SYSTEMIC VULNERABILITY AND RISK ANALYSIS OF BUILDINGS AND INFRASTRUCTURE IN THE CITY OF THESSALONIKI, GREECE

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The paper presents the application of the SYNER-G general methodology and tools to the city of Thessaloniki in Greece (Pitilakis et al. 2014). The application includes the electric power network (EPN), the water supply system (WSS), the building stock (BDG) and the road network (RDN) with specific interdependencies between systems. The seismic hazard model is based on the seismic zones proposed in the SHARE project (Giardini et al. 2013). For each system, the main features for the systemic analysis and the system topology and characteristics are described. A Monte Carlo simulation (MCS) has been carried out (10,000 runs) based on the methods and tools developed in SYNER-G. The analysis results include expected damages, casualties (deaths, injuries) and displaced people for BDG and connectivity-based Performance Indicators (PIs) for EPN, WSS and RDN systems. Apart from the average performance and the Mean Annual Frequency (MAF) of exceedance of the PIs (Fig. 2), the distribution of estimated damages and losses for specific events is also given through thematic maps. The significant elements for the functionality of each system are defined through correlation factors to the system PIs (Fig. 1, Fig. 3). A shelter demand analysis is also performed based on a multi-criteria approach that takes into account the outcomes of the systemic risk analysis for buildings and utility systems as well as other indicators (Fig. 4).

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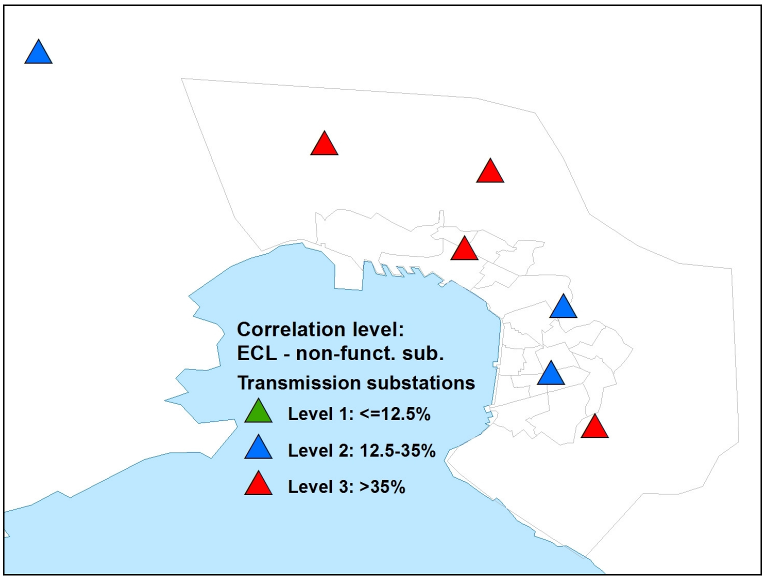

Figure 1. Correlation of non-functional transmission substations to electric power network connectivity loss. The network is composed of 30 nodes (1 generator, 8 transmission substations and 21 demand nodes) and 29 edges. Transmission substations are the only vulnerable components. Edges are non-vulnerable transmission lines (underground and overhead) connecting the generator with the transmission substations and the transmission substations with the demand points. The network performance is analyzed in terms of pure connectivity. The network components with profound effect on the overall system performance are characterized by high correlation levels to the PI.

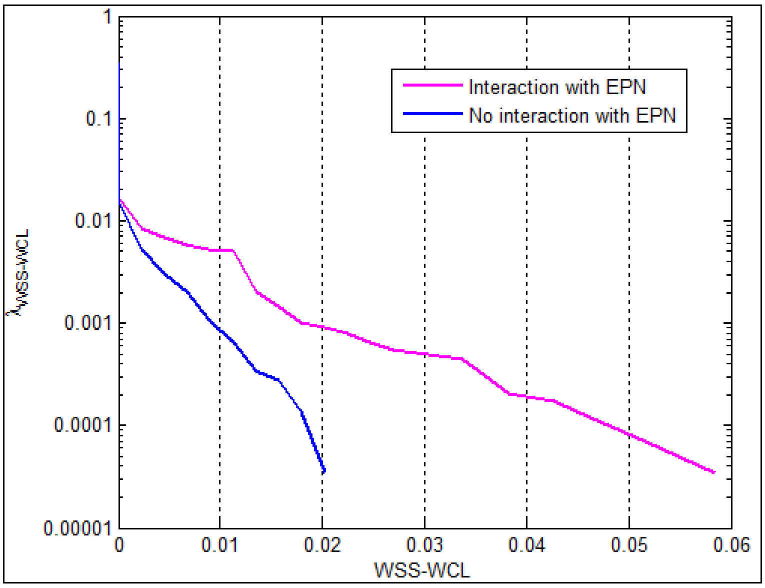

Figure 2. MAF curve for connectivity loss of WSS, with and without interaction with EPN. It can be seen that for 500 years return period of the PI (i.e. 0.002 probability of exceedance), the connectivity loss of the system is 1.4% and 0.7%, with and without interaction to EPN respectively. The used network comprised of 477 nodes (demand nodes, pumping stations and tanks) and 601 edges (pipes).

