THE INFLUENCE OF CRITICAL INFRASTRUCTURE INTERDEPENDENCIES ON POST-DISASTER RECONSTRUCTION: ELEMENTS OF INFRASTRUCTURE INTERDEPENDENCY THAT IMPEDE THE POST-DISASTER RECOVERY EFFORT

Erica Mulowayi[1], Vaughan Coffey[2], Jonathan Bunker[3] and Bambang Trigunarsiah[4]

[1, 2 and 3]*Department of Civil Engineering and Built Environment, Queensland University of Technology, Queensland, Australia*

[4]*King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia*

The importance of developing effective disaster management strategies has significantly grown as the world continues to be confronted with unprecedented disastrous events. Factors such as climate instability, recent urbanization along with rapid population growth in many cities around the world have unwittingly exacerbated the risks of potential disasters, leaving a large number of people and infrastructure exposed to new forms of threats from natural disasters such as flooding, cyclones, and earthquakes. With disasters on the rise, effective recovery planning of the built environment is becoming imperative as it is not only closely related to the well-being and essential functioning of society, but it also requires significant financial commitment. In the built environment context, post-disaster reconstruction focuses essentially on the repair and reconstruction of physical infrastructures. The reconstruction and rehabilitation efforts are generally performed in the form of collaborative partnerships that involve multiple organisations, enabling the restoration of interdependencies that exist between infrastructure systems such as energy, water (including wastewater), transport, and telecommunication systems. These interdependencies are major determinants of vulnerabilities and risks encountered by critical infrastructures and therefore have significant implications for post-disaster recovery. When disrupted by natural disasters, such interdependencies have the potential to promote the propagation of failures between critical infrastructures at various levels, and thus can have dire consequences on reconstruction activities. This paper outlines the results of a pilot study on how elements of infrastructure interdependencies have the potential to impede the post-disaster recovery effort. Using a set of unstructured interview questionnaires, plausible arguments provided by seven respondents revealed that during post-disaster recovery, critical infrastructures are mutually dependent on each other's uninterrupted availability, both physically and through a host of information and communication technologies. Major disruption to their physical and cyber interdependencies could lead to cascading failures, which could delay the recovery effort. Thus, the existing interrelationship between critical infrastructures requires that the entire interconnected network be considered when managing reconstruction activities during the post-disaster recovery period.

Keywords: post-disaster recovery, critical infrastructure, infrastructure interdependency.

[1] erica.mulowayi@hdr.qut.edu.au

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INTRODUCTION

The financial and emotional burden of natural disasters is expected to increase in the coming years (World Bank, 2011). Factors such as urbanization and environmental degradation, as well as climate instability are major contributors to the severity and the rate at which natural disasters occur since the 1980s (World Bank, 2011). Despite all of the mitigation and preparedness measures taken in advance, and which have partially succeeded in few cases, the occurrence of natural disasters and their consequences in the built environment are almost inevitable. Therefore, there is increasing recognition that the reconstruction process can contribute to reduce the risk of damage from future disasters, even if the sole reconstruction of the built environment will not eliminate the broad ranging consequences of natural disasters (Amaratunga and Haigh, 2011). Thus, it is during the post-disaster recovery period that disaster vulnerabilities which appear mainly in the forms of economic, social, environmental and physical variables need to be minimized (Australian Government, 2013 ; Bureau of Transport Economic, 2001; Chang *et al*., 2014).

