ETH zürich

Weather and Climate Risks Group

Critical infrastructure failure cascades & basic service losses: A globally consistent model.

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1 Introduction

The gaps:

- Natural hazard risk models often focus on direct damages only, ignoring system-dynamics within critical infrastructures[1,2] (CIs).
- CI models are often small-scale, specific to proprietary data or capture only few interactions among them.
- Impacts of CI failure cascades onto people (esp. loss of basic services) are rarely considered.

Our contribution:

A globally consistent and spatially explicit implementation to CI failure cascades and their impacts on basic service losses from natural hazards at national scales.

2 Methods: From direct infrastructure damages to basic service losses.

We combine a state-of-the-art **probabilistic natural hazard risk modelling platform**[3] and spatially explicit data on CIs to obtain **direct infrastructure damages** after disasters (e.g. tropical cyclones, floods).

We identify **dependency heuristics** within and between CI systems to model **failure cascades** using **complex networks** (cf. [4]) and CI-specific **functional models**.

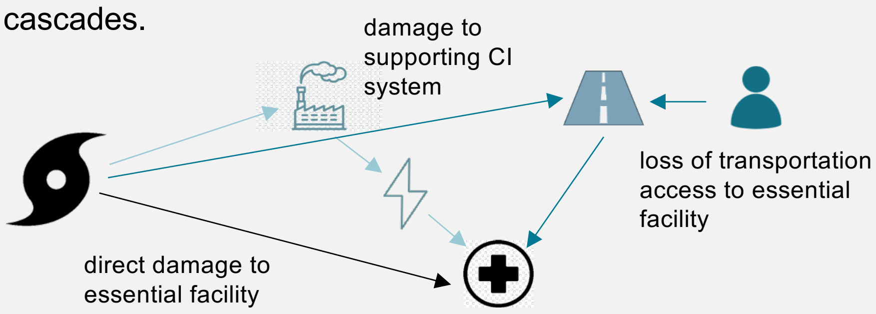
We estimate numbers **of people without access to basic services** (healthcare, power, communication, mobility) as a result of the cascading breakdown of CI functionalities.

3 Data & Models: Global, spatially explicit and open-source.

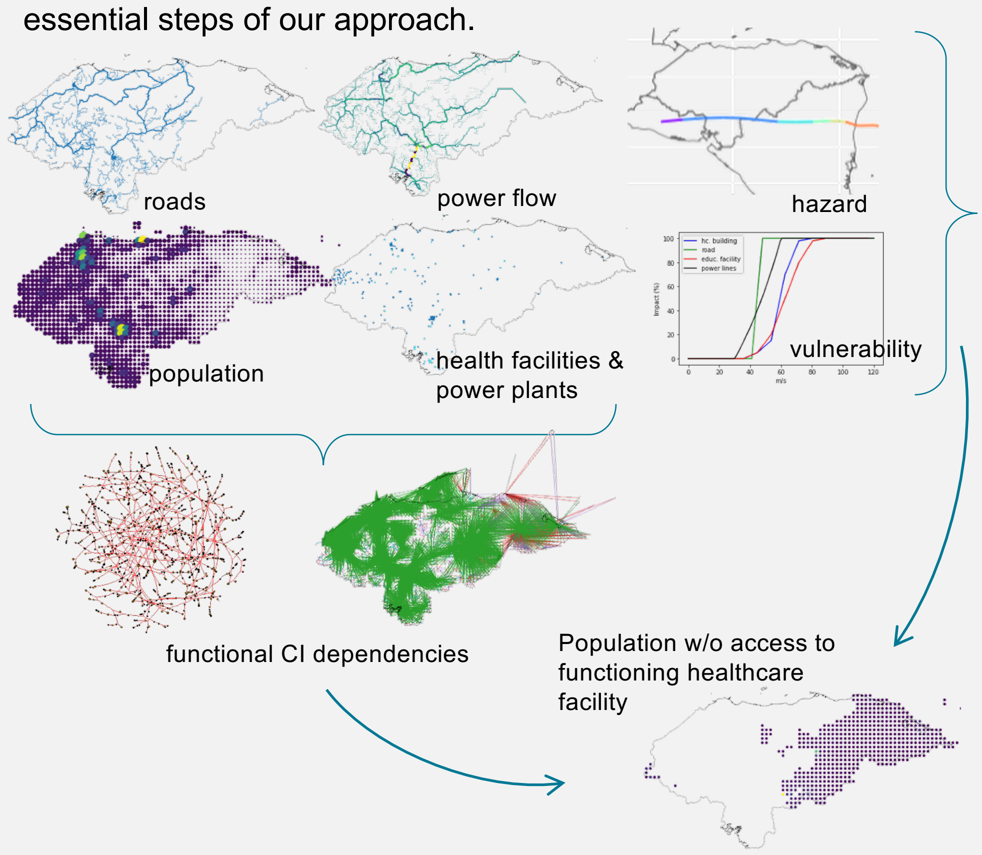
- CLIMADA[3], for the direct damage calculations.
- CI data (roads, power, telecom, hospitals, educational facilities, etc.) from OpenStreetMap, Gridfinder & others.
- Complex network model (igraph) & functional models (e.g. pandapower for power flow).

4 Simple illustration: Loss of access to healthcare services after a tropical cyclone.

Conceptual illustration: End-to-end calculation chain, from hazards to loss of basic services over multiple CI failure cascades.



Conceptual case: TC Iota (Nov. 2020), in Honduras. Note: The following is of illustrative character, visualizing some of the essential steps of our approach.



5 In a nutshell

- We bridge **small-scale CI engineering & large-scale, but static NH risk** models.
- Our automated model works for any geographical location, producing a **consistent estimate of hot-spots for basic service losses** after disasters.

Up next: Validation of CI failure dynamics & basic services losses Inclusion of recovery snapshots; Sensitivity analyses for uncertainty quantification & robust adaptation

References **[1]** Koks, E. E., et al. 2019. "A Global Multi-Hazard Risk Analysis of Road and Railway Infrastructure Assets." Nature Communications 10 (1): 2677 **[2]** Raymond, C., *et al*. 2020. "Understanding and Managing Connected Extreme Events." Nature Climate Change, June, 1–11. **[3]** Bresch, David N., and Gabriela Aznar-Siguan. 2020. "CLIMADA v1.4.1: Towards a Globally Consistent Adaptation Options Appraisal Tool." Geoscientific Model Development Discussions, August, 1–20. **[4]** Thacker, Scott, *et al*. 2017. "System-of-Systems Formulation and Disruption Analysis for Multi-Scale Critical National Infrastructures." Reliability Engineering & System Safety, 167 (November): 30–41

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Take a closer look: