CRITICAL INFRASTRUCTURE SYSTEMS: A CASE STUDY OF THE INTERCONNECTEDNESS OF RISKS POSED BY HURRICANE SANDY FOR NEW YORK CITY

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ABSTRACT :
The goal of this paper is to investigate the impact of Hurricane Sandy from the perspective of interdependence among different sectors of critical infrastructure in New York City and to assess the interconnected nature of risks posed by such a hurricane. Critical areas and sectors where interdependent risks led to a catastrophic cascading effect are identified. This study uses indirect damages of each sector to estimate the degree of interdependence among the sectors. This study consist of three parts: i) the review of a comprehensive report prepared by New York City Government (2013); ii) a quantitative analysis using Geographic Information System (GIS) map; and iii) the review of new initiatives to increase the resilience in New York City after Sandy.

First, this study reviews New York City Government (2013) that summarizes the damages to various critical infrastructures: buildings, utilities, liquid fuels, healthcare, telecommunications, transportation, water and wastewater, and other critical networks. In particular, this study focuses on what the percentage changes in service levels were in each sector. For example, in the healthcare sector, flooding and power outages resulted in reducing bed capacity by 8% citywide.

Second, the study examines the impact of the hurricane on different critical infrastructures by combining hazard maps of actual inundation areas with maps of critical infrastructure. The direct damages of each sector are calculated from the inundation areas in the flood map. The indirect damages are estimated by considering the areas that were not inundated but affected by Sandy through the interconnected infrastructure. The electricity sector was the key sector to propagate risks to other sectors. The area of 173 square kilometers, which was about 12.7% of NYC, was affected by electricity outage or overload, including both the direct (9.9% of NYC) and indirect damages (2.8% of NYC). In the transportation sector, 10.7% of the total transportation mileage was directly damaged while 19.4% was indirectly damaged. In the health care sector, the direct damage was about 7.5% of the total number of facilities while the indirect damage was 2.4% of the total number of health care facilities. 7.0% of the number of buildings was built in the directly damaged areas while 16.8% were built in the indirectly damaged areas. Thus, in these sectors, the direct damage ranged from 7.0 to 10.7% and the indirect damage ranged from 2.4 to 19.4%. The variance of the direct damage in each sector is relatively small, while the variance of the indirect damage is large. This means that the degree to which one sector affects other sectors depends on the degree of interdependence among each sector. As a result, the transportation sector experienced direct damage by the storm surge the most, followed by electricity, health care, and building sectors. The most severely indirectly damaged sector by the electricity outage was transportation, which is followed by building, and health care sectors. This study's estimates of damages are close to the damages reported by New York City Government (2013) in the building and health care sectors. In contrast, the direct and indirect damages in the transportation sector are not estimated well by our study because the damages in the sector are influenced by other external factors and are not easily measured.

Third, the examination of new initiatives to increase the resilience of critical infrastructures in New York City after Sandy reveals that these initiatives focus primarily on building hard infrastructures to decrease direct damages. They understate the importance of interdependent risk across sectors. Future disaster risk reduction strategies must address interdependent infrastructures to reduce indirect damages.

KEYWORDS:
Hurricane Sandy, Critical Infrastructure, Cascading Failure, Direct and Indirect Damages, GIS-mapping, Interdependencies

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