Major disasters generally require substantial efforts to rebuild physical infrastructure and recover from personal loss (Amaratunga and Haigh, 2011). The impact of natural disasters can have long-lasting implications for the national development of a country as they can impinge development efforts and drain economic resources. This is primarily due to the disabled functioning of critical infrastructures, which are essential enablers to economic and societal living conditions (De Bruijne and Van Eeten, 2007; Moteff and Parfomak, 2004). All developed societies, to a large extent, rely on the constant operation of a set of vital infrastructure systems such as energy, transport, water including sanitation, as well as information and communication technologies (ICT). The incapacitation or destruction of such infrastructure systems would have a debilitating impact on national security, economic security, and the public health and safety of communities (De Bruijne and Van Eeten, 2007; Moteff and Parfomak, 2004). Disabled critical infrastructures can exacerbate poverty, disrupt large industry as well as small businesses activities, and quite often suppress vital lifelines responsible for economic activity and service delivery (Canterbury Earthquake Recovery Authority, 2012; Hyogo framework, 2005). Given these realities, it is indispensable to develop a comprehensive approach for the effective reconstruction of interdependent critical infrastructures.

Analysts and decision makers have recently started to recognize that critical infrastructure systems have become highly interconnected and mutually dependent on each other's uninterrupted availability, both physically and through a host of information and communication technologies (Dudenhoeffer, Permann, and Manic, 2006; O'Rourke, 2007). When disrupted by natural disasters, such interdependencies have the potential to promote the propagation of failures between critical infrastructures at various levels, having dire consequences on reconstruction activities (Dueñas-Osorio and Vemuru, 2009). In this context, infrastructure interdependency refers to the reciprocal influence or relationship that exists between two or more infrastructures, through which the condition of one infrastructure affects the condition of the other infrastructure (Dudenhoeffer, *et al*., 2006; O'Rourke, 2007). Under normal working conditions, the relationship is apparent when critical infrastructures depend on the inputs and outputs of services they share between each other (O'Rourke, 2007; Rinaldi, Peerenboom, and Kelly, 2001). For instance, in most cases, without electricity, a variety of other critical services will also fail during the post-disaster recovery period. Energy systems provide power for switches and to operate ICT networks. Water and sanitation systems are dependent on electricity to run pumps and control systems, as well as to generate petroleum fuels for transportation of repair and maintenance personnel. Similarly, ICT systems provide network services (including information and telecommunication services) necessary for the operation and supervision of electrical networks. Additionally, energy requires water for cooling and to reduce emissions. Transport infrastructure systems provide accessibility to other infrastructure operators, recovery crews and the logistics chain during the post-disaster recovery period, and are in turn dependent upon electrical and ICT systems as well as drainage systems.

It is indisputable that infrastructure interdependencies have always been acknowledged by many industries. However, the real challenge is to incorporate and prioritise these interdependencies during the reconstruction period to prevent existing damage from escalating and resulting in additional damage, which could hinder the post-disaster recovery activities. Therefore, in order to develop robust infrastructure protection strategies after disasters, it is important to identify and understand the overall behaviour as well as the inherent vulnerabilities of these interdependent systems during the recovery period. This paper contributes towards an understanding of the risks that interdependencies pose to the post-disaster reconstruction of critical infrastructures. The paper also examines the fundamental roles that interdependency's dimensions including the types and degrees of interdependencies play in impeding post-disaster recovery effort.

CRITICAL INFRASTRUCTURES

One of the main challenges in overcoming the damaging effects of critical infrastructure interdependencies on post-disaster recovery is to understand the meaning of the concept of interdependency itself. Additionally, critical infrastructures being large complex systems, very often made of large collections of interacting parts and entities, understanding and preventing the propagation of failure due to interdependency remains a major technical challenge for the construction industry (Alesch, 2005; Dueñas-Osorio and Vemuru, 2009). To a large extent, targeting infrastructure interdependencies during post-disaster recovery requires an understanding of the dynamics and characteristics that underline not only the individual functioning of critical infrastructures, but also the linkage between them. Conscious of their criticality, several organisations around the world have been seeking to manage infrastructures and reduce the impact of their failures on the well-being of society (Canterbury Earthquake Recovery Authority, 2012; Hyogo framework, 2005). Infrastructures owners have recognised the need for clear identification of their assets' criticality in order to know exactly which assets to protect, how well to manage them as well as how to prioritise the reconstruction process. The list of critical infrastructures varies across countries and changes over time. In 1996, for example, US President Clinton signed the Executive Order 13010, establishing the President's Commission on Critical Infrastructure Protection (PCCIP) (Clinton, 1996). This Executive Order (E.O.) listed and classified critical infrastructures according to their national importance. These critical infrastructures included:

- Telecommunications;
- Electrical power systems;
- Gas and oil storage and transportation;

- Banking and finance;
- Water supply systems;
- Emergency services (including medical, police, fire, and rescue), and
- Continuity of government (Clinton, 1996).

