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Regionale Ermittlung der Wirkung von Überflutung für Kiel und Eckernförde, Deutschland

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Regional flood impact assessment for Kiel and Eckernförde, Germany

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It is well-observed that extreme flood events bring considerable destruction to coastal communities. The estimates of damage increases when direct and indirect losses are both considered in the assessment. This study applied the INtegrated DisRuption Assessment (INDRA) model which is designed to estimate and compare not only tangible but also intangible losses such as risk to life, recovery mechanisms and household displacement. Multi-criteria analysis (MCA) was performed in order to compare hotspots of high flood risk on the regional scale and detect which impact indicators influence results the most. INDRA allowed assessing the following impact indicators: direct damages to buildings and roads, transport disruption, risk to life and financial recovery mechanisms of private households and businesses. The focus was on two hotspots of flood risk, where direct and indirect impacts from 200 years flood were assessed and analyzed in terms of relative importance to the region. The region here was defined as municipalities located on the Baltic Sea coast within the Schleswig-Holstein state, Germany. The hotspots are the towns of Kiel and Eckernförde. They are urban areas with a high concentration of people and assets, which previously experienced extreme flood events. From the performed investigation it was found out that modeled flood differently impacts Kiel and Eckernförde. The results produced by MCA show that the scores of direct and indirect damage are slightly higher in Eckernförde than in Kiel. Transport disruption is a compelling element in the performed regional impact assessment and demonstrated immense weight. Extreme events may pose significant direct and indirect impacts on the coastal roads, obstructing not only the access to important landmarks such as hospitals, train stations, harbors, etc. but also to contiguous municipalities. Yet, the analysis showed that other impact indicators are rather of local importance and would not cause vast damage on a regional scale. Nonetheless, the study suggests, that these effects should not be underestimated in terms of losses.

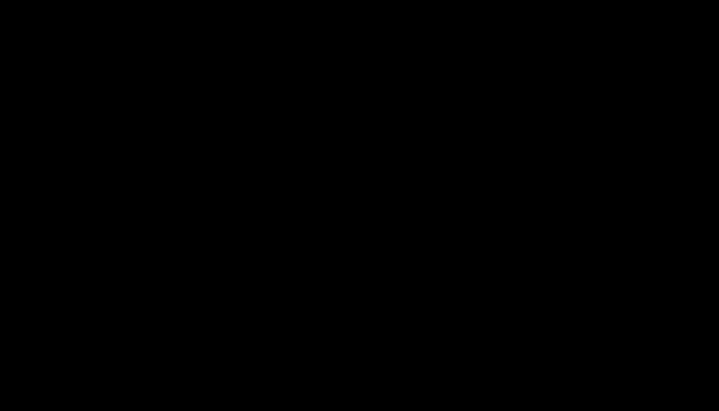

Figure 1. An overview of the study region including the area of interest

Multi-criteria analysis (MCA) approach

The **weighted summation** method is based on the multiple Regional indicators transformed into a scale from 0 to 1 (where 1 represents maximum disruption) for household displacement, household financial recovery, risk to life, business financial recovery and regional transport service disruption. Each indicator is multiplied by the weight (0 - 100) and aggregated together to derive a total MCA score.

The ranking of the hotspots in this research is performed using MCA by comparing those scores. The evaluation criteria and their weight were assigned by generating all possible combinations where intervals of weights are 5 and maximum weight is 50 (3246 scenarios in total). The indicator weights always sum up to 100.

The number of exposed receptors within both hotspots is unequal; there are 4 times more receptors in Eckernförde than in Kiel. Importantly, the number of residential properties is 10 times bigger in Eckernförde, whereas ecosystem and open urban spaces are defined by the area rather than receptors number (see Table 2).

The hazard parameters and the structural vulnerability of buildings are the reason of the dominance of none, low and moderate damage in Kiel and Eckernförde (about 81 and 90% respectively) (see Figure 3). This means that the majority of buildings in both hotspots would require only cleaning or inventory replacement.

