Journal of Tourism, Hospitality and Environment Management JTHEM
EISSN: 0128-178X

Volume 7 Issue 27 (March 2022) PP. 103-112
DOI 10/35631/JTHEM.727009

JOURNAL OF TOURISM, HOSPITALITY AND ENVIRONMENT MANAGEMENT (JTHEM)
www.jthem.com

GLOBAL ACADEMIC EXCELLENCE

A REVIEW ON THE RESILIENCE MODELS AND ATTRIBUTES WITHIN THE BUILT ENVIRONMENT

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Article Info:

Article history:
Received date: 15.12.2021
Revised date: 13.01.2022
Accepted date: 25.02.2022
Published date: 08.03.2022

To cite this document:

Ali, A. H., Khaizdir, K. A. M., & Rashid, A. M (2022). A Review On The Resilience Models And Attributes Within The Built Environment. *Journal of Tourism Hospitality and Environment Management, 7* (27), 103-112.

DOI: 10.35631/JTHEM.727009.

Abstract:

Resilience is considered as the ability of systems to cope (or adapt) with adversity over time. However, there is an ongoing debate around the resilience paradigm, and similarly, most resilience descriptions are often application specific. This article reviews various resilience models in the built environment such as the representation of resiliency and its characteristics (e.g., sociocultural networks), objectives (e.g., enhancing knowledge systems), challenges (e.g., adaption), and applications (e.g., climate resiliency and disaster). This paper aims to establish a foundation for further investigation in built environment resilience. Open issues are drawn toward the end of this article to reveal new research avenues to shed light and spark new interest in this research field.

Keywords:

Resiliency, Risk, Protective Factors, Built Environment

Introduction

Built environment as a concept was initially proposed by social scientists (Rapoport, 1976). The built environment has been applied to address: a) the complexity of the urban fabric, which includes systems (e.g., socio-technical) that scales to buildings, cities, as well as regions, each

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with its own policy-makers, constraints (e.g., time), and agendas; and b) environmental issues resulted from the human-made buildings and infrastructure. One of the main factors that pose a significant challenge to the built environment is the growth of the natural population, in which development is rising across the globe, and people are living in urban areas (i.e., urbanization) due to the developing world economy. Research has focused on: a) developing successful sustainability strategies for energy consumption (Gu et al. 2018); b) the relationship between the built environment and unbuilt environment (e.g., social-ecological system), which resulted in investigating built environment from the perspective of culture and nature (Hassler et al. 2014); and c) establishing sustainability and resilience across the different domains of the built environment (e.g., socialecological systems, buildings, cultural heritage, and climate change) alongside with factors such as urbanization (or modernization).

Resiliency provides opportunities to explore the changing conditions of planning and designing methodologies (or approaches) (Hassler et al., 2014). It is essential to identify risk factors of the built environment and their protective factors that can boost and support resilience. Traditionally resiliency has been the ability of entities (e.g., individuals, family, and communities) to cope with adversity; however, it is challenging to conceptualize the resilience concept due to the various components (e.g., social networks, humans, infrastructure, and public authorities) and concepts (e.g., recoverability, vulnerability, exposure, and adaptively) evolve around it. This paper presents an overview of the state-of-the-art resilience models, frameworks, and applications in the built environment by grouping the journal articles according to resilience attributes.

Origins and Definition of Resilience

Resiliency originated from the field of medicine; however, behavioral sciences are the primary investigators of resiliency around 1970 (Cicchetti, 2006; Masten, 2007; Masten, 2011). Resiliency from a theoretical perspective has been addressed in several fields such as social science, education, and psychology. Resiliency is primarily evolved around two components, one is the protective factors such as institutional, family, personal, and social factors, and the others are life challenges that may threaten individuals such as psychosocial and society (i.e., individual's relations to society) challenges. (Alvord et al. 2005) state that resilience definition requires an identified risk, crisis, or challenge followed by a specified positive outcome. However, there are still debates regarding what establishes resilience and how to measure successful coping mechanisms. Research has noted that a resilient individual must exhibit positive outcomes in different aspects of life (Zolkoski et al., 2012) and that resilience is acquiring considerable skills in various fields that enable an individual to cope (Alvord et al. 2005).