In 2004, the Information Analysis and Infrastructure Protection Directorate (IAIPD) provided a much broader list with approximately 1,700 infrastructures considered to be critical (Moteff and Parfomak, 2004). Several infrastructures that were identified were not listed in previous reports. Nuclear power plants, for example, have recently been considered to be a critical infrastructure in some countries; while they are still non-existent in others (Moteff and Parfomak, 2004; Partnership, 2006). The variation in number of critical infrastructures over time is mainly due to the ever evolving influence that technological, economical and geo-political factors have on public safety (Australian Government, 2012). Nevertheless, the scope of this research is limited to critical infrastructures that predominantly form the resource pillars on which the global security and prosperity of a country such as Australia stands. As mentioned earlier, these critical infrastructures vary in numbers but are essentially limited to energy (including electric power), transport (including roads and railway systems), water supply (including sanitation), and Information and Communication Technology (ICT) systems (Australian Government, 2012 ; Bureau of Transport Economic, 2001).

As much as these infrastructures are considered to be critical, some are more critical than others during post-disaster recovery, and within the same infrastructure, various elements can be more critical than others, either because failures due to interdependency have minimal impact on them, or because failure of one infrastructure does not preclude the other to function (Rinaldi, *et al*., 2001). Energy and ICT systems for example, are considered as high priority systems during recovery as they provide services directly to most infrastructures, unlike water systems from which other infrastructures could possibly abstain, depending on the circumstances. However, this does not exclude the fact that both potable water and wastewater evacuation and treatment are fundamental to the well-being of the community. In many ways, water is essential to minimise the risk of untreated effluents from contaminating water systems where humans come into contact, especially after floods and cyclones. The criticality of infrastructures during recovery depends to a large extent on the amount of services needed not only by the local community but also by other dependent infrastructures in order to recover quickly from natural disasters. In a series of recent interviews conducted in Queensland, Australia, as part of this study, five out of seven infrastructure' owners rated ICT as being the most critical infrastructure during the recovery period as the inoperability of such systems would inevitably hinder the recovery efforts of not only the dependent critical infrastructures but also the recovery crews involved in the reconstruction process. Being unable to communicate with recovery crews or other community members was considered by respondents as being the worst case scenario that could be encountered during and after disasters. Only two respondents rated energy and transport systems as being the second most critical after ICT systems. Having constant electricity and available access and mobility (through roads, bridges or rails) to reach damaged infrastructure was also considered indispensable during recovery. Nonetheless, when taking these factors into consideration, it appears evident that securing a unique infrastructure, isolated from all other interdependent infrastructures has become increasingly inefficient, particularly during post-disaster recovery.

ELEMENTS OF CRITICAL INFRASTRUCTURE INTERDEPENDENCIES WHICH AFFECT POST-DISASTER RECOVERY

Interdependencies are generally driven by the need to maintain interactions between critical infrastructure, in order to deliver efficient services that are transmitted both physically and through a host of information and communication technologies. Disruption of critical infrastructures due to interdependencies generally falls into two categories: physical disruptions (which may correspond to shortage of supply/consumption/production of an asset) and cyber disruptions (which may correspond to electronic, radio-frequency, or computer-based attacks, to name a few). It was by investigating these emergent behaviours of critical infrastructures that several researchers, including Rinaldi *et al*. (2001), defined the six dimensional characteristics of interdependency as followed:

- Types of interdependency;
- Coupling and response behavior (or degree of interdependency);
- Infrastructure characteristics and environment;
- The state of operation of infrastructures; and
- The types of failures (Buldyrev, Parshani, Paul, Stanley, and Havlin, 2010; Dudenhoeffer *et al*., 2007; O'Rourke, 2007; Setola, Bologna, Casalicchio, and Masucci, 2009).

