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Investigating the Role of Urban Morphology in Designing Resilient Cities

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Abstract

Nowadays, natural catastrophes and human activities are considered unknown, unpredictable urban threats. To deal with a wide range of natural and manmade hazards that threaten the productivity, livability, and functionality of the cities, they need to build on their resilience. The key challenge in this regard is the planning, design, and management of urban settlements where, according to sustainable standards, human beings will be able to have the desired quality of life.

The national resilient cities initiative seeks to solve these issues with the vision of the resilient city as the target that encompasses all forms of hazard mitigation.

Cities' physical form has important consequences for their capacity to cope with adverse events and changing circumstances. It is examined that all indicators of topology and design measures have implications for urban resilience. A systemic strategy and a consistent vision of urban resilience must therefore be created for the development and strengthening of cities against new disturbances.

There are highly developed structures for the study of urban form in the field of an urban morphology that can be utilized to compile data on resilience, its aggregation and disaggregation, and impacts on smaller and larger-scale analytical units. A few studies have started to draw connections between these areas, opening the door for more comprehensive analyses. They propose that, through the design of city urban morphology, it might be possible to enhance its resilience.

The goal of this paper is to apply resilience thinking to urban studies and to identify the necessary basis for more urban resilience research by reviewing and synthesizing theoretical evidence on how urban morphology can promote or hinder urban resilience in the physical structure of cities.

Keywords: *resilient city, urban morphology, city form, environmental threats*

Introduction

The word "resilience" is derived from the Latin word "resiliere," which meaning "to bounce back." Beginning with Holling's introduction of resilience to the scientific world in 1973, According to the studies by Francis and Bekera in 2014, the notion has evolved along largely independent routes in fields like as psychology, physics, economy, and ecology, resulting in a substantial number of alternative perspectives, definitions, and categories of it based on the circumstances of relevance. Cities are increasingly confronted with ecological, sociological, and economic problems, all of which pose a danger to the resilience of urban communities and the people living and working there. The effects of environmental change are exacerbating these situations. Solutions related to nature are contributing factors to improve cities in terms of resilience, however, knowledge of the components and vehicles for their execution in urban areas is still evolving (Bush, J. and Doyon, A. 2019). Despite the enormous emphasis on materials and actions in urban contexts, it is clear that

improving the resiliency in urban areas is vital for keeping up the economic progress and social satisfaction. So, cities must strengthen their resiliency to succeed in the face of global warming and climate change. While cities' physical forms may be inflexible, their features have an impact on social, economic, and environmental aspects. Also, the built environment has effects on hazard control, responding capability, construction, and transportation energy usage. Beneficial urban shapes can help communities to improve their economy while also promoting the healing and well-being of their citizens. As an outcome, it may be claimed that interfering in the urban morphology of cities should be viewed as a strategy for improving resiliency (Sharifi, A. and Yamagata, Y. 2018). As a result, urban morphology is critical to the overall resilience of the urban system. The goal of this study is to look at how urban morphology can help designers and urban planners to make cities more resilient.

Background: Resilience and urbanism

Researchers from a variety of fields have created the literature on urban resilience, so it should recognize the fact that it has become “a patchwork of interpretations with no uniformity in its concept and implementation” (Cutter 2016, 742). The concept of people's interaction with their spatial environment has an ancient legacy in urban planning theory, most notably in the strong strain of systems theory that has inspired everyone from Geddes (1885) to Jacobs (1993). Yet, several urban planners were expressly inspired by environmental resilience ideas in the 1970s and 1980s (Holling, 1973).

For instance, in the foreword to On Streets (1978), Sanford Anderson develops a concept of “ ecosystem, explaining ways various social communities utilize urban space for diverse purposes. In this article, he explores his views of space, resilience, and latency. Anne Vernez Moudon (1989) particularly mentions neighbourhood resiliency in her typo-morphological examination of Alamo Park in San Francisco. She demonstrates how the neighbourhood sustained its character, form, and functionality over time through a hard edge and smooth movement in which relative stability at the level of the street network was complemented by changing circumstances and reaction to financial pressure at the neighbourhood scale.

Yet, such particular remarks on the spatial position of urban resilience are limited. An emphasis on open platforms, resilience, and procedures is more frequent. Landscape Urbanism, for instance, explores the possible link between ecosystem, ecological philosophy, and urban design as a means of resolving the postmodern challenge of creating in and for a continuously moving, complicated, and variable environment. (Waldheim, 2006). In communities, these ideas usually favour procedure above space and shape formation (Corner and Wall, 1999). Infrastructure is frequently co-opted as a foundation for future progress and environment, or it is generally included as a fail-safe method of incorporating procedure and promoting participation (Waldheim, 2007).