Risk Factors in Built Environment

Risk is well known and identified in the medical field and being accepted in behavioral sciences in the 1970s (Jens & Gordon, 1991). Risk in the built environment mainly emerges from natural hazards that vary in terms of threats and impacts to buildings. These natural hazards include: flooding, earthquakes, storms, and winds. Besides natural hazards, there are some other risk factors to be considered. These factors result from the ecosystem and include:

- Modernization and globalization: both modernization and globalization may not always be a negative impact; however, in regions such as the middle-east modernization and globalization brought several challenges to the built environment such as energy security, desertification, and land degradation (Rózsa, 2014.). Moreover, post-war

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modernization, is a significant risk factor due to the impact of war on building and social environments, in which post war cultural identities, national identity, and social behavior are affected negatively by modernization (e.g., post war impacts on Hiroshima and Nagasaki).

- Natural hazards and environmental risk factors are address in the literature using two main approaches: a) engineering approach, in which performance and engineering-based (i.e., at the level of buildings) approaches are taken to address them. This includes building materials adaption to changes, robustness, and stability (Hassler et al. 2014). These approaches analyze the building in terms of models and simulations and obtain numerical evaluations (Mavrouli et al. 2014) that lead to measuring the level of resilience; and b) environmental approach, in which ecosystem-based (i.e., at the environment level) approaches are taken to address them. This includes neighborhood, urban, the capacity of adaption, and cultural changes (Hassler et al. 2014). These approaches take indicators as input, process the indicators using experts and knowledge systems to identify the risks, and utilize the protective measures that lead to resilience.

Protective Factors in Built Environment

Protective factors are the promoting attribute to resilience, while resilience is inhibited by risk factors (Alvord et al. 2005; Fergus & Zimmerman, 2005). Figure 1 shows the procedure of obtaining resilience model and frameworks in regards to risk and protective factors. Protective factors change the course of events to eliminate future adverse outcomes and promote positive outcomes. Both risk and protective factors are dynamic units that vary according to the situation (or event) and can lead to different outcomes (Walsh, 2003). According to (Benzies et al. 2009), to optimize resilience, protective factors should be decisive at the borders (i.e., the interactive levels) of the three main levels resilience emerge from (i.e., individual, family, and community). Protective factors include, individual attributes (or characteristics), which are the unique factors that distinguish a resilient individual from individuals who find it challenging to overcome risk factors (Werner, 2000), organizational structures and public authorities, construction and rebuilding, and community support.

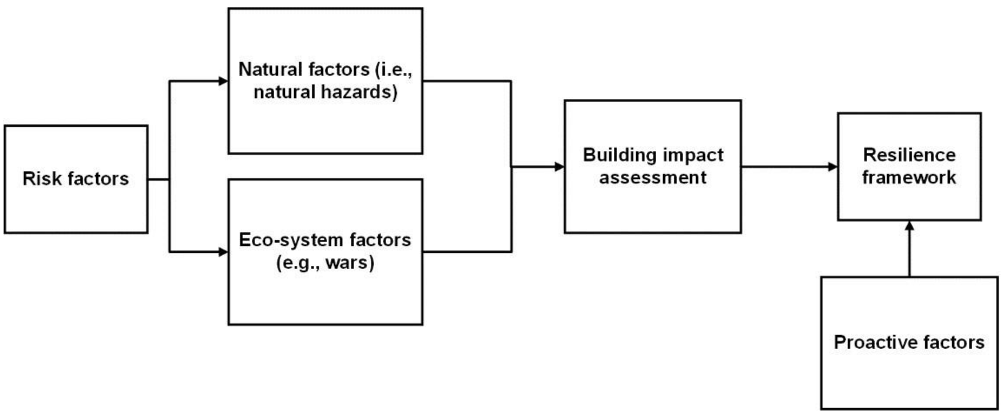

Figure 1: Concept of Developing Resilience Framework

Resilience Attributes

Resilience attributes in literature are shown in Figure 2. Firstly, resilience models have three main objectives: a) enhancing knowledge systems, in which it reflects that expert-driven information is met and cooperated into knowledge systems to be used in various aspects such as decision making; b) stability, which refers to maintaining the flexible behavior of materials

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in dynamic systems over time; and c) enhancing cultural resiliency: which refers to various approaches that influence the resilience of individuals or communities.

