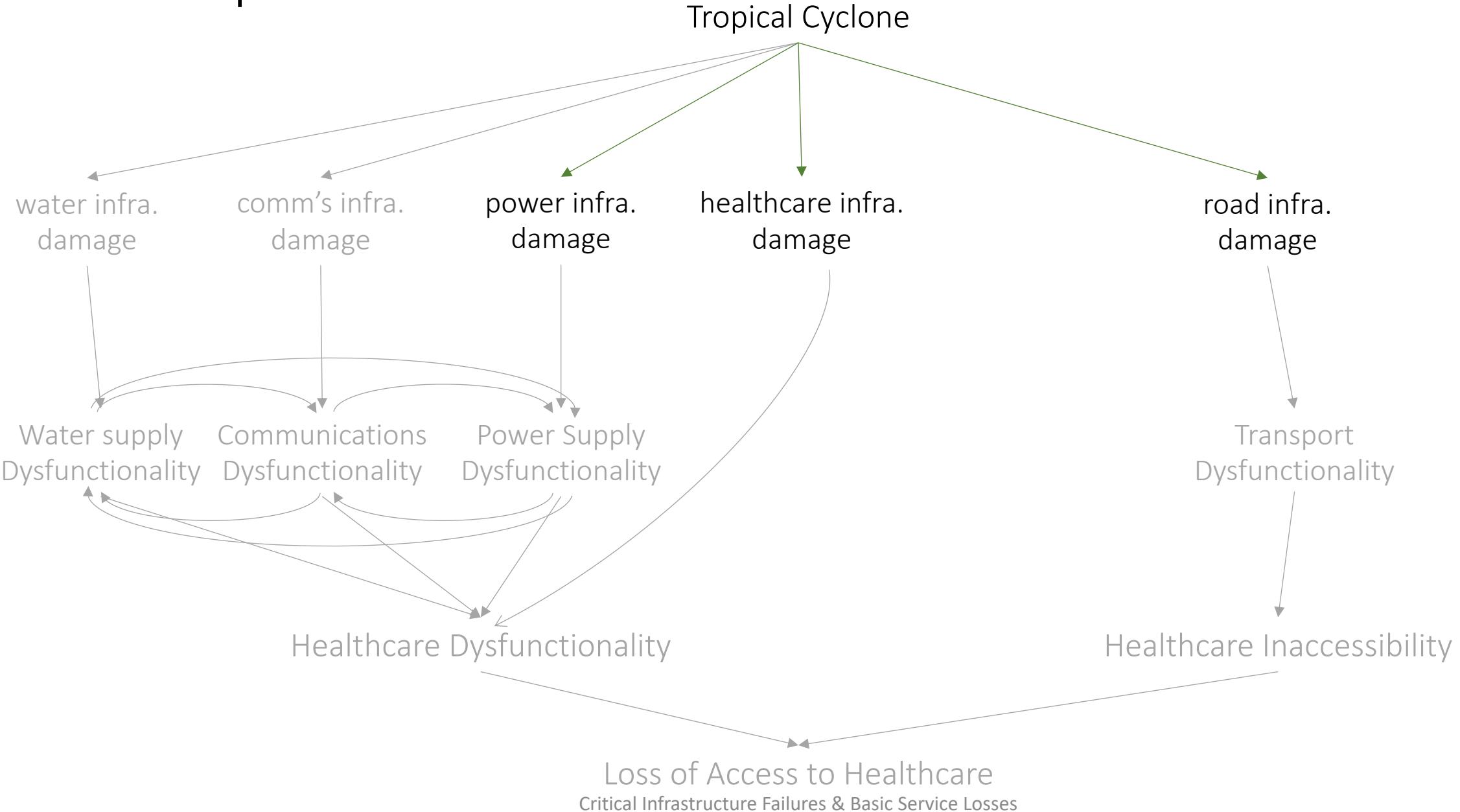


Exposure Network & Infrastructure Functionality

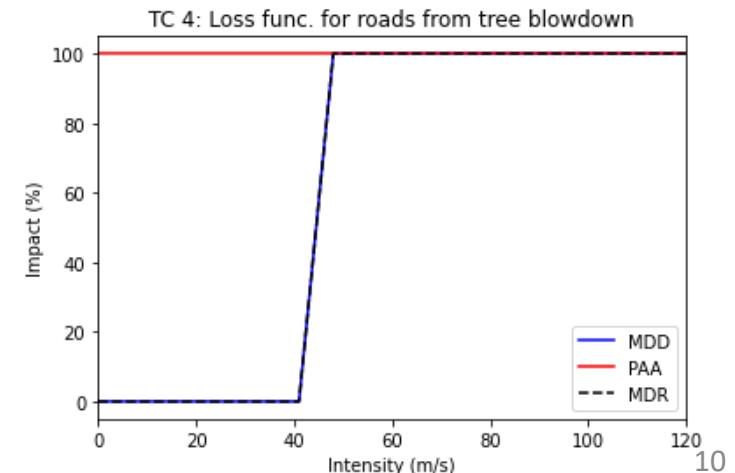
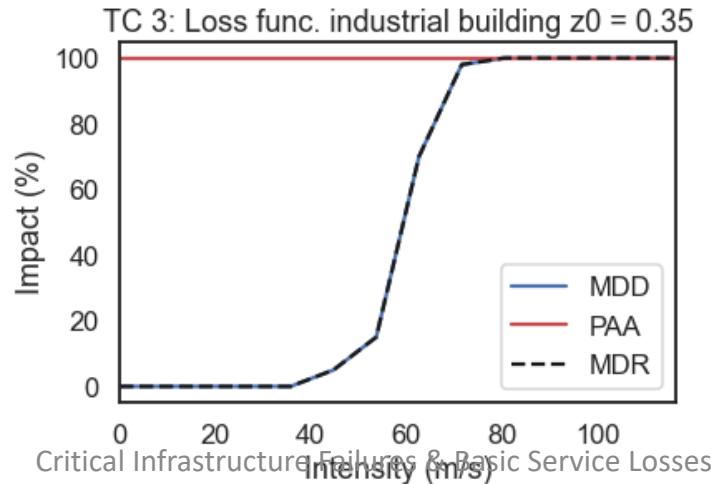
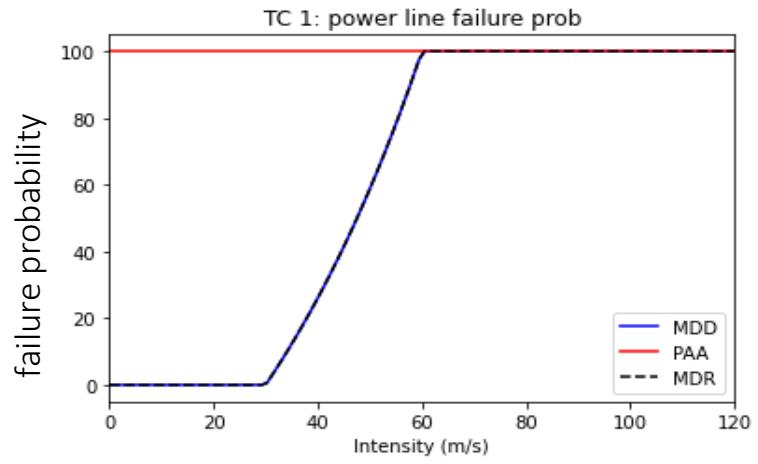
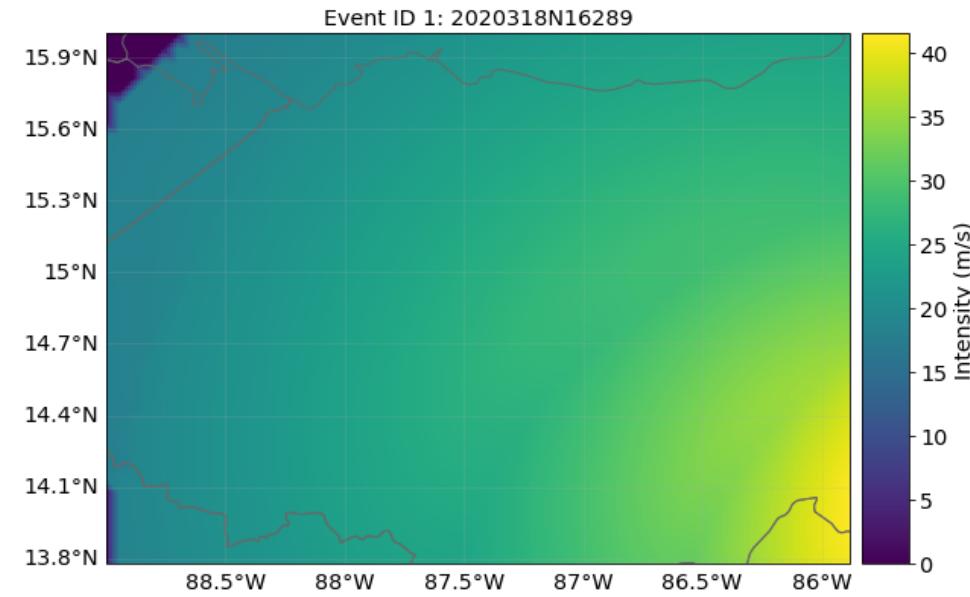
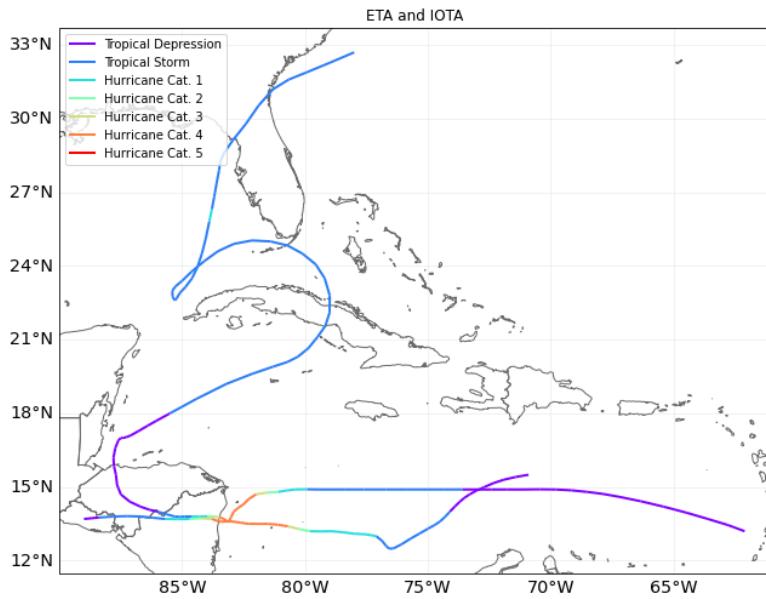
