Available online at www.sciencedirect.com
ScienceDirect
Procedia Economics and Finance 18 (2014) 181 – 189
Procedia Economics and Finance
www.elsevier.com/locate/procedia

4th International Conference on Building Resilience, Building Resilience 2014, 8-10 September 2014, Salford Quays, United kingdom

The role of urban built heritage in qualify and quantify resilience. Specific issues in Mediterranean city.

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Abstract

The Mediterranean city represents a significant example of urban organism, based on masonry construction and characterized by typological processes of growth. The material consistency and the temporal continuity of built heritage in Mediterranean city make relevant its interpretation and analysis according to the resilient approach. The declination of this approach in many disciplines generated a substantial diversity among the definitions of resilience (Francis and Bekera, 2014).
Consequently, frameworks, adopted for a quantitative or qualitative assessment, underline the lack of standardization and rigor in defining resilience measurements. A review of resilience literature and actual applications in urban context permit to understand that there are different operators working on the field: on the one hand there are international organizations, on the other hand there are academics. The review of both the two ambits of investigation intends to clarify specific properties and convergence points in order to trace an evolution of conceptual framework and to identify general features of urban resilience. This process is fundamental in focusing the main aims of the research program: the definition of the role of urban built heritage, given by the close correlation between masonry constructive technique, typologies and morphologies, its material value in urban system, and its relevance in Mediterranean city in constitution of urban resilience (UNISDR, 2012a). Despite an increasing number of academic studies concerning the role of built environment in defining and improving cities resilience, their major attention is still focused on street patterns and lifelines infrastructures. The paper concludes how the role of built heritage remains insufficiently explored and a correct definition of urban structure is still missing inside the domain of infrastructural resilience.

Selection and/or peer-reviewed under responsibility of the Centre for Disaster Resilience, School of the Built Environment, University of Salford.

Keywords: urban resilience; built heritage; resilience framework; resilience assessment; Mediterranean city.

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Selection and/or peer-reviewed under responsibility of the Centre for Disaster Resilience, School of the Built Environment, University of Salford.
doi:10.1016/S2212-5671(14)00929-0

1. Introduction

The word resilience owes its derivation to the Latin word "resiliere", which literally means to "bounce back". The common use of the word has seen it commonly playing the role of adjective or ability related to an entity, precisely the ability to bounce back. The content of this interpretation, which is nowadays widely in use both from a physical and sociological perspective, enlarges the original derivation upon the common perception of "to spring back after receiving a hit."

Starting from the introduction of resilience to the scientific world, by Holling (1973), the concept has been developed following generally independent paths in disciplines like ecology, psychology, economy and physics, leading to a significant number of different opinions, definitions and classifications of it depending on the context of interest, as remarked by Francis and Bekera (2014). Though the recent attention to resilience of systems and enterprises, triggered by the events of 9/11, has conferred relevance to the concept, a lack of standardization and rigor manifest itself when quantitatively defining resilience. This deficiency appears to be exactly what refers to Hollnagel et al. (2006), when he points out how different researchers working in the area of resilience operatively tend to come up with their own subjective definitions of it.

The paper retraces the differentiation of the concept of resilience through both a review of literature and activities of international organizations, and through a possible reorganization of the framework, focusing on urban resilience in engineering systems. The final propose of this paper is the discussion of the role of built environment and built heritage on improving urban resilience, with a focus on specific issues of the Mediterranean city.

2. Resilience: a review of the concept

2.1. General Concept

As an acknowledgment of the devastating and long-term consequences resulting from a disaster, the term "resilience" has been widely adopted by researchers and policy makers in attempt to describe the preferable way in reducing our society's susceptibility to the threats posed by natural, human and technical hazards.

After the first definition in ecological literature, where resilience was defined as the amount of disturbance that an ecosystem could withstand without changing self-organized processes and structures, Holling and Meffe (1996) focused on two very different definitions of resilience that had emerged since then. In the evolving concept, some authors (Horne and Orr; Sutcliffe and Vogus) refer to resilience as a return to a stable state following a perturbation, as the ability to absorb strain or change with a minimum of disruption. Other authors mention it as a transition through multiple stable states, and resilience could be defined as the property that mediates transition among these states (Haigh and Amaratunga, 2010).

This requires very different attributes, as the one pleaded in favor by Douglas and Wildavsky (1982), who define resilience from the perspective of risk, as "the capacity to use change to better cope with the unknown: it is learning to bounce back" and emphasizes that, "resilience stresses variability". In a similar vein, Dynes (2003) associates resilience with a sense of emergent behavior, characterizing it as improvised and adaptive.

