Proceeding: 3rd International Conference on Tourism, Technology and Business Management (3rd ICTTBM, 2020) (ISBN:xxx)
Kuala Lumpur, Malaysia

RESILIENCE: A REVIEW OF ROLE AND SIGNIFICANCE IN PHYSICAL ASSET MANAGEMENT

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Abstract: *Concept of resilience have been discuss in many area of studies such as social studies, health, engineering, ecology and management. The objectives of this studies is to understand the role of resilience in physical asset management. The study use previous studies and investigate the definition of resilience and role of resilience in physical asset management. The study found out that resilience and physical asset management have connection. Understanding and good governance on physical asset management can yield a resilience system towards any interruptions however resilience planning must be organize thoroughly by physical asset management. It is suggested that resilience planning should take place in the initial phase of system development and the decision making process of physical asset management.*

Keywords: *Resilience; Physical Asset Management; Strategic Planning; Infrastructure Asset Management, Good Governance*

Introduction

The concept of resilience is to describe the state of things to get up to its normal performance. The concept of resilience is a multivariate concept applied in any situation, time, condition, and shape. Understanding the definition of resilience made by various previous studies can explain why this concept is multivariate and can be applied in any situation and time. Then, we need to analyse what is the true meaning of resilience that can be understood by all the researchers. Another key point is asset management. Asset Management is a management program to organise, administrate, and operate the asset to benefit the organisation that owns or uses it. But why asset management need the resilience concept in its form? The asset is proven eventually to fail and perform poorly across time. The life cycle of an asset give its limitation to continue its function to the best of its ability. In the case of disruption that causes damage for an asset, it will affect the asset to perform poorly to deliver its true objective in the system.

Thus, to understand this issue, it is essential to review the articles discussing the relationship between resilience and asset management. Does resilience give high significance in asset management or otherwise? Then we can assume how resilience works in asset management

thoroughly. The definition of resilience is identified from previous research where the papers are collected using Google Scholar. The list of the definition is listed in Table 1.