This paper will mainly focus on the challenges from the types of interdependencies as well as the extent or degree to which these interdependencies occur.

Challenges due to types of interdependencies during post-disaster recovery

In the interview questionnaires that were tested during the pilot study, the types of interdependency were depicted according to the nature and sort of interaction that exist between critical infrastructures through the sharing of physical supplies and commodities (physical interdependency), virtual information (cyber interdependency), the same geographical location (geographical interdependency) as well as the same legislation and public opinion (logical interdependency). These classifications were performed using key concepts and sub-concepts derived from the notion of interdependency described in various literatures (O'Rourke, 2007; Rinaldi, *et al*., 2001).

The results revealed that during post-disaster recovery, geographical interdependency is considered to be almost an integral part of physical interdependency. Logically, to be physically interdependent, critical infrastructures need to be somehow geographically interdependent (within the same location, region or country etc.), even though the reverse is not obvious. Physical interdependency results from the exchange of services between two or more critical infrastructures (O'Rourke, 2007; Rinaldi, *et al*., 2001). The change in condition from one infrastructure could have serious impact on the functioning of the other infrastructure. Geographical interdependency on the other hand, results from the influence that a natural disaster (or external cause) such as flood can have on critical infrastructures located in close proximity to one another, creating simultaneous disturbance in the state of interdependent infrastructures

(O'Rourke, 2007; Rinaldi, *et al*., 2001). In this case, the change of condition of one critical infrastructure does not affect the operation of the other infrastructure. Thus, critical infrastructures that are geographically interdependent are not necessarily physically interdependent. Nevertheless, general managers responded collectively that during post-disaster recovery, physical interdependencies are usually restored first, regardless of the location of the infrastructure. This is why in this research the two types of interdependencies have essentially been reconceptualised and examined within the physical interdependency facet of critical infrastructures.

One of the main issues with regards to physical interdependency that was raised by general managers and risk practitioners from transport industries was the necessity of having inexhaustible resources available in order for infrastructures to continue to operate. Therefore to remain physically interdependent, the amount of shared services between critical infrastructures needs to be constantly available. Resource availability in a sense is also an indication of the performance of a critical infrastructure during post-disaster recovery. This anticipation that an infrastructure system will still remain operational and continue to provide resources to another infrastructure, allowing it to operate during post-disaster recovery, requires a certain level of reliability to be established between interdependent infrastructures and their organisations as well (Kapur, 2014). Infrastructure reliability in this context refers to the probability that resources or services will still be available to facilitate the sharing process between critical infrastructures during post-disaster recovery (Kapur, 2014). In this case, reliability is measured in function of the availability of resources and represents the probability of an infrastructure to continuously produce resources during the recovery period. The fewer available resources an infrastructure produces during the recovery period, the less reliable it is considered to be. Analysis of data also revealed that the challenge in maintaining physical interdependency is not only limited to resources availability and infrastructure reliability but it also requires the effective transfer of resources from one infrastructure to another. If access to the distribution channels from which resources are conveyed and delivered from one infrastructure to another are disrupted during recovery, physical interdependency would also cease to exist, regardless of the resources' availability or of the infrastructures' reliability. Therefore availability, reliability, and transferability or deliverability of resources are considered to be essential attributes or main contributors to physical interdependency. If any of the above conditions is not satisfied, then the physical interdependency will fail.