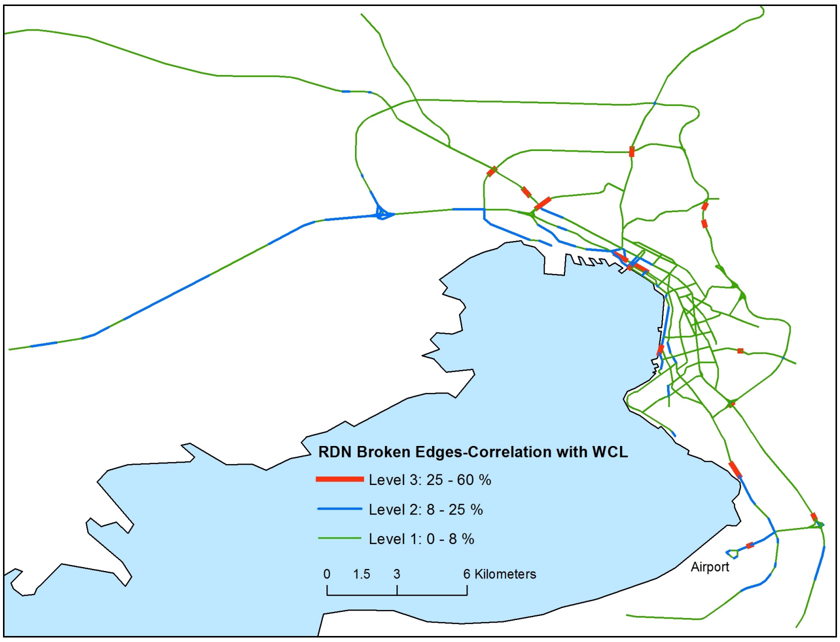

Figure 3. Correlation of broken edges (bridges due to ground shaking or road segments due to liquefaction) to road network connectivity. The road network is composed of 594 nodes (15 external nodes, 127 Traffic Analysis Zone centroids and 452 simple intersections) and 674 edges. Edges, that are the only vulnerable components in the network, are subdivided into road pavements and bridges. Direct (physical) and indirect failures are considered: 1) bridge damage due to ground shaking (peak ground acceleration) or road damage due to liquefaction (permanent ground displacement; 2) road blockage due to collapsed buildings; 3) road blockage due to collapsed bridges (overpasses).

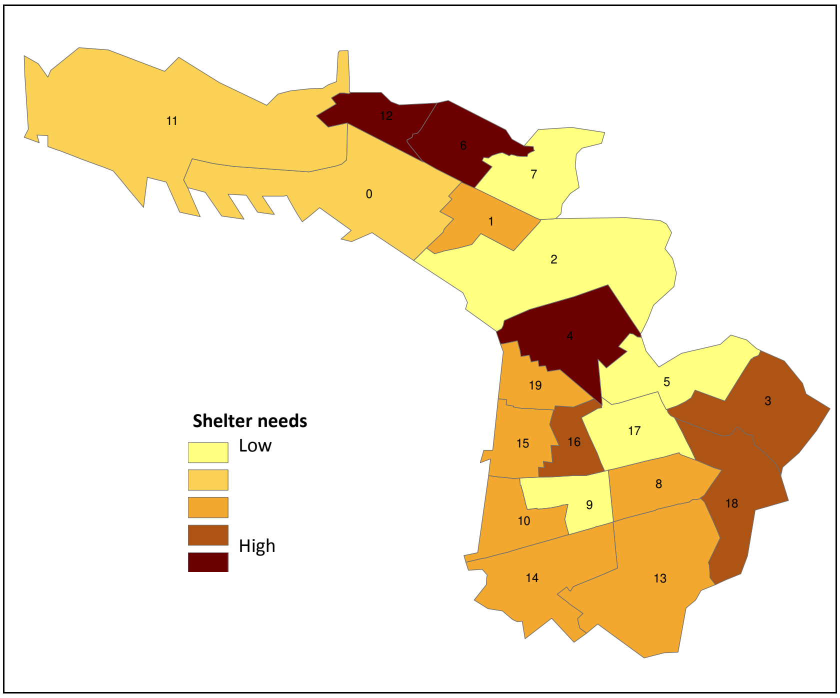

Figure 4. Shelters needs index (SNI) for Thessaloniki's Sub City Districts based on: a) the displaced people estimates for bad and good weather conditions, which are a function of the building damages (BDG) and the utility losses (WSS and EPN), b) the desirability of people to evacuate and c) their access to resources. Criteria b) and c) are evaluated based on indicators from the Urban Audit survey (e.g. age, family status, unemployment rate, education level etc).