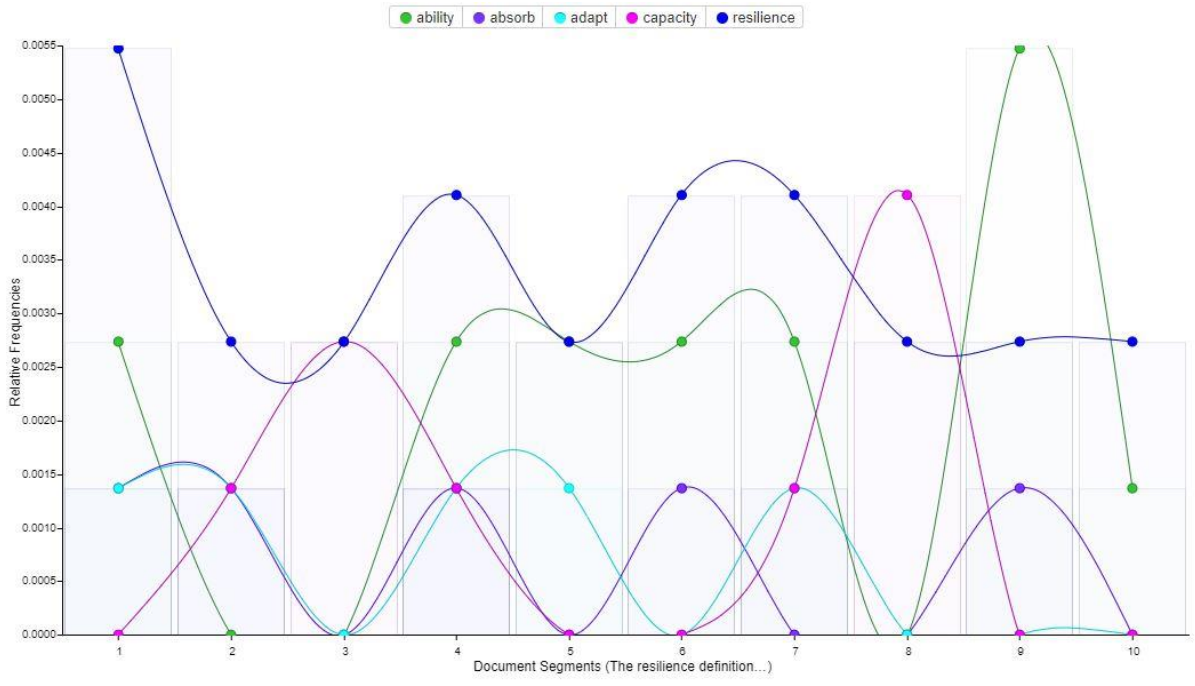
Table 1: Definition of Resilience

No.	Author(s)	Definition	Sector
1.	Juan Garcia et al. (2017)	The resilience definition adopted is: "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events".	Water
2.	Hesketh et al. (2018)	Resilience training could improve employee performance and well being.	Organisation
3.	Dehghanian et al. (2018)	Resilience is the ability of the system to restore itself with little or no human intervention to a safe and reliable operation from any disturbance or outages.	Electric
4.	Williams et al., (2017)	Resilience as the process by which an actor (i.e., individual, organization or community) builds and uses its capability endowments to interact with the environment in a way that positively adjusts and maintains functioning prior to, during and following adversity.	Organisation
5.	Bunch et al., (2011)	Resilience is an approaches that can help reduce vulnerability to natural hazards, maintain ecological flows of water and the provision of other ecological services, and promote long-term sustainability of coupled human and natural systems.	Ecosystem
6.	Hernantes et al., (2019)	City resilience as the capacity to resist, absorb, adapt to and recover from schocks and stresses to keep critical services functioning, to monitor and learn from on-going processes through city and cross-regional collaboration and to increase adaptive abalities and strengthen preparedness by anticipating and appropriately responding to future challenge.	Urban Planning
7.	Arghandeh et al., (2016)	Resilience in power systems and provides a review of key related concepts, including robustness, hazards, vulnerability, risks, capacity and severity, focusing mostly on distribution networks.	Power system
8.	Hoddinott (2014)	Resilience as the capacity that ensures adverse stressors and shocks do not have long-lasting adverse development consequences.	Food Security
9.	IPCC (2007)	Resilience as the ability of a social and ecological system to absorb disturbances while retaining the same basic structure and ways of functioning the capcity of self-organization, and the capacity to adapt stress and change.	Urban Climate Change
10.	Erol et al., (2009)	Enterprise resilience as a function of enterprise flexibility, adaptability, agility and efficiency.	Enterprise
11	Agasisti et al., (2018)	Academic resilience as the ability of 15-year-old students from disadvantaged backgrounds to perform at a certain level in the programme for International Student Assessment (PISA) in reading, mathematics and science that enables them to play an active role in their communities	Academic

		and prepares them to make the most of lifelong-learning opportunities.	
12	Jackson (2007)	Resilience as the ability of organizational, hardware and software systems to mitigate the severity and likelihood of failures or losses to adapt to changing conditions and to respond appropriately after fact	Command and Control
13.	Field et al (2012)	Resilience as the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner.	Social-Ecological System
14.	Rose (2004)	Static economic resilience as the ability of an entity or system to maintain function when shocked. Dynamic economic resilience is the speed at which an entity or system recovers from a severe shock to achieve a desired state.	Economic
15.	Taft (2017)	Grid resilience is the ability to withstand grid stress events without suffering operational compromise or to adapt to the strain so as to minimize compromise via graceful degradation. It is in large part about what does not happen to the grid or electricity consumers	Electric
16.	Rajan-Rankin (2014)	Resilience as the individual's adaptive response to adversity, stress-resistant personality traits and the ability to 'bounce back', yet the processes by which resilience is developed remain under explored.	Social Care
17.	Lin et al., (2013)	Resilience is an enduring ability or capacity that is exhibited as strength of the caregiver when responding to chronic stresses and problem solving.	Social Care
18.	Obrist et al., (2010)	Social resilience as the capacity of actors to access capitals in order to-not only cope with and adjust to adverse conditions (that is, reactive capacity)-but also search for and create options (that is, proactive capacity), and thus develop increased competence (that is positive outcomes) in dealing with a threat.	Social
19.	Cimellaro et al., (2006)	Seismic resilience is loss recovery required to maintain the function of the system with minimal disruption.	Seismic
20.	Francis and Bekera (2014)	Ability to reduce the magnitude and/or duration of disruptive events.	Water
21	Mugume et al., (2015)	Ability to maintain its basic structure and patterns of behaviour through absorbing shocks or stressors under dynamic condition.	Sewerage
22.	Naswall et al., (2013)	Employee resilience as an ability to thrive in a changing environment, which is facilitated by organisational initiatives.	Organisation
23.	Ta et al., (2009)	Freight transportation system resilience is defined as the ability for the system to absorb the consequences of disruptions to reduce the impacts of disruptions and maintain freight mobility.	Transportation
24.	Madni and Jackson (2008)	Resilience engineering is concerned with building systems that are able to circumvent accidents through anticipation, survive disruptions through recovery, and grow through adaptation.	Engineering

25.	Butler et al, (2014)	Degree to which the system minimizes level of service failure magnitude and duration over its design life when subject to exceptional conditions.	Wastewater
26.	Scott et al., (2012)	Resilience is the ability to gracefully degrade and subsequently recover from a potentially catastrophic disturbance that is internal or external in origin.	Wastewater

These are a few definitions regarding resilience in the literature that can be found in the paper articles. The text analysis using the Voyant tools found that resilience is highly associated with ability, adopt, absorb, and capacity. The analysis revealed that most of the definitions of resilience contain words such as ability, capacity, disruptions, stress, events, reduce, adverse, recover, absorb, and maintain, system. Figure 1 depicts the most frequent codes in the corpus: resilience (25), ability (15); capacity (8); absorb (5), adapt (5). This shows that the definition of resilience contains a word such a possession of the means or skill (e.g., ability and capacity) to process towards (e.g., reduce, adverse, recover, absorb, maintain) the causation (e.g., disruptions, stress, events) in the system. The system here is a group of things that work together form a mechanism or a set of the organized scheme that is put together. Most of the studies focus on the resilience of these 'skills' and 'process' to counter the system's causation. The investigation of this skill and process is the central theme for most researchers to emphasize. The next question is how related physical asset management and resilience? Is there any significant between these two relationships? How the role of resilience took place in physical asset management. Thus we need to understand the definition and purpose of physical asset management.



Note: Code frequency in the corpus: resilience (25); ability (15); capacity (8); absorb (5); adapt (5)

Figure 1: The text analysis of the definition of resilience

Hastings (2010) indicated that the meaning of physical asset management is the administration of fixed or non-current assets, for example, equipment and plant. Physical Asset Management offers a systematic approach to the management of these assets from concept to disposal. The

fundamental principles of physical asset management in the asset management process are including initial business appraisal, identification of fixed asset needs; financial evaluation; logistic support analysis; life cycle costing; maintenance strategy; outsourcing; cost-benefit analysis, disposal, and renewal. The importance of managing physical assets are also depicted by the foundation of ISO 55000:2014 and EN 16646:2014.

Maletic et al. (2018) emphasize that physical asset management has a vital role in managing an asset's lifecycle as a whole, pursuing economic and physical performance, and integrating risk measures. Physical asset management uniting other disciplinary in the field such as accounting, engineering, finance, humanities, logistics, and information systems technologies. In this paper, we consider that physical asset management and infrastructure asset management are the same; however, the term related to infrastructure asset management is primarily on public sector infrastructure. Infrastructure asset management, according to Yang et al. (2019), is defined as a series of coordinated activities in organizations to achieve the predefined level of services through cost-effectively managing their infrastructure assets. The term of asset in the dictionary is “Any item of economic value owned by an individual or corporation” or “an item of property owned by a person or company, regarded as having value and available to meets debts, commitments or legacies”. The term ‘physical’ asset refers to items, for example, buildings, water pipes, roads, rail lines, oil rigs, chemical plant, or electrical cables and opposite to financial assets, personal assets such as skills, data, or system. The importance of asset management gives many benefits to organisations, such as reducing the total costs of operating, reducing the capital cost of investing in the asset base, and improving the operating performance of their assets. Reduce the potential health impacts of operating the assets, reduce the safety risks of operating the assets, minimise the environmental impact of operating the assets, maintain and improve the reputation of the organisation, improve the regulatory performance of the organisation and reduce legal risks associated with operating assets (Davis, 2016).

The purpose of the physical asset management plan is to coordinate an organisation to define and deliver a set of actions towards achieving the objectives set out in the Asset Management strategy. Even the set of objectives in each organisation is different, but asset management aims to prevent failure. Any interruption in the system must achieve its normal state again when the preferable condition is accepted. Resilient structures find strategies to keep the backbone intact (Argahandeh et al., 2016). Asset management poise many benefit as proposed by CSS (2004) where a well-defined asset management system provides a specific benefit which includes the following a) reduced life cycle costs b) defined level of service c) ability to track performance d) improved transparency in decision-making e) predicting consequences of funding decision f) decreased financial, operational and legal risk g) ability to discharge to financial reporting responsibilities and statutory valuation. Then we seek the relationship between resilience and physical asset management reported from previous studies.

Literature Review

The study on resilience has many gaps because resilience research can be disseminated in every discipline. The resilience measurement in each study differs, if not significantly, but slightly from one another. Many examples can be observed to prove that resilience in each discipline is different. For instance, Hernantes et al. (2019) describe the cities resilience are involving a) leadership & governance, b) stakeholders, c) infrastructure & resources, d) preparedness e) cooperation. Gay and Sinha (2013) state that civil infrastructure resilience involves physical asset design, construction, operation, maintenance, and performance matric, which can

enhance resilience. According to Ta et al. (2009), freight transportation system resilience properties are redundancy, the autonomy of components, collaboration, efficiency, adaptability, and interdependence. Juan-Garcia et al. (2017) state that water system resilience involves buffering, spare replacement, asset renewal, active asset management, system centralization, asset protection, repair strategy, and energy production. In comparison, these two systems have different measures to enhance their system resilience. Each variant of the system has its measurement to enhance resilience. What is the measurement of physical asset management? Does physical asset management does have its resilience?

Relationship of Resilience and Physical Asset Management

Resilience concept have been discuss in many disciplinary of studies. The importance between resilience and physical asset management have been addressed in Sinha (2014) where the integration of resilience methodologies with asset management is convenient given the increase in risks to infrastructure performance worldwide. The integration of resilience concept and physical asset management are shown by Yang et al., (2019) where the framework of Resilience Infrastructure Asset Management (RIAM) using qualitative analysis were expected to provide an operational basis to the quantitative resilience management of civil infrastructure assets which could also be used to enhance community resilience. The study have focus four themes in their RIAM framework namely a) preparatory process b) resistant and absorptive capacity analysis c) restorative capacity analysis d) long-term and continuous resilience improvement. This studies shows that there are significant relationship between resilience concepts integrated to infrastructure asset management. The framework clearly clarify the process that need to be consider by infrastructure asset management team when certain hazard or disruption occurs in the system.

Resilience concept can be considered add value to asset management where it can clarify the quick response and action need to be taken to the asset management team where the resilience system are dependent on how prepared it is to absorb the disruption either from natural hazard such as floods, earthquake, drought and etc. Even ageing infrastructure such as power outage or breakdown, and mitigate those risks with proper planning. Shah et al., (2014) proposed that resilience concept should be implement in asset management systems and strategies as to support long-term policies and investment. Morevover, policies is seen as key driver in future proofing the infrastructure and making it resilient. This clarifies that resilience must be integrate with planning and design processes where it is not only consider the changes in use and growing age of the infrastructure but also the necessity to invest well in infrastructure maintenance.

According to Alberta (2015) the understanding on asset management itself can build resilience in the system. Alberta discuss that asset management gives many benefits and a set of practices for making good decisions and it is ongoing process. The relationship between asset management and resilience is where understandable asset management can create community resilient towards any hazard and threat that coming in the future. Asset management build the resilience with good decision making. To make a good decision making, we must fully understand the risk, services and costs that build the resilience to the system. Communication and information management are the things that essential for the foundation of asset management. The resilience in physical asset management where the role of physical asset management are fully understand by its stakeholders and asset managers then resilience of a system can be achieved. We must fully grasp the challenges and risks involved by physical asset management to achieve a resilience system. Then all the factors and measurements must

be taken into action such as deregulate the policies, changing the strategies and planning or enhance the funding program to provide better programmes that can enhance the system resilience.

Role of Resilience in Physical Asset Management

The role of the resilience concept in physical asset management is for physical asset management to understand the factors that can make a system more resilient whenever unexpected and expected events hit the system. This can be understood from the expansive definition given. However, the main point is that a system's quickness bounces back to normal after interrupted either by expected or unexpected events.

However, each system's resilience factors covered by physical asset management are entirely different from one another. Physical asset management refers to managing assets from the start of designing a system to the end of an asset until the time it will be disposed of. Each asset management in a different field has different critical success factors of resilience. The resilience concept in physical asset management refers to a system or structure's ability to maintain normal functionality after hits by interruptions (expected/unexpected) through sound asset management practices.

According to Gay and Sunha (2013), system resilience is transdisciplinary. The civil infrastructure resilience depends not only on its physical asset; nevertheless organisation, resources, people, or the community. System resilience will produce good results with the interaction with these components. The role of resilience exists in physical asset management; however, it was not appropriately addressed. The asset manager does not point out the critical success factors that enable the system to withstand the interruptions' impact. Moreover, the success factors that enhance resilience differ from another system.

For example, the article discusses the infrastructure system in three different areas, e.g., water, power, and transport. Generally, each type of infrastructure has various success factors of resilience system. Thus approach, measurement, or action in each system differ and cannot be treated as the same even though there is the same resilience component, e.g., repair strategy for the water system and road system.

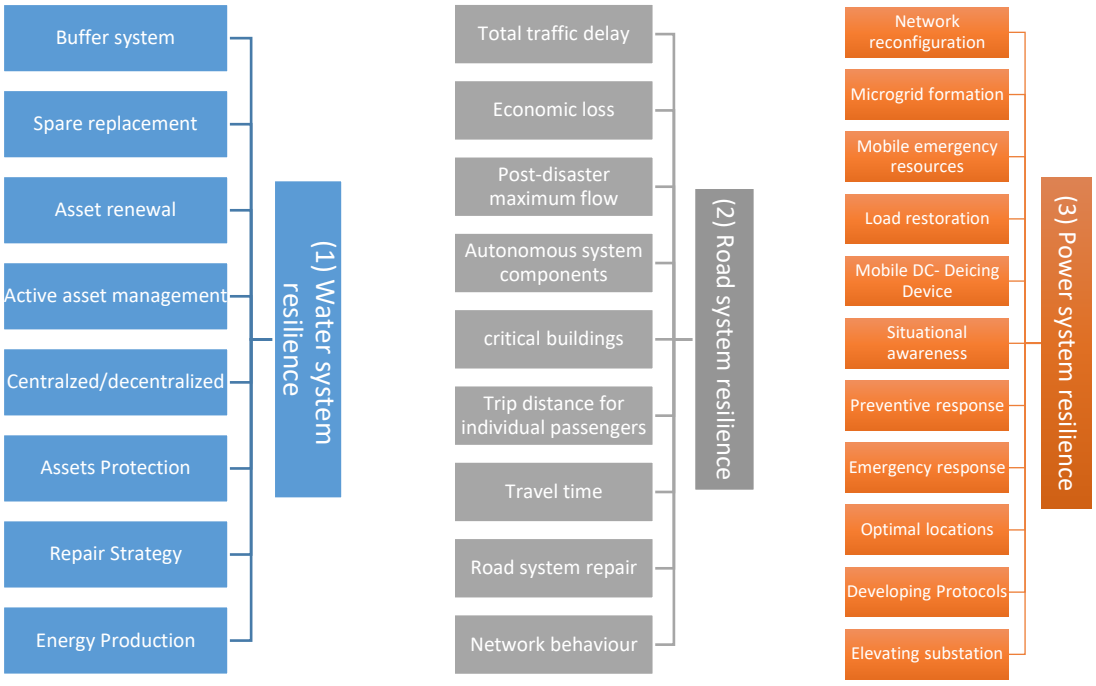


Figure 2: (1) Water System Resilience (Juan-Garcia et. al, 2017); (2) Road Transportation System Resilience (Ganin et. al, 2017); (3) Power System Resilience (Bhusal et. al, 2019)

Each system resilience has a different number of interventions or measurements needed to enhance its system resilience. The number of measurements might increase from time to time, depending on the complexity of the system. Therefore, the system's complexity depends on the growth of technology, engineering, or management progress in the system in the future.

Conclusion

Investing in improvements to infrastructure resilience can demonstrate a legacy of leadership, provide economic growth and job creation, and result in more liveable communities. The concept of resilience can be properly implemented if there are workable asset management practices through good governance. Good governance ensures the main objectives and functionality of assets could be delivered well to the end-users. Resilience, however, is a concept to push back the system's performance back to normal after interruptions hit the system. Physical asset management ensures the functionality throughout its lifecycle in the system to achieve the organisation's objective. Understanding the work of physical asset management can give the system resilience by understanding the key measurements that need to be prioritised in strategic decision making. The relationship between resilience and physical asset management seems correlated; however, some statistical analysis is required to understand whether the relationship is positively correlated or negatively correlated. Another set of the question also arises either these two variables have single or bidirectional causality? The study can be investigated in the future. The resilience concept's role is giving the idea that resilience is a planning process or management process to protect the system from worst failure or total lost functionality and bouncing back the system to normal state performance. The resilience planning or resilience management must be studied in the early adoption of the decision-making process or during the system's initial building to ensure that the system can get total protection from the expected or unexpected interruptions.

Acknowledgments

This paper is supported by the Fundamental Research Grant Scheme (FRGS), Vot. 5F225 of Ministry of Education Malaysia, and Universiti Teknologi Malaysia, Malaysia.

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