2.2. Engineering Systems Resilience and Urban Resilience

Concerning urban resilience in proper engineering definitions and disaster management, Timmerman (1981) first already set a germinal lemma of Engineering Resilience. He defined it as a measure of a system's capacity to absorb and recover from the occurrence of a hazardous event. Being virtually synonymous of "elasticity"; it is reflective of a society's ability to cope and continue to cope in the future.

Bruneau et al. (2003) defined resilience as the ability of social units to mitigate hazards, contain the effects of disasters when they occur and carry out recovery activities that minimize social disruption and mitigate the effects of future earthquakes. Hollnagel et al. (2006) promote resilience engineering as the new paradigm for safety engineering, defying resilience as the ability to recognize, adapt and absorb variations, disturbances and disruptions.

Lettieri et al. (2009) suggest a "contraposition" in literature between two concepts: resilience and resistance. The first has a specific focus on after-crisis activities, while the second concerns before-crisis activities.

Basically, from the literature emerges that in the engineering vision, the resilience of a city or a metropolitan area depends on the capability of all the physical components of the system, including buildings and transportation infrastructures, to absorb the damages due to an external shock and to quickly restore their state before the shock (O'Rourke, 2007; Reed et al., 2009; Bruneau et al., 2003) and focusing on the time of return to a global equilibrium following a disturbance (Gunderson et al, 2002). This may seem slightly divergent from the ecosystem approach, in which the focus is the capability of the whole urban system as a complex system to recover the full set of functionalities and services that existed before the shock, trying to measure the amount of disturbance that a system can absorb before it changes state. This is usually much more articulate than the algebraic sum of the performances of its single components (Holling, 1996). According to Asprone et al. (2013) there is an active debate still in progress for determining which of the two approaches is more appropriate for the quantification of urban resilience.

Nowadays the term "resilience" is widely associated with disaster risk reduction, consequently to the United Nations International Strategy for Disaster Reduction (UNISDR) Hyogo Framework for Action 2005-2015, where disaster risk management is presented as "the systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters". The UNISDR (2005) defines resilience as "the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure."

An important ideal goal is represented by the interpretation of Wilbanks (2007), to whom Community and Regional Research Initiative on Resilient Communities (CARRI) refers to as consolidated definition in its reports: "a community or region's capability to prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to public safety and health, the economy, and national security". This definition appears to be almost constrained by urban resilience concept.

Finally, the Intergovernmental Panel on Climate Change - IPCC (2012) gave definitions of resilience, evolving from the concept exposed in the 2007 by the same working group. It defines resilience as "the ability of a system and its parts to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration or improvement of its essential basic structures and functions". In the last definition, the evolution of the resilience concept stands out, where particular heed to single parts has its first acknowledged role, simultaneously to a whole system observation. In addiction the time component becomes an attribute important in the definition of urban resilience. The discussion seems to plead for an interdisciplinary approach, especially where complex systems as cities are considered. The assessment of the problem of implementing urban resilience thus passes through diverse components, whether social, economic or technical/structural ones.

2.3. International Organizations activities on urban resilience

International organizations as World Bank, UNISDR and UNHABITAT, gave an important contribution to the urban resilience topic, both through publications and practical in urban contexts.

World Bank's activity is extremely wide, and tends to better focus social aspects and economical ones. It would be rather infertile to summarize the subsistent production of reports. At any rate, the goals of this paper confer attention to a publication attempting to arrange the mazy domain of application of urban resilience: "Building Urban Resilience: Principles, Tools, and Practice" (Jha et al. 2013). The handbook is addressed to urban planners and practitioners, containing case studies and tables that provide further details and examples of good practice. Jha et al. refer to resilience definition gave by UNISDR, that became a solid reference for the work of the World Bank and for others not academic organizations: "Resilience is the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to, and recover from the effects of a hazard promptly and efficiently by preserving and restoring essential basic structures" (UNISDR 2011). Additionally, this handbook remarks a framework

reference, partitioning urban resilience into four principal components: infrastructural, institutional, economic, and social, underlying issues that can be addressed and capacity that can be deepened.

- Infrastructural resilience refers to a reduction in the vulnerability of built structures, such as buildings and transportation systems.
- Institutional resilience refers to the systems, governmental and nongovernmental, that administer a community.
- Economic resilience refers to a community's economic diversity in such areas as employment, number of businesses, and their ability to function after a disaster.
- Social resilience refers to the demographic profile of a community by sex, age, ethnicity, disability, socioeconomic status, and other groupings, and the profile of its social capital.

An outstanding example of research activity is the one given by The Making Cities Resilient: 'My City is getting ready!' campaign, launched in May 2010, addresses issues of local governance and urban risk[1]. Trough one of the last reports (UNISDR, 2012a) they provide a snapshot of resilience building activities at the local level and identifies trends in the perceptions and approaches of local governments toward disaster risk reduction. It examines factors that enable urban disaster risk reduction activities.

On June 2012, UNHABITAT has started alongside "The City Resilience Profiling Programme" (CRPP) which focuses on providing governments with tools to measure and increase resilience to multi-hazard impacts[2]. The second and third phase of the program will be very important, as they aim to the design and develop of a quantifiable urban systems resilience framework that integrates a multi-hazard impact model, a risk/vulnerability assessment model, a preparedness model, and production of a set of sub-indices from which it would be possible to derive forward planning/development targets. It's also planned the development of software systems integrating the urban systems model for the quantification of urban resilience. These parts are scheduled for December 2014.

The tools are in a developing state, and especially in the Making Cities Resilient campaign result to be directed to government authorities, conveyed thanks to the compilation of questionnaires and a guide, that will be developed conceiving the 10 Essentials for Making Cities Resilient as a base. The CRPP appears promising in terms of future processes, being centered on assessment and increase parameters of urban resilience that provides quantification alongside. Nowadays, experimentations work is still on progress, thus the model unfortunately result unpublished.

3. Resilience Framework

The multidisciplinary context remarked in the preceding section, allows us to recognize that frameworks, adopted for a quantitative or qualitative assessment, underline the lack of standardization and rigor in defining resilience measurements. The existing quantitative approaches to measuring or computing resilience are also consistent with a significant differentiation of definition from the original mean. According to Henry and Ramirez-Marquez (2012) this prevents the development of a metric to measure resilience in a generic and coherent manner. Such a metric would greatly enable development of resilient systems, comparison of resilience strategies and support of resilience related decisions during design and operation.

It follows a critical review of most shared topics on urban resilience perspective.

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[1] Started during the 2011 Global Platform for Disaster Risk Reduction, the Making Cities Resilient campaign will carry on beyond 2015.

[2] Working through partnerships with stakeholders including international agencies such as UNISDR, academic and research institutes, private sector actors, and NGOs, the CRPP will develop a comprehensive and integrated urban planning and management approach for profiling and monitoring the resilience of any city to all plausible hazards. The tools and guidelines developed under the Program will be tested and refined in 10 cases of research.

3.1. Resilience Capacities

In spite of a large number of theoretical approaches and theory-building developed by different authors, it is possible to detect some common elements. The literature with acquired sensibleness towards resilience, can broadly subdivide the analysis into three general areas of classification (Bhamra et al., 2011). Some authors refer to resilience capacities through explicit mention, other dealing with actions and strategies for these in an indirect way. These three areas of classification are: readiness and preparedness, response and adaption, recovery or adjustment (Ponomarov and Holcomb, 2009). Francis and Bekera (2014) write again about the set of resilience capacities as an ascertained reference in the conceptual framework, defining them as:

- Absorptive capacity: Vugrin et al (2011) define absorptive capacity as the degree to which a system can absorb the impacts of system perturbations and minimize consequences with little effort.
- Adaptive capacity: is the ability of a system to adjust to undesirable situations by undergoing some changes. Adaptive capacity is distinguished from absorptive capacity in that adaptive systems change in response to diverse impacts, especially if absorptive capacity has been exceeded.
- Recovery/restorative capacity: Restorative capacity of a resilient system is often characterized by rapidity of return to normal or improved operations and system reliability (Shinozuka et al., 2003).

3.2. Resilience Proprieties

Reed et al (2009) focuses on engineering resilience, remarking as the concept has several dimensions referring to what O'Rourke (2007) and Bruneau et al. (2003) have previously worked out. He defines these dimensions as robustness, redundancy, resourcefulness and rapidity. Cimellaro et al. (2010) better define these dimensions, elaborating also an analytic formulation, starting from what researchers at the Multidisciplinary center for earthquake engineering research (MCEER) have identified:

- Rapidity is the "capacity to meet priorities and achieve goals in a timely manner in order to contain losses and avoid future disruption" (Bruneau et al. 2003);
- Robustness is "the ability of elements, systems or other units of analysis to withstand a given level of stress, or demand without suffering degradation or loss of function" (Bruneau et al. 2003). It is therefore the residual functionality right after the extreme event;
- Redundancy is "the quality of having alternative paths in the structure by which the forces can be transferred, which allows the structure to remain stable following the failure of any single element" (FEMA 356, 2000);
- Resourcefulness is "the capacity to identify problems, establish priorities, and mobilize resources when condition exist that threaten to disrupt some element, system, or other unit of analysis"[3] (Bruneau et al. 2003).

Among these concepts, Redundancy should be appointed as a very important attribute of resilience, since it represents the capability to use alternative resources. In other words, it describes the availability of alternative resources in the recovery process of a system. If the system is resilient, there will always be at least one scenario allowing recovery, irrespectively of the extreme event, providing alternatives in case of failure (Cimellaro et al. 2010). Jha et al., (2013) remarks the concept, highlighting that redundancy and uncertainty are interconnected, since any disaster impacts cannot be completely quantified or known in advance.

These dimensions represent what MCEER defines the 4Rs of resilience. Even though nowadays, the separation among property, dimension or domain does not appear to be crystal clear, recurrent elements seem to have been satisfactorily shaped in a more and more shared framework. While the 4Rs found themselves cited as "properties" in

[3] Resourcefulness is a property difficult to quantify according to Cimellaro et al. (2010), since it mainly depends on human skills and improvisation during the extreme event. Resourcefulness and Redundancy are strongly interrelated, as resources, and resourcefulness, can create redundancies that did not exist previously. These ones are theoretically managed mainly as attributes undergoing assessment during the phase of planning, more than directly evaluable datas. They do lead to proportionality effects on operative values such as Rapidity and Robustness, aiming to an increase of the resilience value.

some of the web pages of MCEER, in the works of researchers operating in the same research establishment, it is common to refer to the 4Rs as to "dimensions" of resilience (Cimellaro, Reinhorn and Bruneau, 2010). O'Rourke (2007) writes about "qualities" of resilience. Having few specific interests in discussing which term encounters the best linguistic derivation, a suggestion concerning a much more important disambiguation could be made by the generalized adoption of the word "properties". The attempt concerns the set of a reference as much shared as possible, avoiding easy misunderstandings with dimensions or domains of resilience, which proper definitions are going to be analyzed in the following paragraph.

3.3. Resilience Domains / Dimensions

In order to structure the framework with an efficient identification of the field-based actions aimed to an increase of resilience, a splitting of the principal concept into application fields has been proposed, calling the partitions domains, dimensions or components. The already cited studies of Cimellaro, Reinhorn and Bruneau, suggest a partition of the concept of urban resilience into 4 dimensions, defining the acronym TOSE: - technical, organization, social, and economic. Also O'Rourke (2007) refers to these 4 dimensions, preserving the same definition and nomenclature. Jha et al. (2013) illustrate a similar splitting, considering four principal components, mentioned as: *infrastructural, institutional, economic,* and *social.*

- Technical - the ability of physical systems (including all interconnected components) to perform to acceptable or desired levels when subject to disaster;
- Organizational - the capacity of organizations, especially those managing critical facilities and disaster-related functions, to make decisions and take actions that contribute to resilience;
- Social - consisting of measures specifically designed to lessen the extent to which disaster-stricken communities and governmental jurisdictions suffer negative consequences due to loss of critical services due to disaster;
- Economic - the capacity to reduce both direct and indirect economic losses resulting from disasters.

Other authors have proposed divisions in different sizes of the resilience, as Shaw (2009) that defined 5 domains (Natural, Physical, Institutional, Economic and Social), or Renschler et al. (2010) with the contribution of Cimellaro, Reinhorn and Bruneau, suggested a broadened framework called PEOPLE, composed by 7 dimensions.

Ultimately, the partition which has seen a much more plain operative accordance is the one that contemplates 4 dimensions, and thus in this paper, it appears as the chosen one for future developments. The cited framework, in the entireness of its evolutive phases, has been recalled by some recent research studies which faced the problem of resilience quantification. Reed et al (2009), Tokgoz and Gheorghe (2013) and subsequently Francis and Bekera (2014), will refer to this type of interpretation of the problem, pursuing on the path of ascertainment of its validity.

4. The role of Built Environment on building resilience

The built environment is characterized by protective features, which can represent an important element to reduce the disaster risk. On the contrary, the corruption of these features, such as the loss of strategic buildings or infrastructure, can increase a community's vulnerability. With the term "built environment", which came into widespread use in 1990s, we refer to the result of human activities, describing it in one holistic and integrated concept. Research in the built environment encompasses the fields of architecture, building science and building engineering, construction, landscape, urbanism, as described by the Research Assessment Exercise in the UK.

Based on the review of historical events, the performance of the built environment, and the codes and standards used to design and construct the built environment, the following guidance and metrics are needed to promote the development of a resilient built environment. Despite an increasing number of academic studies concerning the role of built environment in defining and improving cities resilience, their major attention is still focused on street patterns, transportation networks and lifelines infrastructures. Undoubtedly, the efficiency of an urban structure depends on the infrastructure network and services, which in turn are closely related to the properties of street pattern. However, it should be underlined that it is not possible to reduce the complexity of an urban system to the

analysis of street network alone, without losing the richness of the system itself that is the outcome of intricate processes of growth and development both in the technological and social aspects. (Asprone et al. 2013).

It is difficult to analyze the built environment in the specificity of the Mediterranean city without connecting to heritage, especially for the conformation of historic towns, such as defined by the "International Charter for the Protection of historic cities". Urban morphology, housing typologies and construction techniques, typically masonry, blend in the built environment of these cities, to become a structuring element of the same.

Although it is difficult to give a classification to the Mediterranean cities, it may be useful to refer to the one made by Clementi (2001) on the characters of urban identity. By merely observing the morphologies of the settlements, he captures some recurring elements of this urban model. Those are not only the similarity of plants of settlement, the specific nature of the architecture, the homogeneity of the geomorphological and environmental conditions, the common culture of the organization and use of space or the common historical background. Their main identifying quality is linked in their being sediment of a long process of selective accumulation that through time has filtered materials for reuse in new facilities of the urban structure and those to abandon, because they are incompatible with the values of the new civilization. Regarding the classification of the city, the same author distinguishes them: the Islamic city, the Levant city and the European city.

Uniform interpretation of the Mediterranean city is neither so simple nor obvious, although it is possible to find many common elements of historical or environmental development (Sommella and Viganoni, 2010). The Mediterranean city represents a significant example of urban organism, based on masonry construction and characterized by typological processes of growth. The material consistency and the temporal continuity of built heritage in Mediterranean city make relevant its interpretation and analysis according to the resilient approach.

Camiz (2012) focuses on another element of the urban structure, the system of open spaces, closely related to the built in Mediterranean cities. In the analysis of the reconstruction of Venzone in Friuli - Italy - following the earthquake of 1976, he highlights how the system of public spaces in a city constitutes a material historical document of considerable importance as expression not of a single individual manufacturer, as sometimes happens for a monumental building, but a number of actors who have determined the configuration through time.

5. Conclusions

Although the concept of resilience has developed much over the past years, is still poorly explored the role of the built environment and of the heritage in achieving urban resilience. UNISDR (2012b) and ICOMOS/ICORP (2013) have recently focused in a decisive and structured manner the importance of the heritage in urban resilience, not only as an element to protect and defend, but as an element that could give rise to an actual increment of resilience.

Heritage is usually not taken into account in global statistics concerning disaster risks and contributes to social cohesion, sustainable development and psychological wellbeing (ICOMOS/ICORP, 2013).

Cultural heritage is often associated with grandiose monuments and iconic archaeological sites, but today encompasses a broader array of places such as historic cities and living cultural landscapes. It is important also to emphasize the importance of such heritage in building resilience in the economic dimension, as regards sources of income from tourism, as well as for the social, embodying principles of identity of local populations.

The lack of care of built environment, urban sprawl and engineering problems in new constructions increase the vulnerability of urban structures to disaster risks. While a well-conserved natural and historic environment, based on traditional knowledge systems embedded in cultural heritage, can play a significant role in disaster prevention and mitigation and in implementation of the resilience of communities as highlighted by Boccardi (2012).

The value of the built environment in its most comprehensive form of the urban structure, and in specificity of the heritage, it is not yet an established part of the concept of urban resilience in the infrastructure or technical dimension, previously analyzed, probably because of its difficulties of immediate evaluation. At any rate it is not possible to ignore this element in assessing urban resilience, especially in cases as the Mediterranean city, where the evolutionary process of the urban structure is constantly evolving, and where the assessment of individual buildings or of the only infrastructure results in a partial and reduced view of a much wider system, with its high absorptive, adaptive and recovery capacities to a calamitous event. In conclusion, the foregoing highlights a development of the

theoretical framework in which we tried to bring order and despite recent literature has pointed out the necessity to introduce ad-hoc metrics to quantify the resilience of a city against shocks (Dalziell and McManus, 2004), to date a unique and universally accepted definition of urban resilience is still missing. However, it is possible to detect an increasing awareness regarding the role of the built environment in the definition of urban resilience, as supported by the growing interest in the field and the many activities examined in the paper.

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