

Multi-hazard risk assessment of critical infrastructure at the global scale

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Critical Infrastructure – why study them?

Critical infrastructure (CI) plays an essential role in the day-to-day functioning of societies and economies. They refer to the array of physical assets required for the operation of under which energy, telecommunication, water and waste systems, and transportation networks. At the same time, occurrences of natural hazards highlight the importance of improving our understanding on the natural hazard risk to these infrastructures. CI has evolved in large interconnected networks, whereby disruption of one asset may quickly propagate into widespread consequences – even outside an exposed area [1]. The disruption of the services critical infrastructure provide have large potential to seriously hamper the daily activities of societies and economies that depend on them [2-3], as well as the recovery in the aftermath of a disruptive event [4].



Natural hazard-induced asset damages. On the left-hand side a damaged road in Germany due to the 2021 flood [5], and on the right-hand side structural damages to power infrastructure due to Hurricane Ida, 2021.

Research scope

To date, however, scientific literature on natural hazard risk to critical infrastructure has remained limited, highlighting that the topic of CI in context of disaster risk management is a relatively new field. More specifically, little is known about (1) the spatial distribution of CI exposure to natural hazards, and (2) the asset damage that may occur accordingly.

In this study, we aim to **provide first global estimates of multi-hazard risk to CI systems under current climate conditions**. To this end, we:

- assess the global exposure of CI to coastal and fluvial flooding, cyclones, earthquakes and landslides
- quantify the potential asset damages as a consequence of these multi-hazards.

Methodology

A traditional risk assessment approach is applied, whereby we combine data on **hazard** intensities and extents, **exposure** of infrastructure and the **vulnerability** of these exposed assets (see figure 1).