- Power Network supply
- Power Network demand
- Power flow optimization vs. cluster approaches vs. network flow w/ constraints



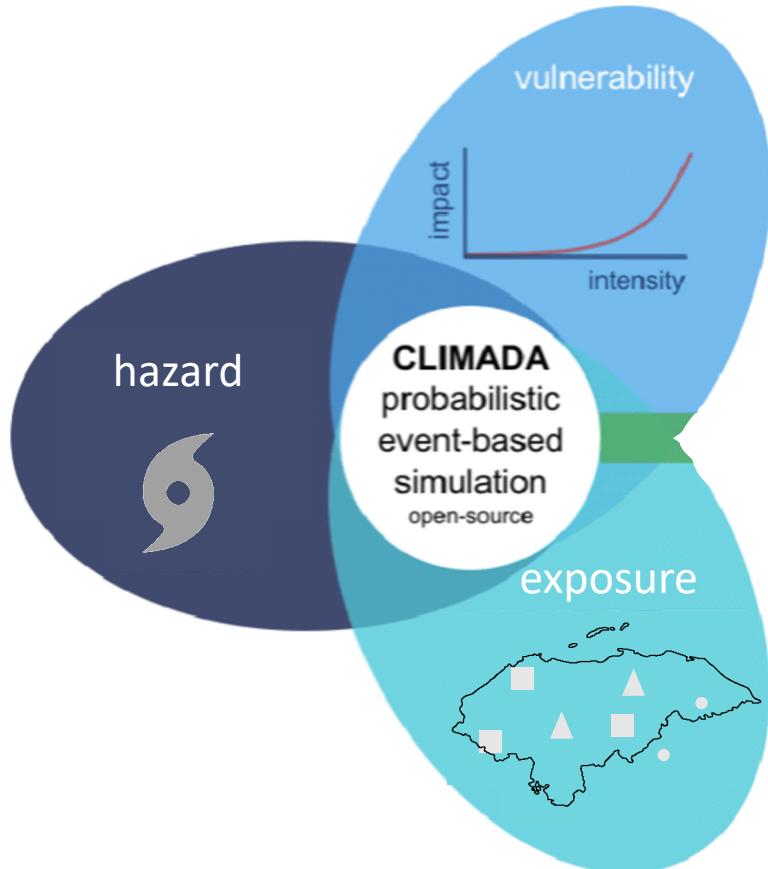
Direct Impacts



Hazard (TC Iota) & Vulnerability (Power lines, Hospitals, Roads)