However, there seems to be very little research connecting resilience and urban morphology. While the idea is not often explicitly addressed, the activities connected with the disturbance-response technique are extremely important. For instance, Manuel de Sola Morales (1999) established his urban intervention theory, which incorporates form and process and promotes communities to rearrange over time compared to disturbance. Others have investigated how societies in impoverished nations restructure and adjust to financial and political challenges by adapting and combining these concepts (Ramirez-Lovering 2008; Dovey and Polakit 2006).

Urban morphology and resiliency after disasters

To examine urban fabric in the framework of resilience thinking, it is necessary therefore to describe resilience and what challenges should be addressed while establishing a theoretical approach for evaluating urban (shape) resilience (Sharifi, A. and Yamagata, Y. 2018). As resilience factors throughout emergency periods following catastrophes, three major aspects of urban morphology were investigated: outdoor space network, usage of public facilities, and closeness to open and constructed components.

The first one, the open area network, has been characterized as a dormant network of streets, gardens, and squares that emerges after catastrophes to meet necessities (Allan et al. 2013). Open areas have been discovered to be important for individuals to evacuate, meet, and obtain protection. In terms of population size, the impact on resiliency is connected to the number and position of open areas that are beneficial after a catastrophe. (Allan et al. 2013; Cutter et al. 2014; Villagra et al. 2014). Second, resilience is linked to the utilization of social facilities (e.g., churches, schools), specifically those which are not affected by disturbances and may be utilized as emergency accommodation during catastrophes. (The Sphere Project 2011; Chou et al. 2013). Third, accessibility and connectivity to the public (e.g., commuter infrastructure) and constructed components (e.g., facilities) are critical for resiliency due to the requirement to connect geographically dispersed locations and behaviours. Connections in communities examine the level of bonding (inside a neighbourhood) and linking (between communities), which shows the extent and efficiency of a system. (Allan and Bryant 2011; Walker et al. 2015).

Methodology

This research employs an analytical-exploratory approach. The current research can be divided into two sections regarding methodology; the first section was done through a descriptive and analytic method. Through performing a library study, reviewing the literature, and analysing different views about resilient cities, required information about all features and relations between these concepts were gathered. In the second section, required information about the situation of Kashan City and its urban morphology was gathered through field studies and referring to relevant resources. This interpretation has been carried out following the urban studies framework proposed in Italy since the 1960s by S. Muratori and his School, which is focused on the theory that a city's history is "written" within its building fabric and that every urban area

is inseparable from the regional organism within which it is situated. As a result, such argument says that it is possible to interpret the distinct periods of a city's creation within the layout of its building fabric by resolving it into its components and classifying it according to the various development stages, to identify all the moments in the process that determined its form and structure. A constant reference text is represented by the essay by Caniggia, G.: Lettura di una Como. Roma 1963 Reviewing the theoretical background of research, assessing research outcomes, and concluding and providing solutions are all phases of this study (Gaube et al. 2018).

Results and Discussions: Urban form and its constituent elements

We split urban form components into three primary scale-based groups, namely macro-, meso-, and micro-scales, to offer a more complete classification that considers cross-scale interactions.

By using a hierarchical approach, cities are better understood in terms of their geographical distribution, their relationship to one another, and their effect on one another (Sharifi, A. and Yamagata, Y. 2018).