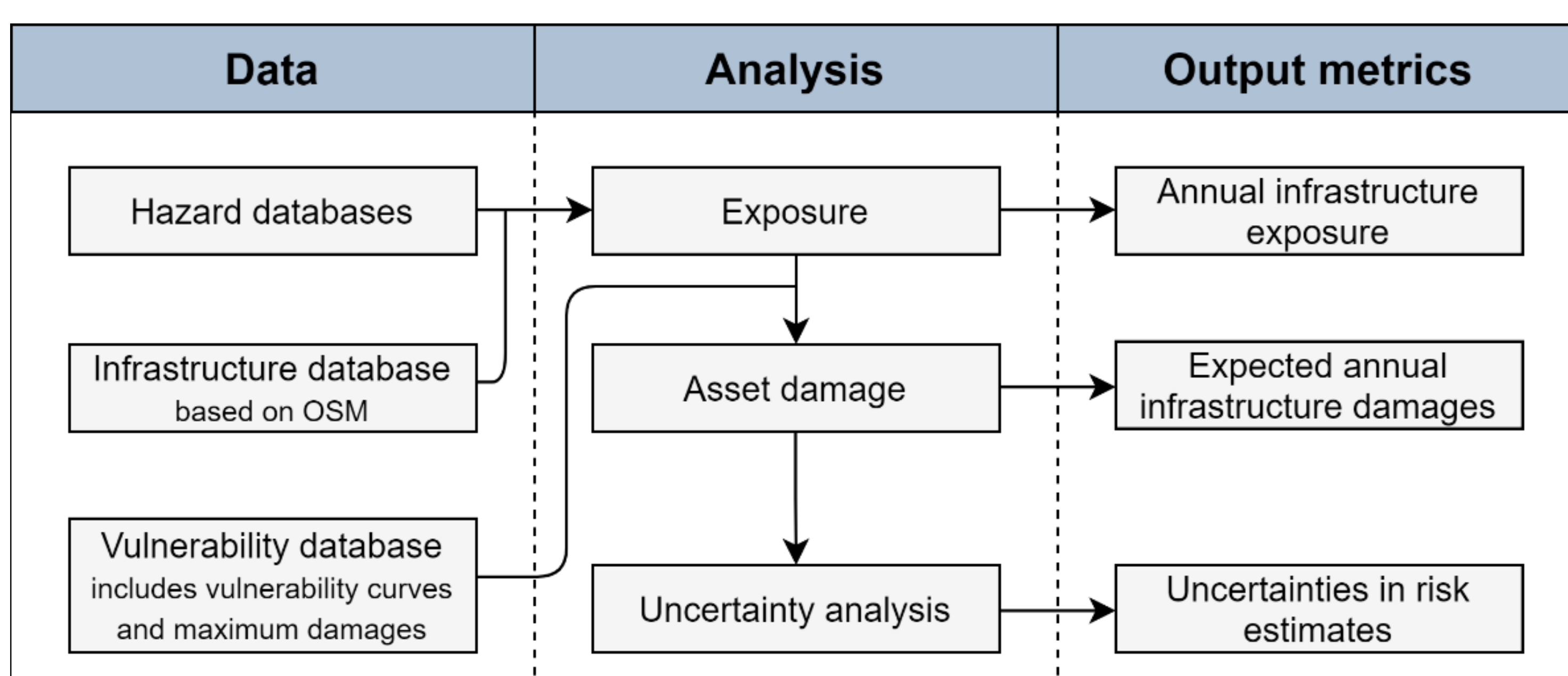


Figure 1: schematic representation of workflow

We represent the infrastructure network by seven overarching CI systems: *energy, transportation, telecommunication, water, waste, education, and health*. We use OpenStreetMap (OSM) to extract the geospatial location of **42 infrastructure types**.

The current body of literature is searched to develop an **extensive vulnerability database** that contains vulnerability curves and maximum damages per infrastructure type for each hazard.

The multiple databases are used as input for a model that is able to process high-detailed spatial data. Hence, we are able to derive potential damages that may occur due to a hazard for each individual asset. This data is further processed to obtain the expected annual damage (EAD).

Preliminary results

We present first results of estimated asset damages for a flood along the coastline of Northern Germany (figure 2). Figure 3 presents the relative contribution per infrastructure type categorized by the overarching CI systems.