Although cyber interdependency is created through the share of virtual information and communication between critical infrastructures during recovery, most critical infrastructures possess a supervisory control and data acquisition (SCADA) system, which allow them to individually operate. The main role of ICT in regards to interdependencies with other critical infrastructures is to provide telecommunications services necessary for the supervision, control and evaluation of the state of these systems at any given time (Ventura, García, and Martí, 2010). Therefore availability, reliability, and transferability are also essential conditions in attaining cyber interdependency. In the same way that physical interdependency will fail if these conditions are not reached, cyber interdependency would also be inexistent. Logical interdependencies, in contrast, do not rely on these attributes as they are tailored by human decisions or factors including procedures and policies that shape a specific region. Logical interdependency is also associated to the conformity of critical infrastructures to the laws, rules and regulations of their organisations (Dudenhoeffer, *et al*., 2006; O'Rourke, 2007). An example of logical interdependency can be observed after a road closure following a natural disaster, which destroyed a section of a motorway. The decision of closing the road could necessitate an increase in traffic on a parallel railway due to a large number of persons and goods travelling by railway instead of using personal vehicle, bus or truck. The increase in rail traffic volume would require more electric power to sustain the traffic flow, which in turn could possibly generate an overload usage of the electrical network and possibly lead to a failure of the latter. Thus, logical interdependency (based on human decisions) influences all other types of interdependencies and can hinder the reconstruction or repair of critical infrastructures during post-disaster recovery.

Challenges due to degrees of interdependencies during post-disaster recovery

The degree of interdependency denotes the extent (or intensity, strength, and amplitude), to which interdependencies between critical infrastructures exist and are manifest (Dudenhoeffer, *et al*., 2006; O'Rourke, 2007). This sort of interdependency is generally perceived in the reciprocal influence exerted between critical infrastructures, which is also observed through the mutual exchange of services that occur among them. The strength of the interrelationships between critical infrastructures varies considerably. Some interdependencies are loose and thus relatively flexible, whereas others are tight, leaving little or no flexibility for the system to respond to changing conditions or failures due to natural disasters (O'Rourke, 2007; Rinaldi, *et al*., 2001). Loose interdependency implies that infrastructures are relatively interdependent of each other at a certain level, and thus the state of one is weakly correlated to the state of the other infrastructure (Ventura, *et al*., 2010). Tight interdependency means that infrastructures are highly dependent on one another (Rinaldi, *et al*., 2001). For instance, nineteen percent of respondents amongst general managers agreed that energy and ICT systems induce high degree of interdependencies to other critical infrastructures systems as they provide services, which are crucial to the functioning of these infrastructures at all time. Railway systems for example are strongly dependent on electric power to function, while energy systems are loosely dependent on railways. Although railway systems provide access and transport for natural gas derivatives and energy utilities, disturbance of rails does not necessarily induce the disruption of electric power.

Disturbances tend to propagate rapidly both through and across tightly coupled infrastructures. According to Rijpma (1997) and Weick, Sutcliffe, and Obstfeld (2008), tight interdependency is likely to be found with infrastructure systems that rely mostly on the use of unifiable, invariant, and time-dependant processes (Rijpma, 1997; Weick, Sutcliffe, and Obstfeld, 2008). These processes must be performed in a set sequence to avoid halting the exchange of services at one stage and restart again (Rijpma, 1997; Weick, *et al*., 2008). Rijpma (1997) further explains that such orderly systems both increase the likelihood that tasks will be accomplished and that disturbances could easily escalate and be diffused more widely to the rest of the interdependent systems. Whereas in loosely coupled systems, the production sequence can be easily redesigned during post-disaster recovery if a disturbance occurs (Rijpma, 1997; Weick, *et al*., 2008). Therefore, tightly coupled systems could cause greater concern for the reconstruction and repair of critical infrastructures. This is why it is essential to determine the extent to which critical infrastructures are interrelated, and in certain conditions to determine whether or not their degrees of interdependence could have an impact on their recoveries.