Direct Impacts

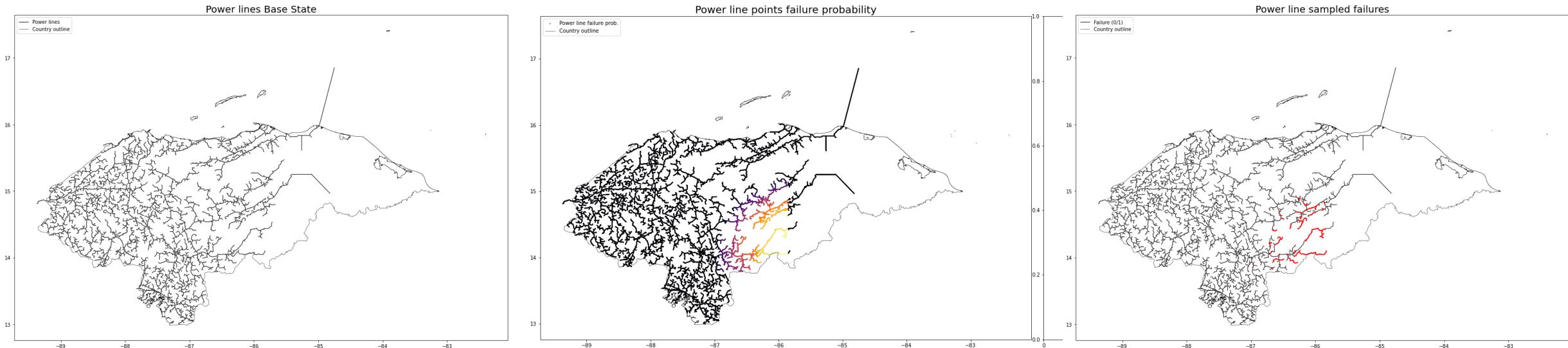


Aznar-Siguan, Gabriela, and David N. Bresch. 2019. "CLIMADA v1: A Global Weather and Climate Risk Assessment Platform." *Geoscientific Model Development* 12 (7): 3085–97. <https://doi.org/10.5194/gmd-12-3085-2019>.

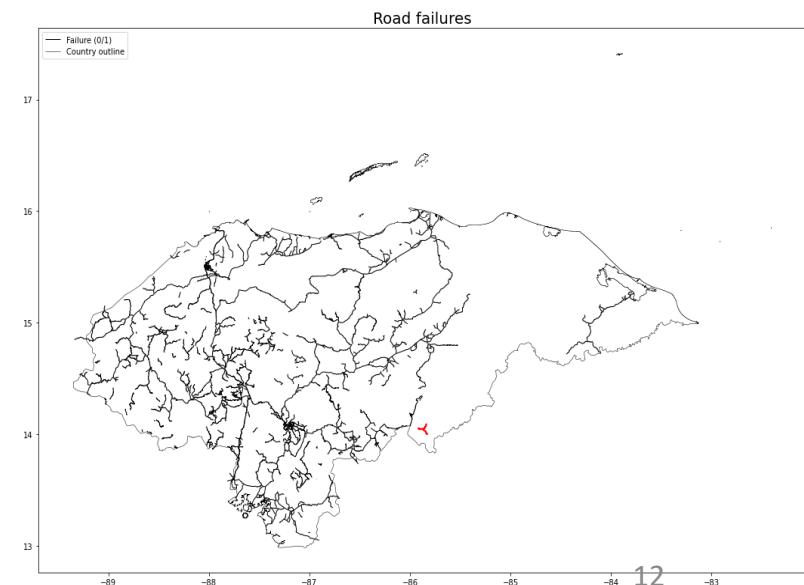
[CLIMADA overview](#)

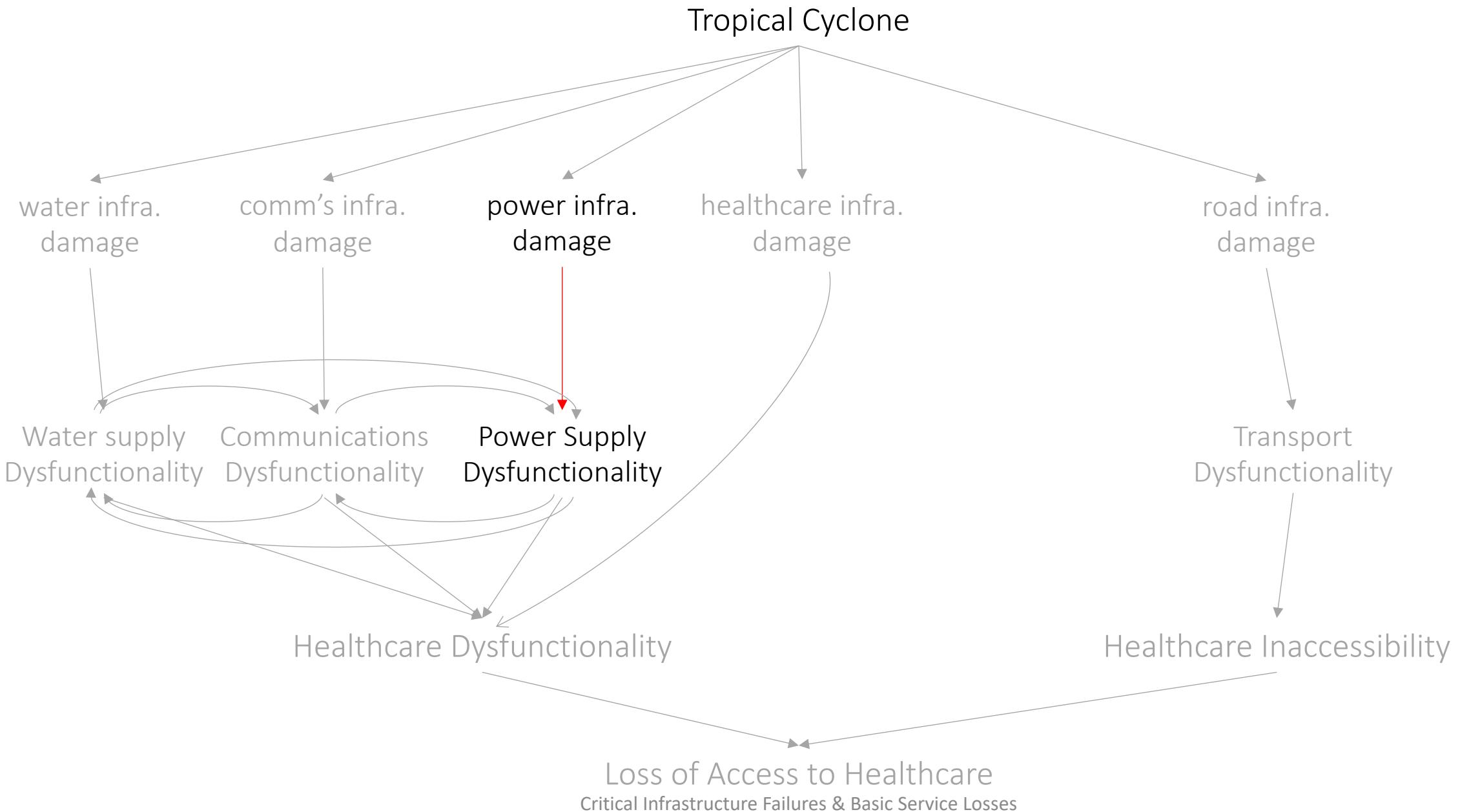
[CLIMADA on GitHub](#)

Direct Impacts

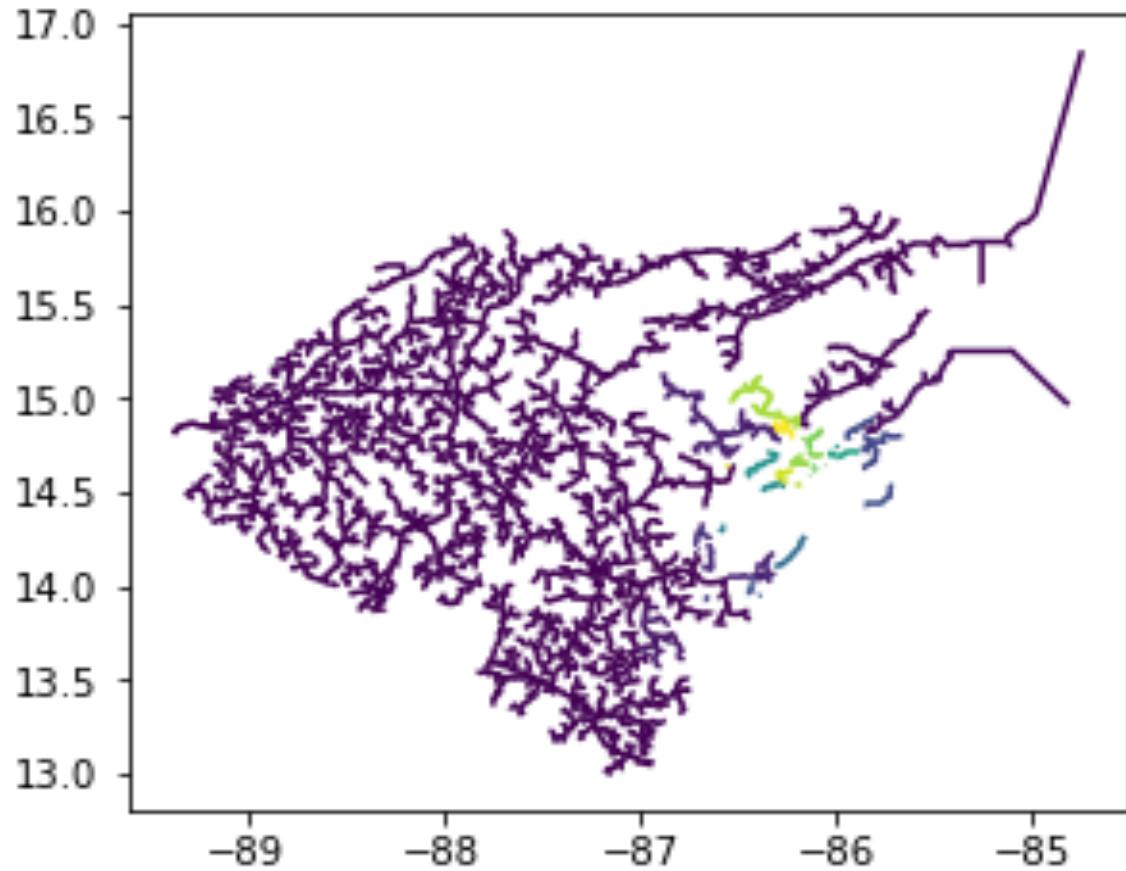


Power Lines: 451 km out of 13'070 km
Healthcare Facilities: 0 out of 356
Road: 24 km out of 9'907 km