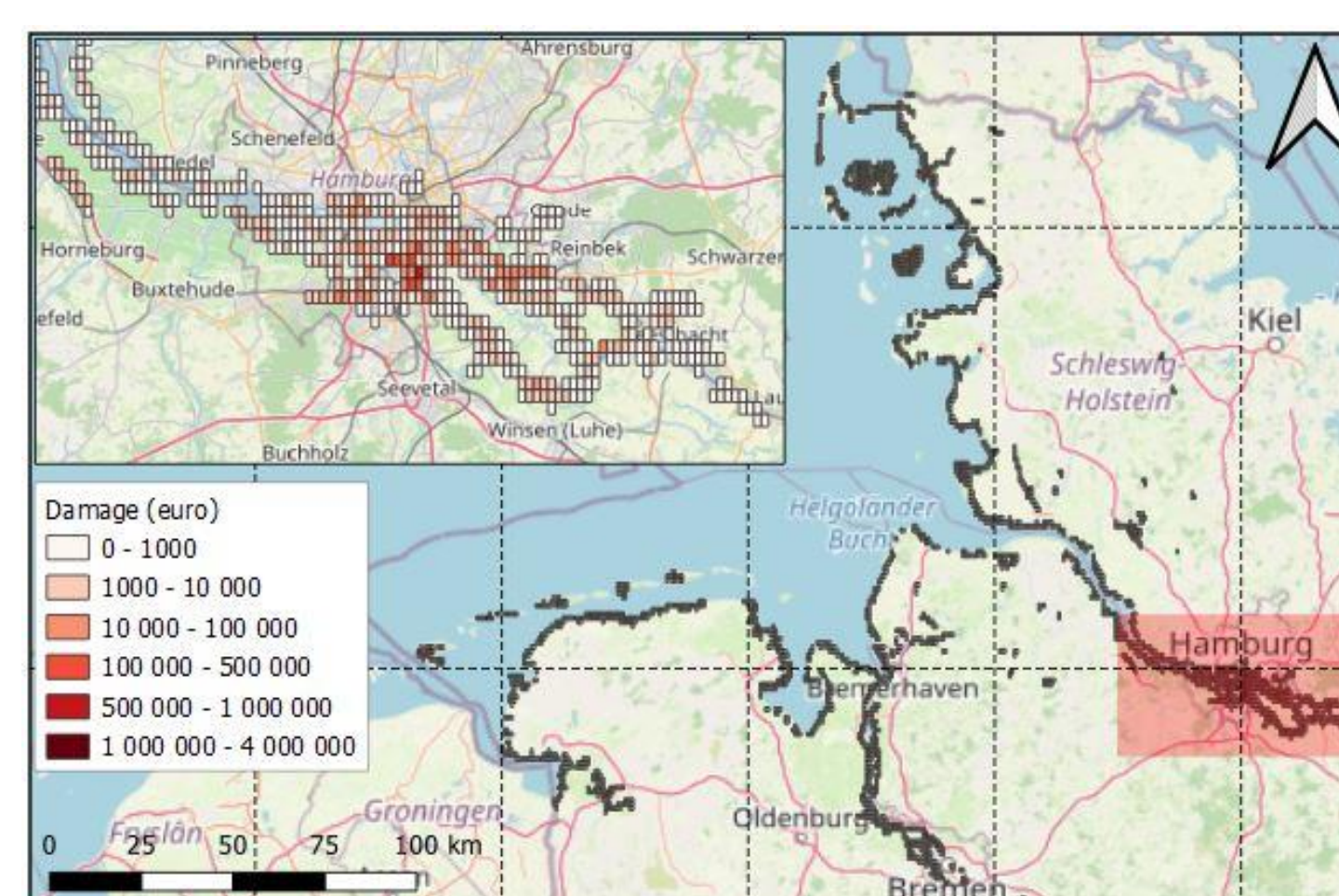
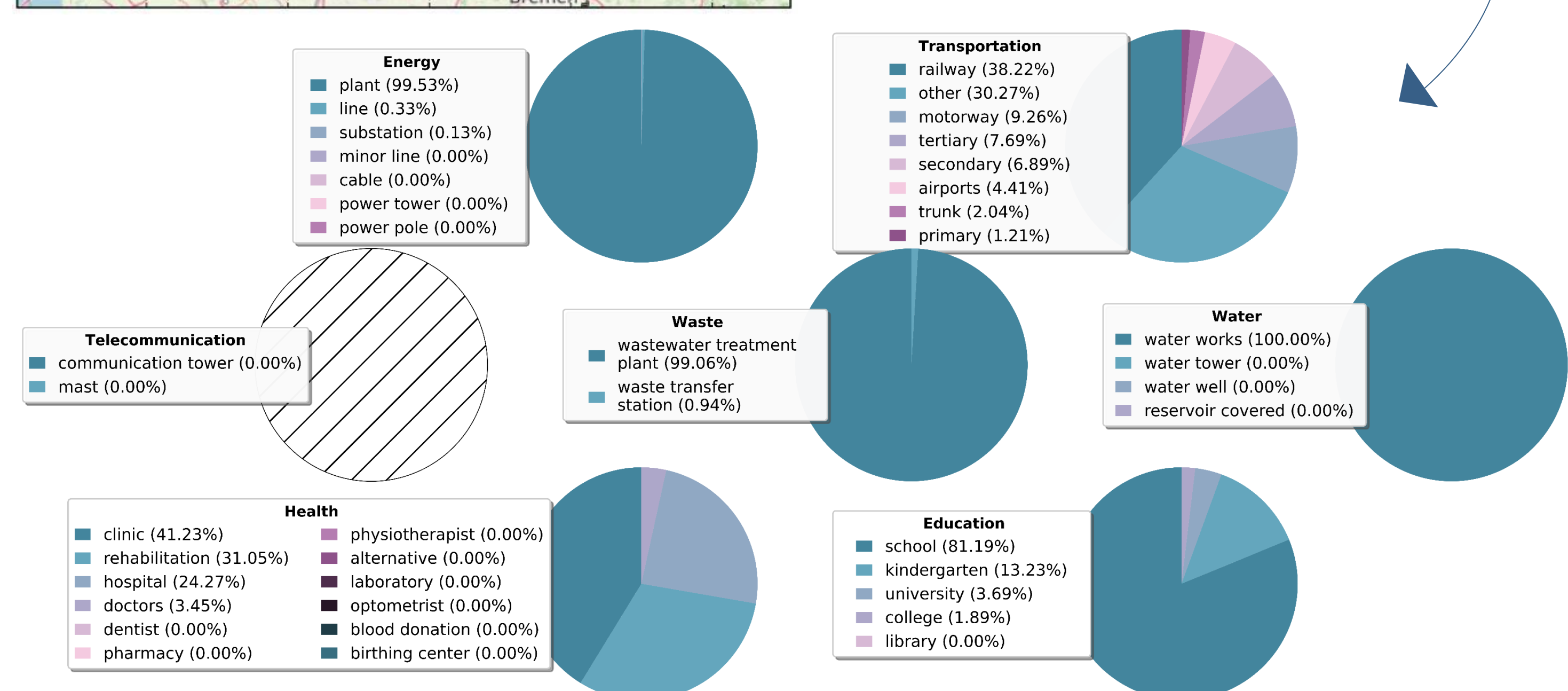


Figure 2 (on the left): the spatial distribution of locations that suffer CI damages along the coastline of Northern Germany due to flooding, with a detailed overview of the aggregated damages for Hamburg.

Figure 3 (on the bottom): Relative asset damages per infrastructure type for each overarching CI system due to flooding



What's next?

- Upscaling of model in order to assess asset damages at a global scale
- Investigate further the countries with high CI exposure and risk to multi-hazards
- Determine the global CI risk contribution per hazard
- Identify differences between infrastructure types at risk
- Perform a sensitivity analysis to justify meaningful global estimates
→ include ranges for maximum damages, and adjust shapes of vulnerability curves

References

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