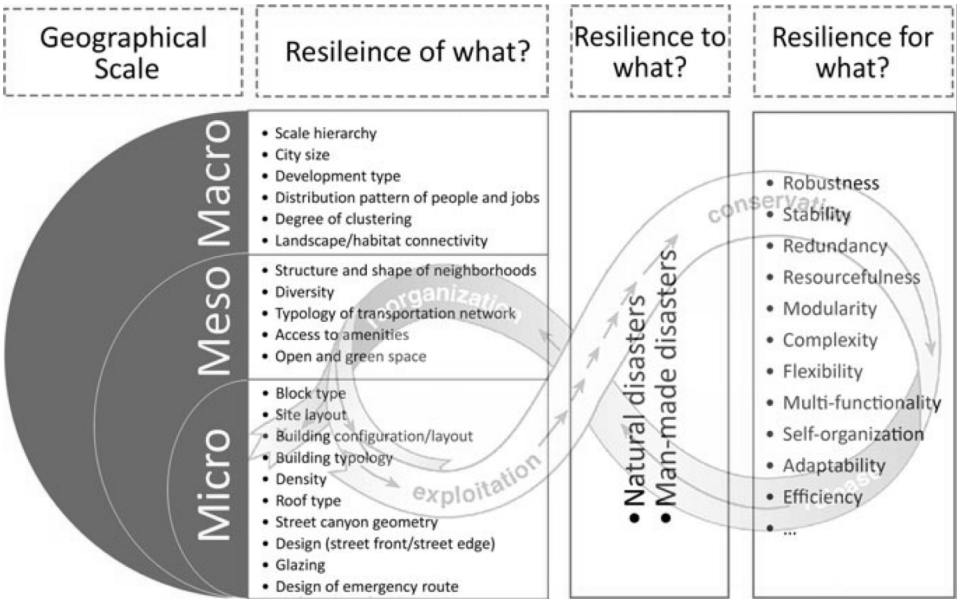

Figure 1. A conceptual framework for assessing the resilience of urban form (Sharifi, A. and Yamagata, Y. 2018).

1- Macro-Scale Elements

At the macro scale, urban fabric refers to the city's overall structure, current location, and future growth in respect to all other communities and communities in the bigger scope of cities and urban areas. The macro-scale category has six important features: scale hierarchy, city size, development type, population and employment distribution pattern, degree of clustering, and environment interconnection (Sharifi, A. and Yamagata, Y. 2018).

2- Meso-Scale Elements

At the mesoscale, urban area refers to the overall layout of communities and regions. The layout and design of communities, variety, the layout of transport systems, access to services, and the quantity and shape of open and green areas are all factors to take into account. The entire community structure is characterized by

dependence on the size and form of the community, as well as the distribution pattern of blocks and open areas. The form of a community can have a great influence in enabling or restricting passenger experience. The variety characteristic is mostly connected to the degree of property usage diversity in the surrounding area (Dempsey et al. 2010).

Transport systems are the foundation of cities, and transportation-related variables play an important role in determining urban morphology. The spatial design of cities, as well as how they grow, is strongly affected by the organization of transport systems. It is possible to find several kinds of ways in cities (e.g. orthogonal and non-orthogonal grids; curvilinear, cul-de-sac; radial; organic; hybrid). Transportation options for inhabitants may be influenced by the design, structure, and width of roadways and paths, which can also impact the energy efficiency of neighbouring structures. Interrelation between connectivity and permeability, as well as other urban form variables like block size, have an impact on people and vehicles moving around. Size, form, and distribution of green areas play a key role in ensuring that these facilities are delivered optimally (Sharifi, A. and Yamagata, Y. 2018).

3- Micro-Scale Elements

At the micro-scale, urban form is concerned with the construction of buildings, their relationship with each other (on the site), and their position concerning pedestrians and transportation networks at a higher degree of detail. Furthermore, the degree of clustering, connectivity, and accessibility.

Feliciotti in 2017 mentioned that to a significant extent, the number of urban blocks determines how well cities are connected and accessible. The layout of emergency routes affects resilience, as it may impact various building kinds (such as detached, semi-detached, multi-story, terraced, and courtyard) display different energy consumption patterns, and have clear relationships with other urban form metrics, such as compactness, which merits more investigation and research. Street canyon geometry influences air circulation in the urban canopy layer and can intensify the urban heat island effect. Finally, design at the street level affects walkability and has socio-economic and environmental implications. Street edges need to be permeable so that they can facilitate connections between different urban modules. Air movement in the urban canopy layer is influenced by street canyon geometry, which increases the urban heat island effect. And lastly, the design of streets has an impact on walkability as well as cultural and ecological implications. So that various urban modules may be connected, street margins must be permeable to allow for this (Feliciotti et al. 2017).

Reading methodology of the different phases of urban formation in Kashan

According to the recognition of the components of urban morphology (continuity of routes; convergence of routes towards urban nodalities such as gates, abanbars, and specialized buildings; regularity of the urban fabric and size of the blocks of houses; the presence of housing around specialized buildings denoting a synchronic construction process; traces of ancient walls; the presence of cemeteries defining expansion phases; bypass routes indicating the presence of obstacles or limits), the reading of the formation phases of

Kashan has been done. These components lead to those particular patterns of texture and types readable with a specific urban organization that allows spotting the traces of the main phases of the formation of the building fabric over time.

Figure 2. Morphological analysis of the urban Fabric of Kashan. The behaviour of the plots and the alignment of the routes (Analysis derived from Ph.D. Thesis of the author which is still in progress)

We relied on the tool of process typology and the identification of some structures readable in the building fabric. In this interpretation, measuring the rhythm of the traces (with the different units of measurement used in the various epochs) is useful. In particular, the reading of the spontaneous routes is useful to identify the main components of the city (walls, main routes and bazaars, mosques, and religious buildings) in its different phases of formation and to define, the structuring that occurred during such different phases, the fine-grained texture of the building fabric. For a close examination of these topics, see Petruccioli, A.: After Amnesia. Learning from the Islamic Mediterranean Fabric. Bari 2007 (Gaube et al. 2018).