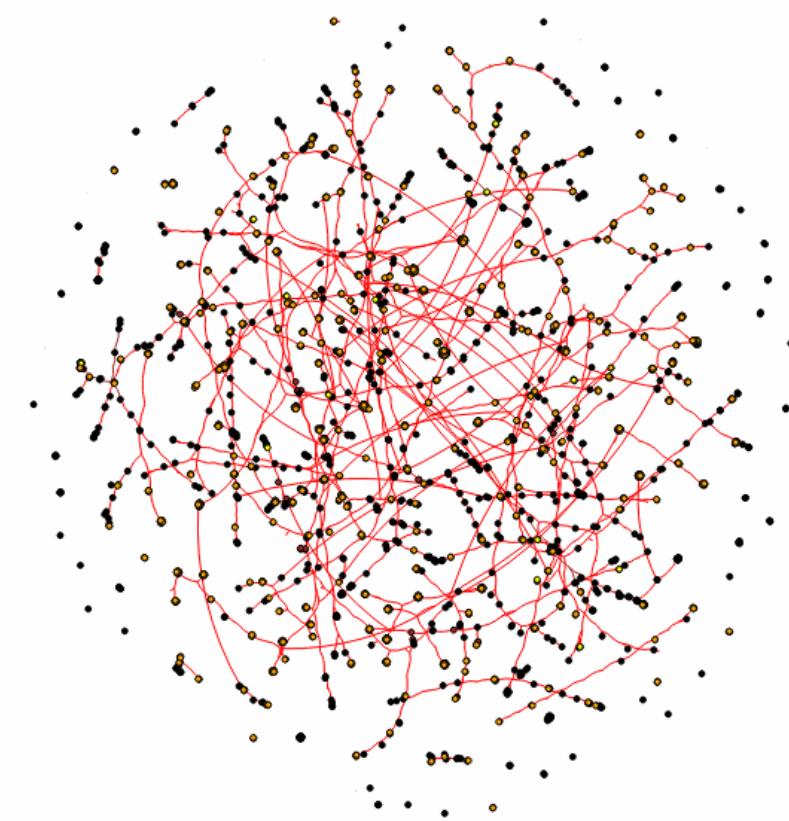




Network impacts (I) - Cluster-wise supplies & demands

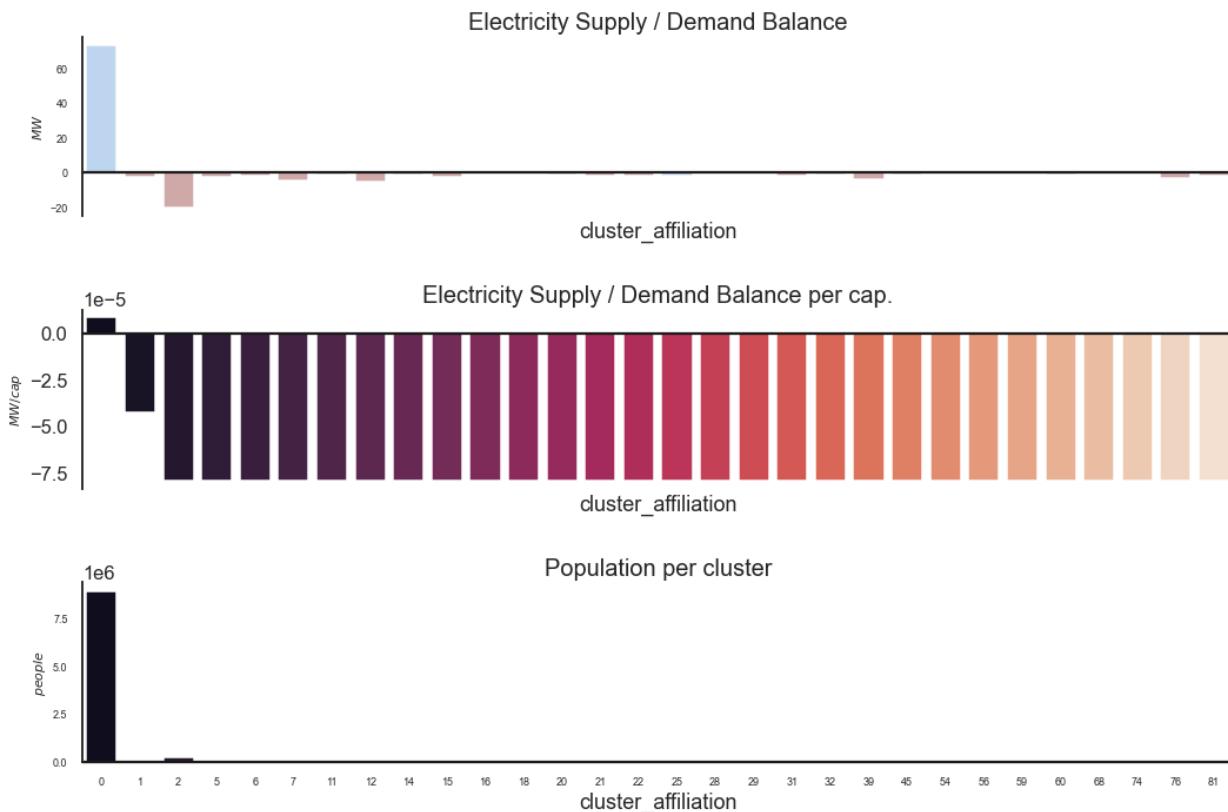


remaining powerlines, by cluster (29)



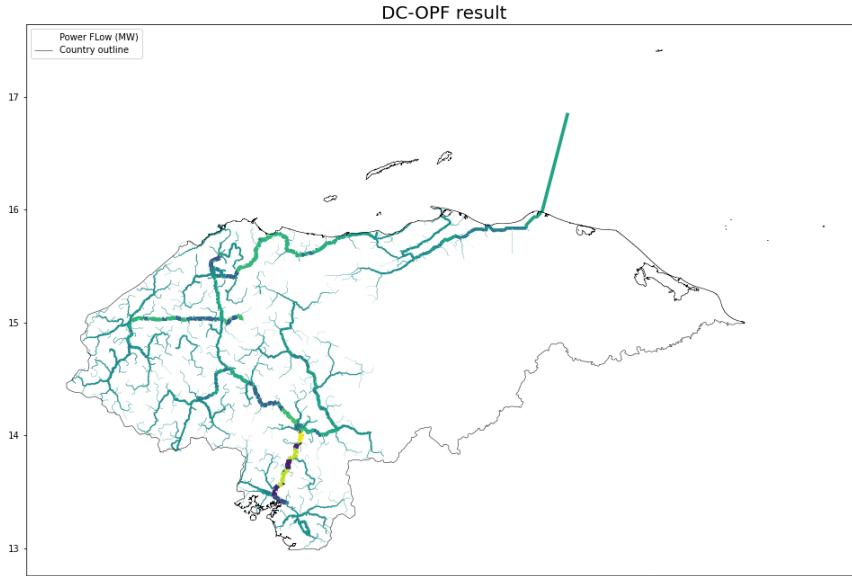
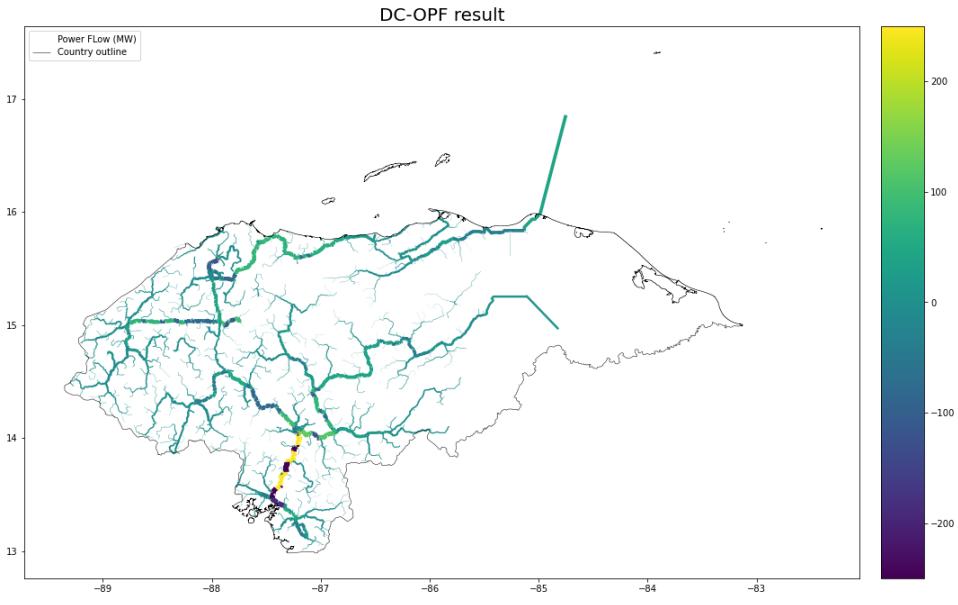
entire graph, after