Secondly, resilience models have four main characteristics: a) dynamic systems, which refers to a system that is dynamic in nature, such as ecological systems; b) Heterogynous entities, which refers to the existence of several components in the system and that diversity is a significant component in the design criteria for resiliency; c) technology, which reflects that technology is the predominant attribute of the system and is the major component in the design criteria for resiliency; d) socio-cultural networks, which reflects that the community exhibits bounded socio-cultural networks that contribute to resilience.

Thirdly, resilience models address three main challenges: a) higher growth, which reflects population growth and growth of social-cultural networks in terms of conservation and reorganization; b) complexity, which refers to the complexity of the decision-making due to the connection of transdisciplinary concepts such as investigating buildings, sites, and regions; and c) adaption, which refers to the ability to adapt to changes such as crises. Resiliency has been applied to tackle the challenge of adaption.

Fourthly, resilience models have been applied to two main applications in the built environment: climate and disaster and cultural heritage buildings. Fifthly, resilience models have been applied to enhance one main performance measure, which is sustainability (Lizarralde et al., 2015).

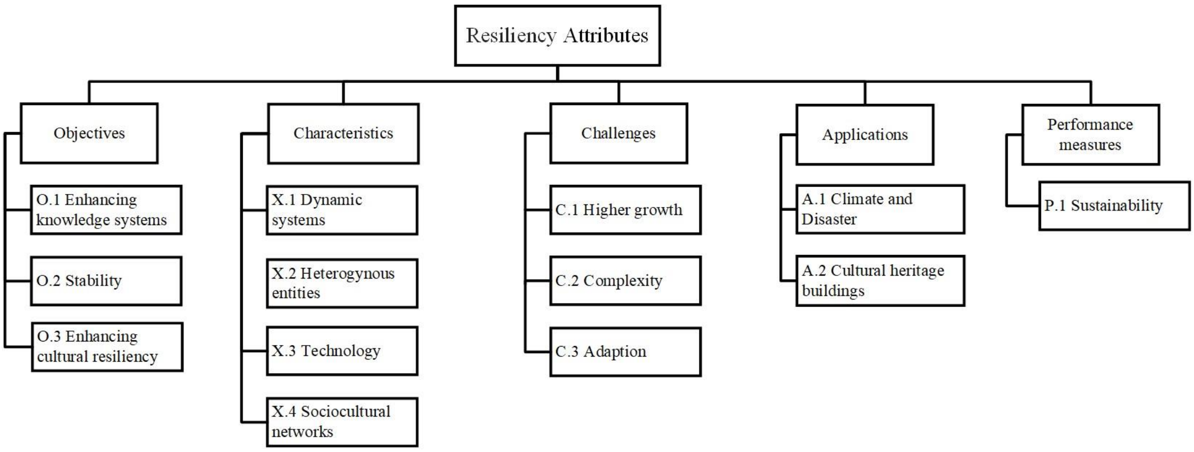

Figure 2: Resilience Attributes

Resilience Models and Frameworks

This section presents a brief application of resiliency approaches in a diverse range of applications.

Carpenter (Carpenter, 2013) investigated the capacity of community resiliency to disasters. The author identifies resilience as the ability to rebound from natural disasters such as hurricanes and earthquakes. The main aim of the study is to identify how the relationship between the built environment that has great influence (i.e., contribute or affect) on socio-cultural networks that face the challenge of higher growth to contribute to resilience. The author states that a sociocultural network is key to enabling individuals to cope and rebound from disasters by

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reducing risk factors such as vulnerability and prompting protective factors such as facilitating response evacuation procedures. Therefore, the study aims to contribute to knowledge systems by identifying the connection between risks and protective factors in the built environment. Resilience is when a disaster occurs, and socio-cultural networks are utilized, including heterogynous entities such as family, risk and management teams, construction and rebuilding, political and economic entities. The author concludes that a socially strong community is more sustainable and resilient giving that a strong foundation of streets and hybrid spaces with diversity promotes socio-cultural networks engagements.