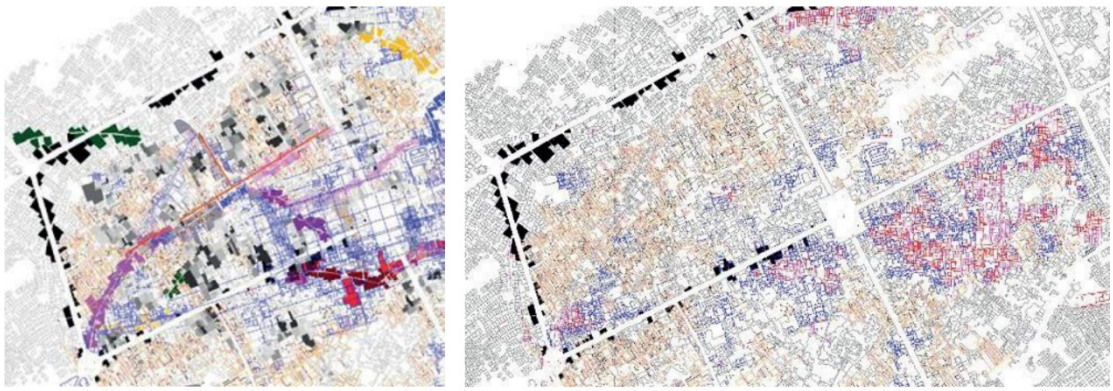

Figure 8. Kashan: Analysis of urban fabric. Band of the pertinence of breakthrough street built in a different time. Kashan: Hyper-grids and hyper-blocks superimposed and alignments of the ancient phases of development (Carlotti, 2020).

Accordingly, in the urban area of Kashan, these urban patterns are recognizable as listed here:

1-Organic urban texture and irregular grid

It is located in the historical area and the old texture of the city. The compaction of parts in such urban tissues is very high and the passages have very low and undesirable widths. The formation orientation of the plots is also unknown and varies according to the direction of the passages.

2- Semi-geometric urban texture and semi-regular grid

It has been formed in post-historical periods. The compaction of the plots is also as high as the historical texture. The formation orientation of the plots changes with the street patterns.

3-Geometric urban texture with hyper grids and hyper blocks

This model, which in modern times is defined as a model for all cities in the country, regardless of climatic considerations, is, in fact, a response to facilitate the transportation system. In the urban area of Kashan, this pattern can be seen in newly established suburbs. The formation direction of the plots is mainly Northwest-Southeast. The city of Kashan has 754,3 hectares of worn-out urban textures. Following the urban morphological analysis, it has resulted that the level of urban vulnerability due to natural hazards in urban areas such as Kashan with a historical texture that has some urban tissue characteristics like non-resistant physical texture and low-quality buildings, low durability materials, lack of access to open space, narrow passage network, High population density, etc. is more in comparison to the other contexts.

Conclusions

The study discussed in this essay analyses the nature of urban resilience as well as the impact of urban morphology on it. While there is a large body of research on various socio-economic, organizational, and ecological aspects of urban resilience, there has been very little emphasis devoted to the role that cities' physical design may play in supporting or inhibiting urban resilience. This research might be viewed as a first step in bridging the gap.

The macro-, meso-, and micro-scales of urban systems are classified into three primary groups for urban form elements. When analysing the resilience of urban form, it is important to consider how various parts of the urban system are related to each other through the entire urban system.

This study proposes the following recommendations for urban resilience strategies based on research in this subject and assessments of the Kashan.

- Incorporating resilience thinking into long-term urban planning, which entails assessing cities' adaptive capabilities following a crisis.
- Integrating and assessing urban morphology resilience indicators during the reconstruction and planning processes for future urban projects to guarantee resilient cities that can withstand future catastrophic incidents.
- Promoting the open space system's multi-functionality and ability to transition from leisure activities to a mitigation tool.
- Development and expansion of open spaces in the historical context of Kashan City in order to lay the groundwork to take rehabilitation and regeneration measures
- Expansion of routes and development of urban facilities and equipment and development of safe and appropriate services in each neighborhood

- Designate some large-scale parks in the city to create and equip central rescue centers
- Widening the width of narrow passages and preventing the increase of urban densities in the margins of narrow passages
- Apply rules to strengthen old buildings and increase the safety factors in new constructions
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