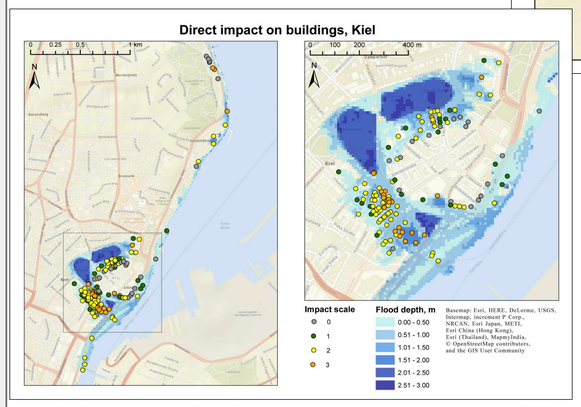

Figure 2. Representation of the direct impact in Kiel and the water depth of 200 years flood

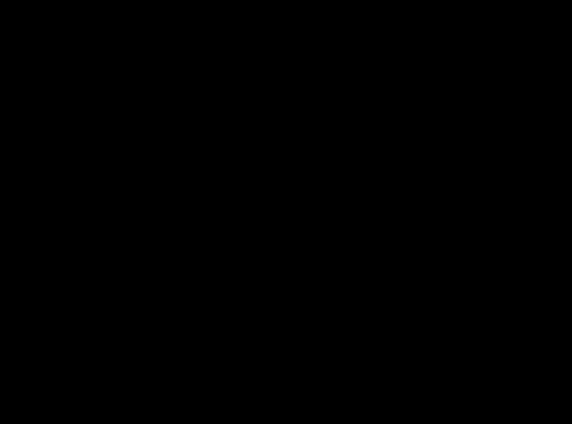

Figure 3. Representation of the direct impact in Eckernförde and the water depth of 200 years flood

It is estimated, that 200 years flood inundation extent in Eckernförde is virtually twice as large as in Kiel (0.536km² and 1.008 km² correspondingly).

Table 2. The number of receptor types in Kiel and Eckernförde

Receptor type	Kiel	Eckernförde
Residential buildings	33	339
Non-residential buildings	112	158
Open urban spaces	16 (0.36 km²)	100 (0.6 km²)
Ecosystems	0	45 (0.26 km²)
Total	161	642

transport indicators and shows that more or less significant scores are produced within 1 day after the event and drops considerably over 30 days. 24 hours after the flood event it is expected that the disruption is much higher, as there was not enough time for the system to recover.

The weighted summation of all abovementioned MCA scores showed that the scores of direct and indirect damage for identical weighting scenarios and their combination are slightly higher in Eckernförde than in Kiel (see Figure 5).

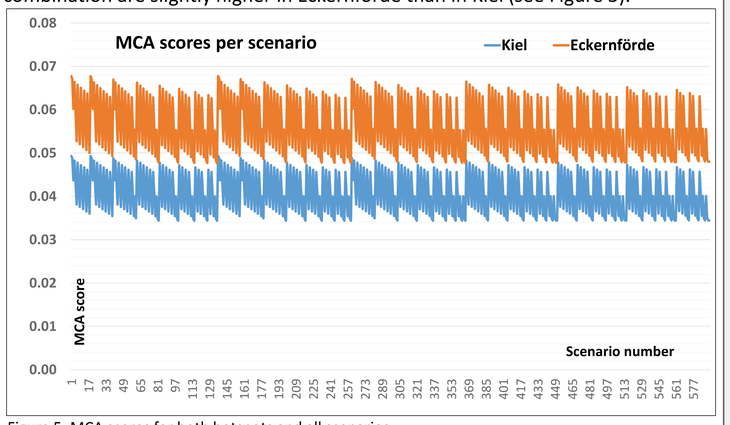

Figure 5. MCA scores for both hotspots and all scenarios

Concluding remarks. Transport disruption is a compelling element in the performed regional impact assessment and demonstrated immense weight. Extreme events may pose significant direct and indirect impacts on the coastal roads, obstructing not only the access to important landmarks such as hospitals, train stations, harbours, etc. but also to contiguous municipalities. Yet, the analysis showed that other impact indicators are rather of local importance and would not cause vast damage on a regional scale.