Jankovic (Jankovic. 2018) proposed a resilience framework to enable buildings to withstand extreme weather events. The study investigates buildings in terms of three separate blocks: the building, the site, and the region using technological tools (i.e., simulation engine called multiobjective optimization). Due to the multiple interrelated domains, the proposed resilience framework inherits a degree of complexity. The proposed framework addresses the challenge of adaption and proposes a resilience framework that enhances sustainability and stability by providing provisions (i.e., protective factors) for building thermal insulation, green regions adaptability, and social interaction adaptability. Resilience is obtained from analyzing the risk factors using multi-objective optimization and provide application-specific protective factors that promote resilience.

Majid et al. (Majid et al., 2020) highlight that urban livability indicators face the challenge of dynamic reconfiguration of urban settlements caused by demographic shifts from rural to urban areas. The study aims to identify livability indicators and propose a prototype knowledge system (i.e., urban resiliency indicators) for secondary cities. Urban livability metrics embedded with a clear manifestation of decision-making enable a sustained urban livability because sustainability impacts affect the resiliency of communities with socio-cultural characteristics. Livability issues could obstruct the development and establishment of livable and sustainable urban areas. The authors emphasized the significant importance of indicators in achieving systematic monitoring and assistance in detecting the patterns of societies to be used in outlining a clear manifestation of decision-making and management.

Wijsman et al. (Wijsman et al., 2019) investigated traditional knowledge systems to enhance knowledge systems of societies with high technological capabilities and socio-cultural networks in climate and disaster. Cities suffer from the challenge of adaption, such as climate change adaption, and require a set of knowledge systems to achieve urban resiliency. The study suggests that climate change adaption requires a dynamic set of knowledge systems (e.g., technical, local, and scientific) due to the threat of rapidly changing weather events against aging city infrastructures, and therefore climate and adaption resiliency are affected. Therefore, the resiliency of knowledge systems must be taken into account when making critical decisions for overcoming catastrophes such as climate and disaster.

Campanella (Campanella 2006) studied the catastrophe of Hurricane Katrina in New Orleans and its relation to climate and disaster. The author mentions several factors that affect cities' resilience, such as political and economic functions; cities with a robust economy can adapt to changes quickly than cities with a weak economy. Another factor is the planning and management; cities with robust evacuation and management plans can endure the crisis. The author also states that city resilience depends significantly on people's (or citizens) resiliency

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with characteristics such as socio-cultural networks. Resilient citizens enable urban resiliency.

Moreover, in New Orleans, citizens such as African Americans and the working-class Vietnamese Americans showed resiliency after hurricane Katrina by holding onto a common cultural heritage.

Schalk (Schalk et al. 2014) studied the Metabolist architecture and its influence on achieving a utopia of cultural resiliency. Metabolist architecture is the Japanese post-war architectural movement that proposed architectural ideas in building megastructures. Metabolist architecture in Japan approached resiliency in terms of exosystemic adaption response in times of crisis. The author claim that the aesthetic of Metabolist can provide political strategies for the modern built environment equipped with cultural identities. Metabolism introduced generic new models and terms applicable to architectural design worldwide (i.e., beyond Japan). Moreover, metabolism established a connection between traditional culture and ahistorical and structuralist spatial conceptions. The term metabolism refers to the anabolic and katabolic processes of the living body, and it relates to architectural design by referring to cities as an organism that grew and changed. The study reveals that a systematic conceptual approach such as the metabolism concept would greatly affect achieving cultural identity resiliency in sustainable architecture.

Godbolt et al. (Godbolt et al. 2018) investigated the climate resilience of cultural heritage buildings in order to identify the challenges of achieving resilience of cultural heritage buildings from the perspectives of public authorities and resident's user's requirements. The study aims to enhance knowledge systems by understanding residents' and public authority' perspectives to enable decision-makers to take sustainability measures, including transformation, selecting information, and conserving cultural heritage buildings. The authors use empirical study based on qualitative case study (i.e., 1890 old building in Oslo, Norway) and focus group interviews on identifying the main challenges faced by residents who try to make their cultural heritage building more resilient, and the climate resilience approach followed by the public authorities (i.e., the directorate for cultural heritage). The main challenge faced by the cultural heritage building (i.e., the case study) is the adaption, in which residents have difficulties practicing climate adaption and mitigation procedures regarding their cultural heritage building. The study identifies resilience as the ability of buildings to cope with natural hazards and human-made risks. In order to take resilience approaches, the authors found that residents on their own have to consult public authorities and explore the wide variety of public requirements and interests.