Network impacts (I) - Cluster-wise supplies & demands

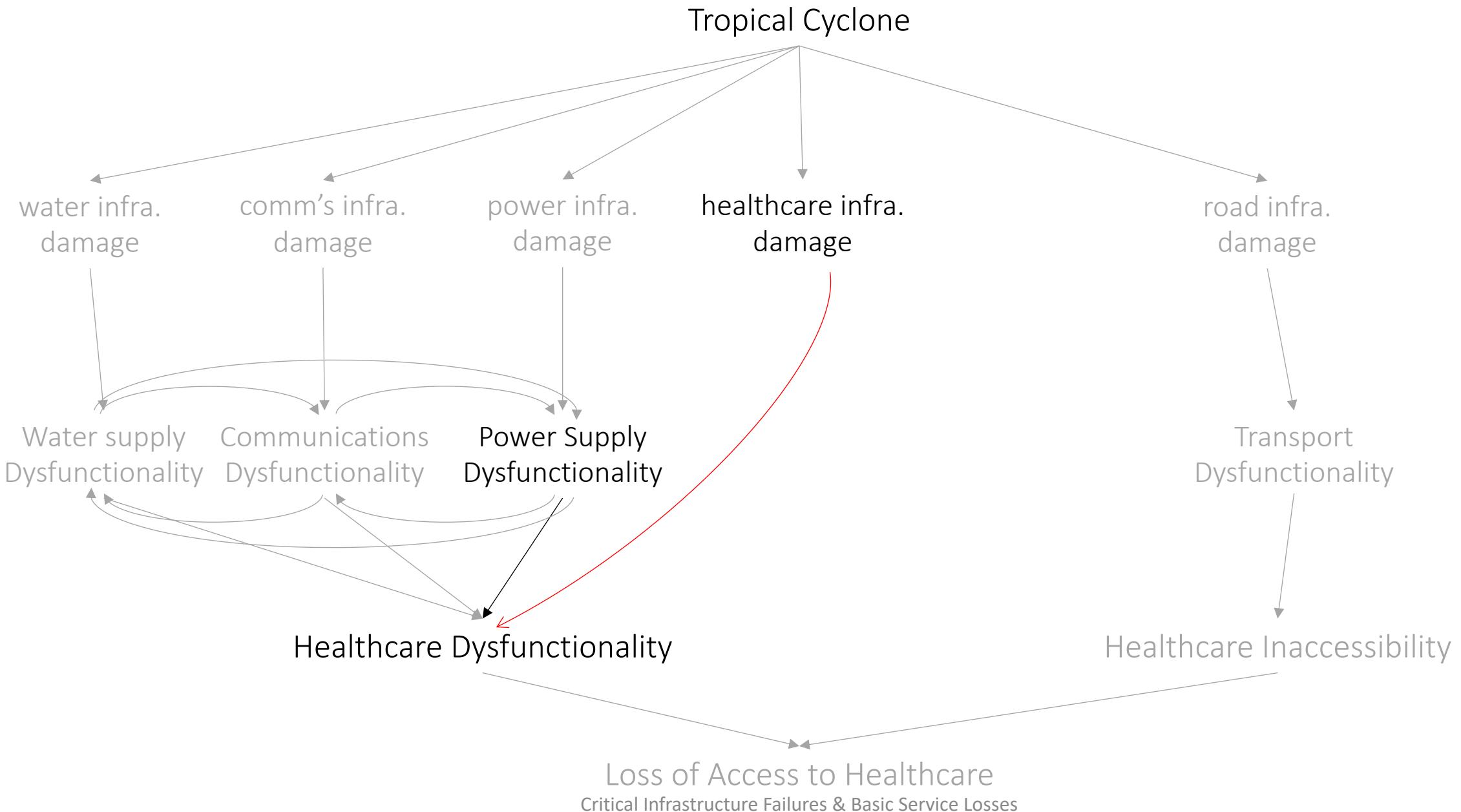


Demand	"Actual" Supply	Under-served pop.	Non-served pop.	Non-served health f.
base state				
785 MW	785 MW	0	0	0
disrupted state				
785 MW	785 MW	54'731	901'441	20

Network impacts (II) – Power Flow Optimization



Demand	"Actual" Supply	Under-served pop.	Non-served pop.	Non-served health f.
base state				
785 MW	785 MW	0	0	0
disrupted state				
785 MW	710 MW	0	956'173	20

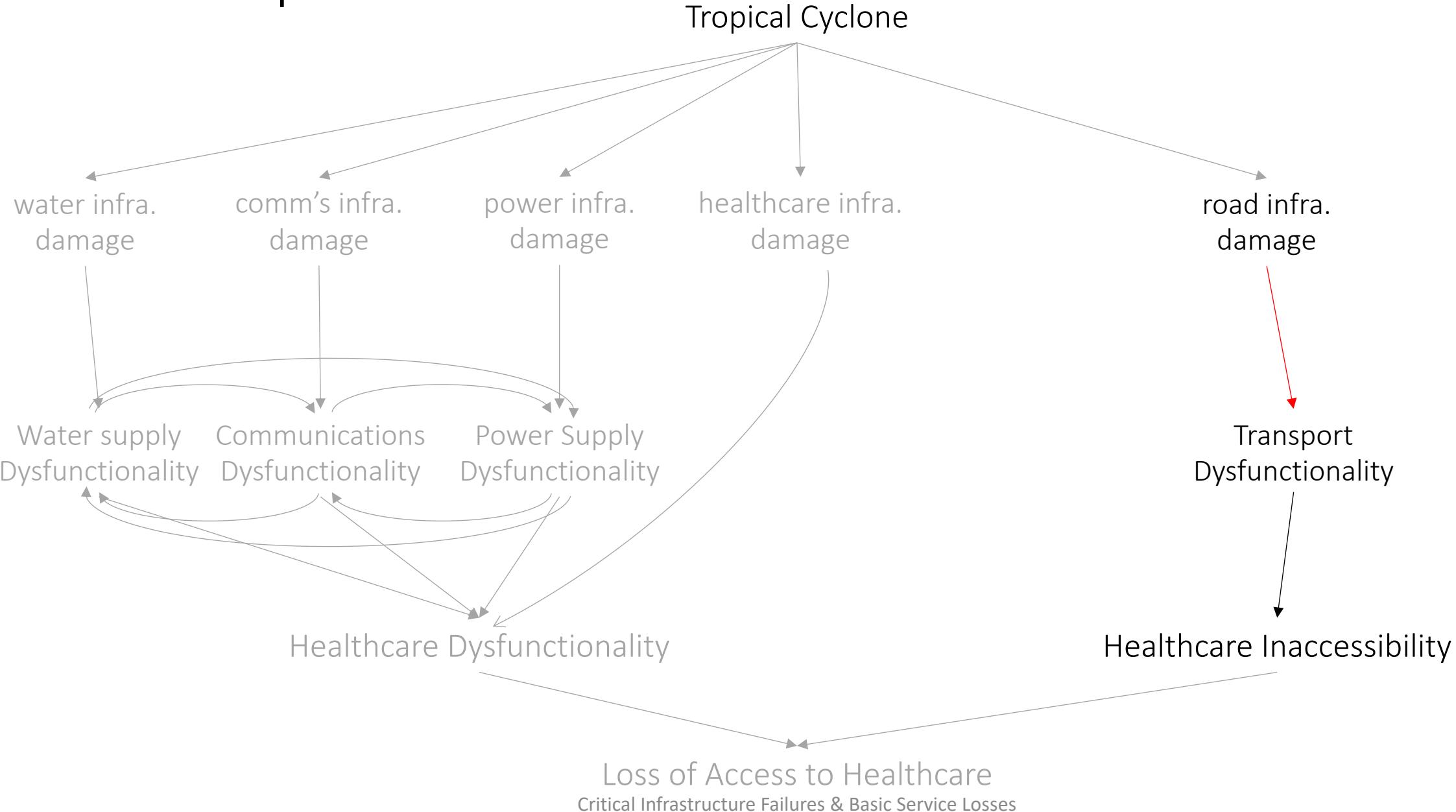


Network Impacts – Healthcare dysfunctionality

Simple & arbitrary “threshold approach” for healthcare

- Binary (functioning / non-functioning)
- From direct damage: if asset damage > 30%
- From power loss: if supply < 80%

Network Impacts



Network impacts— Transport functionality, healthcare accessibility

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- People → closest node in road network
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Functionality:

Simple threshold approach:

Non-functional if road section $> 30\%$ damaged

Accessibility:

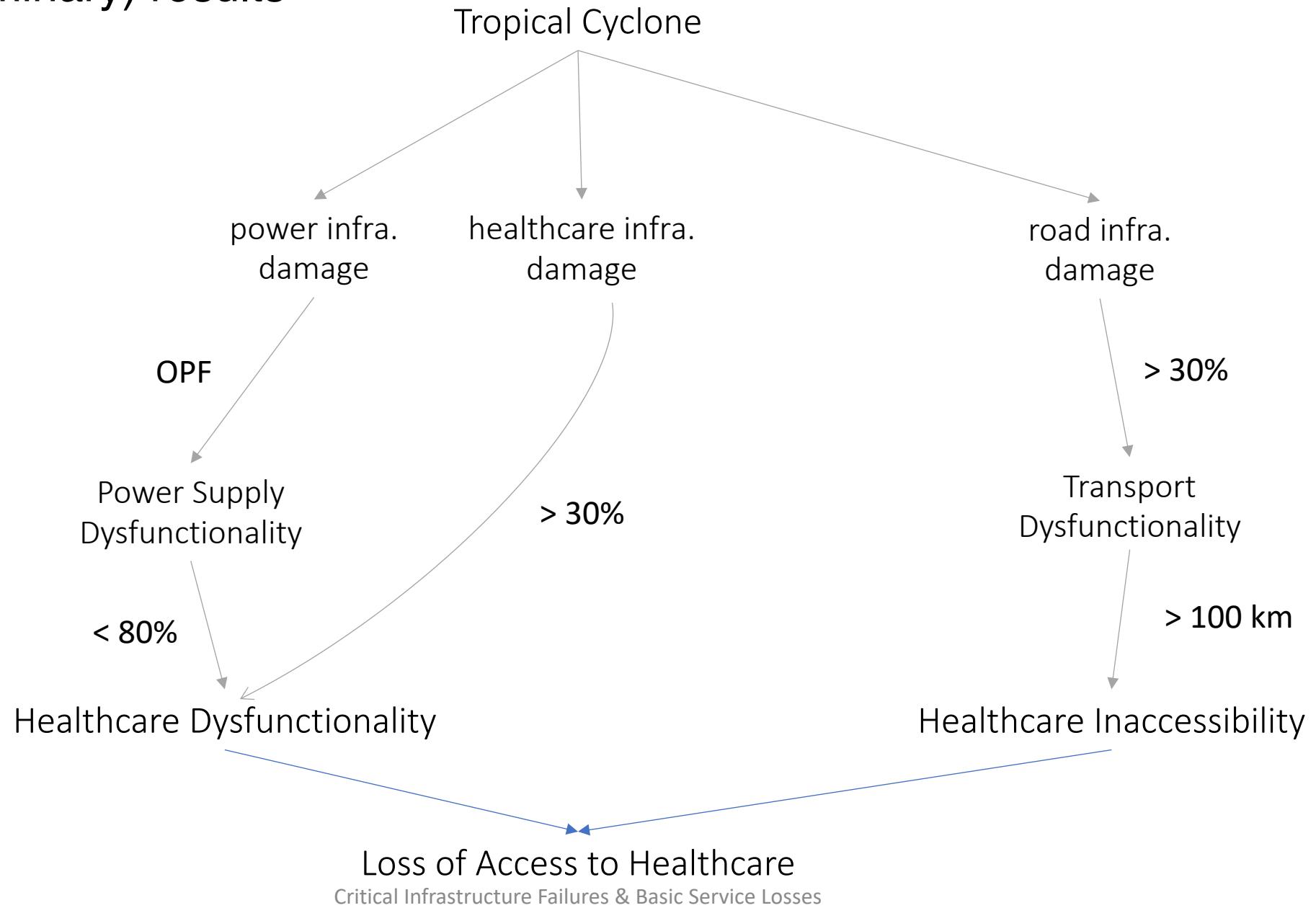
Shortest path-approach:

Accessible if travel distance on roads $< 100\text{ km}$

People w/o transport access to healthcare at base state: 138'000

People w/o transport access to healthcare at disrupted state: 138'200

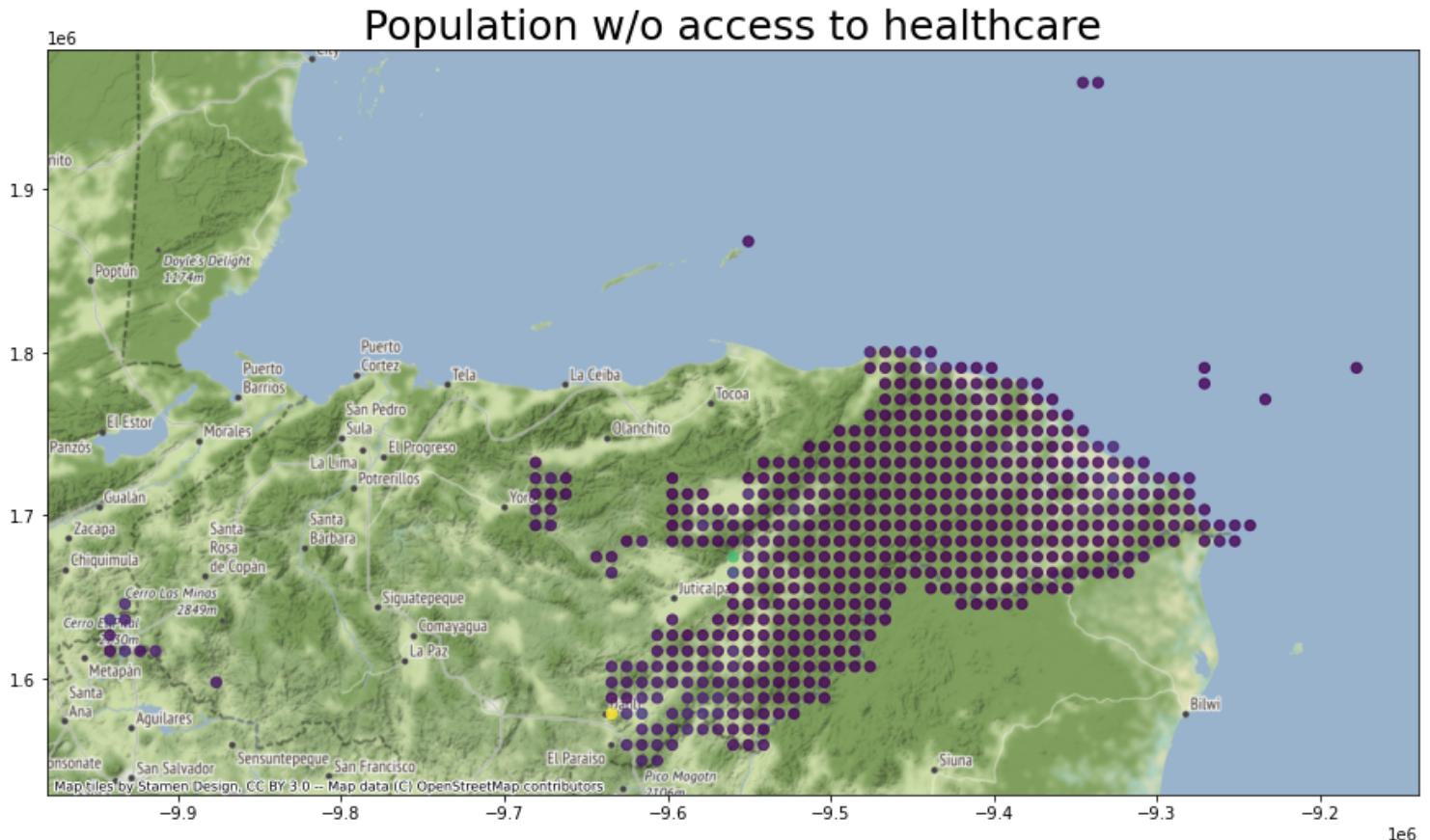
Final (preliminary) results



Final (preliminary) results

People experiencing loss of healthcare access
("> 100 km travel distance to a hospital that is < 30% damaged and has > 80% of usual power supply")

770'785 (Δ 632'785)



Wrapping up..

- Current work update & a few learnings on the way
 - It's a long way from hazards to basic service inaccessibility
 - There's lots of assumptions and un-verified / unknown steps, especially on the infrastructure *functionality* side
 - A basic calculation chain using both impact modelling & graph theory leads somewhere (proof of concept)
- A look ahead
 - Integrating feedback loops into failure mechanisms
 - More & better data on vulnerability & functionality
 - Verification
- Your inputs, ideas and questions

