SYSTEMIC CRITICALITY

Systemic criticality and cascading effects

BACKGROUND

Overall negative effects of mega disasters are mainly caused by a failure or disruption of **critical infrastructures (CI)**. A common definition by the European Union (EU) defines CIs as "*assets or systems, essential for the maintenance of vital social functions, health, safety, security and economic or social wellbeing of people*" (Article 2, Council Directive 2008/114/EC). Important subsectors with possible physical damages on CIs are electricity/power supply, IT & telecommunication, emergency response, public water supply, transport, and health infrastructure. Due to their importance, critical infrastructures are to be highly protected regardless of their sensitivity or vulnerability.

Criticality is an emerging topic in a globalized interconnected world. It is a relative measure of the importance of an infrastructure in relation to the consequences of a disruption or failure for the security of supply of important goods and services to society. The **systemic criticality** defines an infrastructure of very high importance for society within an overall system based on its structural, functional and technical position. Research shows that power supply is the CI with the greatest systemic criticality.

CASCADING EFFECTS

CIs are highly interconnected to and interdependent from each other and thus show an increased risk of failures resulting in possible **cascading effects**. These effects could lead to a higher magnitude of consequences and may take place elsewhere outside the exposed planning area. Exemplarily, Figure 1 shows the many possible consequences on multi-infrastructures caused by a single failure of electric power infrastructures.

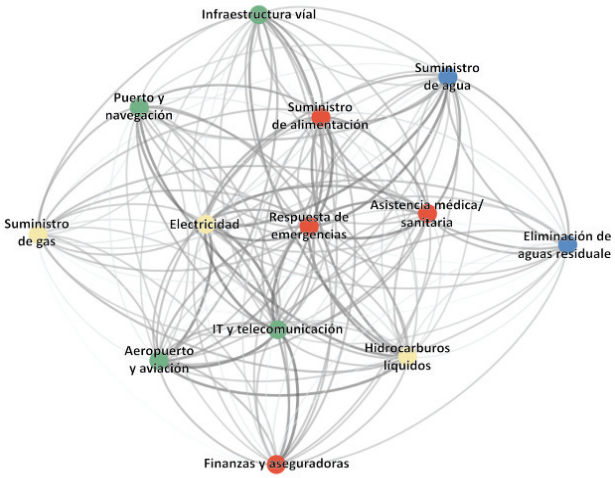

Figure 1: Examples of infrastructure dependencies of critical sectors (Greiving et al. 2020: Risk governance of critical infrastructures in urban regions – the case of Metropolitan Lima)

A prominent event with cascading effects was the Great East Japan Earthquake in 2011 which triggered a tsunami and lead to the failure of the Fukushima nuclear power plant resulting in the contamination of radioactivity of people, water and food supply amongst others. Cascading effects often originate from the energy and telecom sectors and occur frequently even though they appear with low cascading effects.

ASSESSMENT OF CRITICALITY

A proper assessment of criticality requires a **network-wide, over-sectoral perspective** and the observation is therefore required on a metropolitan region or even the national level. How can criticality of infrastructure be assessed? The EU determines **criteria for criticality** (Article 3 §2, Council Directive 2008/114/EC):

- ***Causalities criterion:*** *potential number of fatalities or injuries*
- ***Economic effects criterion:*** *significance of economic loss and/or degradation of products or services; including potential environmental effects*
- ***Public effects criterion:*** *impact on public confidence, physical suffering and disruption of daily life; including the loss of essential services*

Negative consequences caused by hazards of any kind are typically assessed through an examination of vulnerability. Criticality counts as an additional factor for the evaluation of risks, based on a criticality assessment (see figure 2).

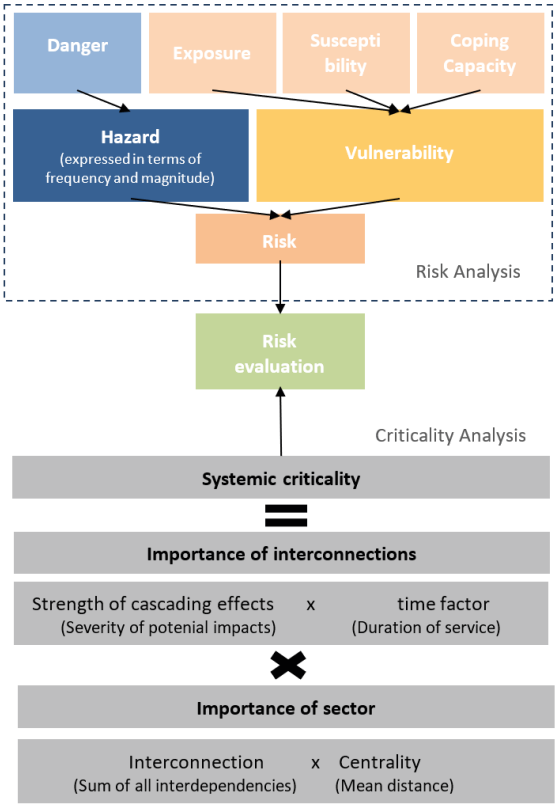

Figure 2: Integrated multi-risk evaluation framework (Based on Schmitt 2019: Systemisches Kaskadenpotenzial von Kritis-Teilsektoren, in: Raumforschung und Raumordnung, vol. 46, no. 4, pp. 48-61)

COPING WITH CRITICALITY

Planning approaches could be the implementation of development plans or projects, e.g. by locating emergency management facilities at safe places which are redundantly accessible and can be supplied with energy and internet through various options. Land-use planning authorities are legally responsible for managing the land-use of their area of responsibility and thus operate just for a specific territory. At the same time the planning area often does not capture an entire network which calls for a **stronger horizontal co-operation of spatial planning and emergency response authorities**.

RIESGOS APPROACH

As a part of a five-step virtual dialogue RIESGOS will carry out a gaming simulation, consisting of a participatory criticality analysis and a discussion of results, recommendations and validation.

More information about the project:
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