Mulholland et al. (Mulholland et al., 2002) proposed a digital narrative to support the knowledge system of cultural heritage buildings. The authors used socio-cultural networks and a narrative approach due to the importance of narratives in understanding heritage collections and presentations. The narrative is used in hypertext technology to enable readers to control and immerse (i.e., feeling of being inside a story). The resiliency of technology has significant importance due to the advantages of digital narrative that support knowledge systems for sustaining urban liveability.

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MacKee (MacKee et al. 2014) proposed a resilience model to conserve and repair cultural heritage buildings from the impact of natural hazards, and contribute to knowledge systems,

and enhance cultural resilience. The proposed model involves dynamic systems and heterogeneous entities, with organizations and public authorities serving as the decisionmakers. The model address the challenge of adaption, in which the cultural heritage building's adaption capacities to natural hazards are addressed. The proposed model uses adaptive cycles (i.e., growth (or exploration), conservation, collapse (or release), and reorganization) due to the integration of cultural heritage building into socio-ecological systems, which inherits a degree of complexity. The proposed model describes cultural heritage buildings as a complex socio-ecological system, and adaptive cycles such as exploration lead to understanding how cultural heritage buildings adapt to change and cope with natural hazards.

Open Questions and Future Directions

Built environment resilience is an emerging and evolving research trend. In the following, we present some open issues and future directions.

Comprehensive research: built environment requires extensive resilience research covering the aspects of the built environment (i.e., building and infrastructure and climate change). Most studies in resilience cover climate change and building as a standalone system; however, there is a lack of extensive research that targets the physical aspect of the built environment and its relation to social consequences as a system (i.e., relating the building and infrastructure to the urban environment). Comprehensive research regarding the built environment can be achieved by investigating the following strategic areas.

Risk-based resilience design: current approaches to resilience require several functionality criteria of buildings (e.g., service functionality) to achieve optimal resilience. Careful resilience design based on risk analysis could relax those requirements and criteria. Risk can be drawn from the larger scale that encompasses urbanism, socio-cultural networks, and cities' economic affluence. Future approaches should: a) understand and analyze the risks (i.e., natural hazards and environmental factors) in terms of how risk impact buildings, social interactions, economic, and culture; b) focus on developing methodologies for managing and reducing risk impacts; and c) develop a detailed resilience design approach drown from risk analysis.

Model-based resilience design: modelbased resilience is an essential approach to support resilience research. Modelbased approaches can use a mixture of data analysis obtained from buildings and infrastructure (e.g., energy efficiency and user requirements) with structural-based analysis (e.g., building management systems) approaches. This enables achieving optimal resilience that covers the whole system (i.e., building and the social consequences). However, there is a challenge to extract and connect useful information from analytical and structural analysis approaches due to the plethora of available data extraction tools (e.g., measurement equipment and building management systems). Further studies could be pursued to enhance resilience using mixture approaches with useful information.

Resilience models for ecosystem risk factors: there is a wide variety of risks (e.g., natural hazards and ecosystem) in the built environment that caught the attention of researchers. However, there are some risks such as modernization, globalization, and war destruction that are un-explored due to the characteristics of slow-moving risks (i.e., a risk with low moving

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impacts), and most importantly, risks such as modernization and globalization are not always a negative impact, and it depends on the investigated environment. Globalization and modernization positively impact developing countries, resulting in enhancing knowledge

systems, infrastructure, and belief systems. While in the Middle East and Africa, modernization has a negative impact resulting in low conservation procedures for cultural heritage buildings and losing the traditional urban fabric. Further studies could be pursue in exploring other risks, identify the impact of the risk, and develop resilience models and frameworks based on current and state-of-the-art approaches.

Conclusion

In this paper, resilience risk and protective factors are outlined, and resilience models and frameworks in the built environment (i.e., cultural heritage buildings and climate and disaster) are presented. This is based on three main objectives: enhancing knowledge systems, stability, and enhancing cultural resiliency. Resilience models and frameworks mainly address three main challenges: higher growth, complexity, and adaption, using five main characteristics: dynamic systems, heterogeneous entities, technology, and socio-cultural networks. The models aim to enhance sustainability measures. Towards the end, open issues and future directions are stated.

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