To determine how strong the interactions between two critical infrastructures exist during post-disaster recovery, it is necessary to determine for each infrastructure the other infrastructure that it continuously (or nearly continuously) depends on to operate normally, and also investigate the channel by which the services are delivered (from one infrastructure to the other infrastructure) (Ventura, *et al*., 2010). Furthermore, time is another factor that indicates how strong interactions between critical infrastructures are. Time, as a measure of interaction, refers to both the frequency (how often exchanges are performed) and the duration (how long infrastructures have been dependent on each other). The latter provides an indication of how long supported infrastructures could function during post-disaster recovery if they were deprived of services coming from the supporting infrastructure (s). According to general managers and risk practitioners, a strength capability measure is used to determine the amount and the intensity of reciprocal services between infrastructures when faced with such complex interactions (Ventura, *et al*., 2010). However in the case of simple linear interactions, considerations are generally given to determining how indirect, or direct, interdependencies between two critical infrastructures are, whether they are directly connected to one another, or indirectly coupled through one or more intervening infrastructures (Rinaldi, *et al*., 2001). Overall temporal interaction affects any other degree of interdependency, whether the relationship was generated in the past, the present or is ongoing.

CONCLUSIONS

The preliminary results of a recent pilot study conducted in Queensland, Australia, revealed that the types of interdependencies, including physical and cyber interdependencies as well as the degree to which infrastructures interact, have the potential to impede the post-disaster recovery effort. The results also revealed that within these elements, critical factors such as resources availability, reliability and transferability can also impede the post-disaster recovery effort. The continued reliability of critical infrastructures is paramount during the post-disaster recovery period. As mentioned earlier, the escalating complexity and vulnerability of infrastructures due to their interdependencies has been evidenced in recent years by their notable failures. For instance, a large-scale power outage could affect simultaneously all the interdependent critical infrastructures. The reliable exchange of services that occurs between interconnected systems also depends on the uninterrupted functioning of these infrastructures. Supposing that interconnected infrastructures fail to achieve their intended purpose, interdependencies will be likely to cause more harm than benefits to the entire network system during recovery. In this case, there are two paradoxical effects associated to the existence or inexistence of interdependencies between critical infrastructures. On one hand, interdependencies could generate widespread cascading failures amongst critical infrastructures in the aftermath of disasters (Buldyrev, *et al*., 2010). On the other hand, the absence of interdependencies as such, could also interrupt the functioning of the entire interdependent network. Viewed from this perspective, in a post-disaster reconstruction framework, it is crucial to maintain reliable infrastructure interdependencies to both the constancy of shared services as well as to the safety of critical infrastructures.

REFERENCES

Alesch, D. J. (2005). Complex urban systems and extreme events: toward a theory of disaster recovery. In *"Proceedings of the 1st International Conference on Urban Disaster Reduction"* (pp. 18-20): Kobe Japan.

Amaratunga, D., and Haigh, R. (2011). *"Post-disaster Reconstruction of the Built Environment: Rebuilding for resilience"*. John Wiley and Sons.

Australian Government. (2012). *"Building a disaster resilient Australia: Earthquake-Christchurch, New Zealand 2011"*. Australian Emergency Management (Knowledge hub) Retrieved from http://www.emknowledge.gov.au/resource/?id=629.

Buldyrev, S. V., Parshani, R., Paul, G., Stanley, H. E., and Havlin, S. (2010). Catastrophic cascade of failures in interdependent networks. Nature, **464**(7291), 1025-1028.

Bureau of Transport Economic. (2001). *"Economic Costs of Natural Disasters in Australia: Report 103"*. Retrieved from http://www.bitre.gov.au/publications/2001/files/report_103.pdf

Canterbury Earthquake Recovery Authority. (2012). *"Recovery Strategy for Greater Christchurch"*.

De Bruijne, M., and Van Eeten, M. (2007). Systems that should have failed: critical infrastructure protection in an institutionally fragmented environment. *"Journal of Contingencies and Crisis Management"*, **15**(1), 18-29.

