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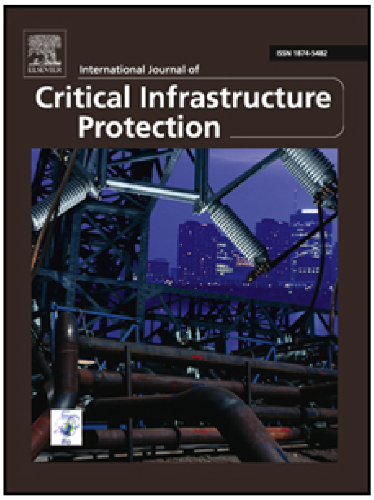

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Proposed methodology for Risk analysis of interdependent Critical Infrastructures to Extreme weather events

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Abstract

Growing scientific evidence suggests that risks due to failure of critical infrastructures (CIs) will increase worldwide, as the frequency and intensity of extreme weather events (EWEs) induced by climate change increases. Such risks are difficult to estimate due to the increasing complexity and interconnectedness of CIs and because information sharing regarding the vulnerabilities of the different CIs is limited. This paper proposes a methodology for risk analysis of systems of interdependent CIs to EWEs. The methodology is developed and carried out for the Port of Rotterdam area in the Netherlands, which is used as a case study. The case study includes multiple CIs that belong to different sectors and can be affected at the same time by an initiating EWE. The proposed methodology supports the assessment of common cause failures that cascade across CIs and sectors. It is based on a simple, user-friendly approach that can be used by CIs owners and operators. The implementation of the methodology has shown that the severity of cascading effects is strongly influenced by the recovery time of the different CIs due to the initiating EWE and that cascading effects that result from a disruption in a single CI develop differently from cascading effects that result from common cause failures. For most CIs, vulnerabilities from EWEs on the CI level will be higher than the cascading risks of common cause failures on the system of CIs; moreover, cascading risks for a CI will increase after its recovery from the event.

Keywords: Critical Infrastructure, Extreme weather event, Climate change, Cascading Failure, Common cause failure

1 Introduction

Extreme weather events (EWEs) constitute a potential threat to human and natural systems, as they are expected to increase in terms of both of frequency and intensity, due to the warming of the climate system [22]. EWEs are among the most prominent global risks, lying in the higher-impact, higher-likelihood quadrant [57] and they can induce hazards such as flooding, drought, ice formation and wild fires, which present a range of complex challenges to the operational resilience of Critical Infrastructures (CIs) [54].

An extreme climatic event is usually defined as one that is rare within its statistical reference distribution at a particular place and time, normally as rare as or rarer than the 10th or 90th percentile of the observed Probability Density Function [43]. For events affecting infrastructures, the characterization of weather event as extreme is performed according to thresholds critical to the infrastructures [9]. CIs are defined as “those infrastructures whose services are so vital that their disruption would result in a serious, long-lasting impact on the economy and the society” [20]. Physical CIs include large scale, spatially distributed and complex networks such as energy supply, transportation, information and telecommunication, water and solid waste systems [17,57]. Those systems are vulnerable to extreme climate changes, since most of them have been designed under the assumption that climate is stationary [34]. Moreover, they are highly interconnected and heavily dependent upon each other and therefore a disruption in any of these systems can cascade across and affect the functioning of the entire system of CIs[44,7,22,17,57].

As climate becomes extreme it is likely that risks for CI failure will increase worldwide [8,17]. Analysing and assessing the risks posed to CIs by EWEs on the basis of future climate scenarios can help in establishing a good basis for decisions regarding risk reduction, monitoring and control [48].