Deloitte Access Economics. (2013). *"Australian Business Roundtable for Disaster Resilience and Safer Communities: Building our nation's resilience to natural disasters"*. Retrieved June 2013, from http://australianbusinessroundtable.com.au/assets/Natural%20Disaster%20Roundtable%20Paper%20Web%20version%20January%202014.pdf

Dudenhoeffer, D. D., Permann, M. R., and Manic, M. (2006). CIMS: A framework for infrastructure interdependency modeling and analysis. In *"Proceedings of the 38th conference on Winter simulation"* (pp. 478-485): Winter Simulation Conference.

Dueñas-Osorio, L., and Vemuru, S. M. (2009). Cascading failures in complex infrastructure systems. *"Structural Safety"*, **31**(2), 157-167.

Hyogo framework. (2005). Hyogo framework for action 2005–2015: Building the resilience of nations and communities to disasters. *"World Conference on Disaster Reduction"*, January, 18–22, Kobe, Hyogo, Japan. Retrieved from

Johansson, J., and Hassel, H. (2010). An approach for modelling interdependent infrastructures in the context of vulnerability analysis. *"Reliability Engineering and System Safety"*, **95**(12), 1335-1344. doi:10.1016/j.ress.2010.06.010

Kapur, K. C. (2014). *"Reliability Engineering"*. Retrieved from http://QUT.eblib.com.au/patron/FullRecord.aspx?p=1658817

Moteff, J., and Parfomak, P. (2004). *"Critical infrastructure and key assets: definition and identification"*. In: DTIC Document.

O'Rourke, T. D. (2007). *"Critical infrastructure, interdependencies, and resilience"*. Bridge-Washington-National Academy of Engineering-, **37**(1), 22.

Parfomak, P. W. (2005). *"Vulnerability of concentrated critical infrastructure: Background and policy options"*. In: DTIC Document.

Partnership, I. S. (2006). *"Regional Disaster Resilience: A Guide for Developing an Action Plan"*. American Society of Civil Engineers

Rijpma, J. A. (1997). Complexity, tight–coupling and reliability: Connecting normal accidents theory and high reliability theory. *"Journal of Contingencies and Crisis Management"*, **5**(1), 15-23.

Rinaldi, S. M., Peerenboom, J. P., and Kelly, T. K. (2001). Identifying, understanding, and analyzing critical infrastructure interdependencies. Control Systems, *"IEEE"*, **21**(6), 11-25. doi:10.1109/37.969131

Santella, N., Steinberg, L. J., and Parks, K. (2009). Decision Making for Extreme Events: Modeling Critical Infrastructure Interdependencies to Aid Mitigation and Response Planning. *"Review of Policy Research"*, 26(4), 409-422. Retrieved from http://dx.doi.org/10.1111/j.1541-1338.2009.00392.x. doi:10.1111/j.1541-1338.2009.00392.x

Setola, R., Bologna, S., Casalicchio, E., and Masucci, V. (2009). An Integrated Approach For Simulating Interdependencies. In M. Papa and S. Shenoi (Eds.), *"Critical Infrastructure Protection"* II (Vol. 290, pp. 229-239): Springer US.

Ventura, C., García, H. J., and Martí, J. (2010). Understanding interdependencies among critical infrastructures. *"In 9th US National and 10th Canadian Conference on Earthquake Engineering"*, Toronto, Ontario, Canada.

Weick, K. E., Sutcliffe, K. M., and Obstfeld, D. (2008). Organizing for high reliability: Processes of collective mindfulness. *"Crisis Management"*, **3**, 81-123.

World Bank. (2011). *"Queensland Recovery and Reconstruction in the Aftermath of the 2010/2011 Flood Events and Cyclone Yasi"*. Retrieved from http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2011/07/22/000386194_20110722031713/Rendered/PDF/633930revised00BLIC00QUEENSLAND0web.pdf.