Shifting Forward _
Resilience Thinking in Out-of-Order Urban Systems

Tijana Vujičić[1]

1 Faculty of Architecture, Civil Engineering and Geodesy, University of Banja Luka, Bosnia and Herzegovina, tijana.vujicic@aggf.unibl.org

ABSTRACT **Complex interplay between spatial, social, economic, natural, political, and other factors made cities more vulnerable and less capable to respond to more frequent uncertainties, sudden upheavals, and disturbances that lead to different types of spatial dynamics such as urban sprawl, shrinkage, brownfield sites, degradation of built environment as a consequence of natural disasters, etc. In response to these multiscale disturbances, the paper introduces and elaborates upon *resilience* as a new term, approach, and philosophy. Based on a review of a large body of literature from the field of ecology, the paper presents origin, history and development of the concept, definition, types and key principles of the resilience approach, i.e. state-of-the-art knowledge and basic ideas about current matters related to the resilience. In the final part, the paper sets the conceptualisation of *urban resilience* by raising the assumption that the city is a *complex adaptive urban system*. Through conceptualisation, the paper gives an interpretation of key resilience concepts from the urban perspective, explains relationships and links among them, proposes classification of resilience applicable in the context of urban studies, and opens the key topics and questions for further research. The main objective of conceptualisation is not to provide ultimate definitions and interpretations, but to open new horizons, create fertile ground for dialogue among scientists and practitioners, as well as to encourage further research in the field of urban planning and design.**

KEYWORDS resilience, complex adaptive system, urban resilience, climate resilience, adaptive management

1 Introduction

From the industrial revolution up to the present day, the human impact on the Earth has been enormous. Civilisation has influenced the biosphere in such a way that it moved humanity into a new geological era, proposed as the *Anthropocene* (Folke C., 2016, p. 7). One of the major anthropogenic marks of new era is urbanisation and climate change. Global warming has led to severe consequences all around the planet, hence society's current witnessing of the melting of Arctic ice sheets, sea level rise, freshwater shortages, floods, hurricanes, heat waves, droughts, species extinction, etc. Recognising the seriousness of human impacts on the biosphere, ecologists have created and developed a new innovative concept/approach for dealing with uncertainties in natural resource management, called *resilience*. Though it is sometimes hard to determine whether resilience is a concept, theory, approach or philosophy, its influence on science, practice, and policies is indisputable.

The last twenty years have been marked by the expansion of resilience research. The idea of resilience is gaining increasing prominence across a diverse set of literatures. The concept has been accepted in academic and policy discourse where it gained large popularity. Nowadays, the resilience concept has spread to such extent that it is almost impossible to give a comprehensive review of the large body of literature associated with it. Such excessive spread across different disciplines and areas has caused some disagreements among different literatures about how to define, apply, and measure resilience. Its overuse and ambiguity put resilience in danger of becoming a vacuous buzzword (Rose, 2007, p. 384). The etymological roots of resilience stem from the Latin word *resilio*, meaning: to bounce back, leap back, spring back or rebound (Davoudi, Brooks, & Mehmood, 2013, p. 308; Klein, Nicholls, & Thomalla, 2003, p. 35). Even though the resilience is a generally accepted notion in the global context, in Balkan countries (Slavonic languages: Serbian, Croatian and Bosnian - SCB) the term resilience is a "non-existing word" (Marot, 2014, p. 1) with more or less (un)related meanings: flexibility, elasticity, resistance. Despite the disagreements among local scientists about its translation, some of them have adopted resilience as an Anglicism, translating it as *rezilijentnost*, while the others use *otpornost,* meaning resistance.

This implies a lack of understanding of the concept of resilience and justify the need for its (re)examination, interpretation, and clarification. Additionally, examination of possibilities and limitations of its application in urban research is needed. Therefore, this paper presents a comprehensive review of a large body of literature, i.e. a review of state-of-the-art knowledge and basic ideas about current matters related to resilience: origin, history, development, and application of the concept on one side, while on the other, it presents definition, types, key principles, and approaches developed within resilience theory. In the final part, a conceptualisation of urban resilience has been given. Key terms, concepts, and tenets of resilience have been introduced and connected with key determinants of the city (components, structure, and processes). Conceptualisation starts with the assumption that a city is a *complex adaptive urban system* (CAUS). Hereafter, meanings of the terms *complex* and *adaptive* are elaborated and connected with principles of resilience. The main objective of conceptualisation is not to give ultimate definitions and interpretations, but to open the horizons and create fertile ground for further research in the field of urban planning and design.

2 Resilience – History and Application

From its early beginnings in psychology (1940s and 1950s) and engineering (1960s and 1970s) to the present day, the resilience approach has expanded within the spectrum of scientific disciplines and academic fields. Although the concept has a long history of use in other disciplines, its contribution in the field of ecology is particularly important. The concept of resilience was originally introduced into ecology and environmental science by ecologist Stanley Crawford Holling in 1973. His work, to some extent, marked the "renaissance" of the concept of resilience (Bahadur, Ibrahim, & Tanner, 2010) in ecology but, at the same time, it started to gain increasing popularity in several other disciplines. Holling's (1973) seminal paper "Resilience and Stability of Ecological Systems*"* is one of the most cited as the origin of modern resilience theory (Folke, 2016; Meerow & Newell, 2015; Meerow, Newell, & Stults, 2016). Early on, resilience began to influence work and discussions in fields outside ecology and environmental sciences such as sociology, economics, geography, planning, management, etc. (reviewed in Baggio, Brown, & Hellebrandt, 2015, p. 7; Brand & Jax, 2007, p. 8; Folke, 2006, p. 255; Folke, 2016, p. 3). Diverse research domains address resilience at different scales, from more general to more specific, more theoretical or more practical, concerning resilience as an approach – *way of thinking,* or as a system feature/property - *desirable goal*. In that sense, resilience has specifically influenced fields focused on global environmental and climate change, risk and disaster management, social justice and equity, socio-economic insecurities, social vulnerability, poverty and food security, social protection, etc. On the other hand, resilience as an approach for dealing with uncertainty, surprises, disturbance, and crisis found its place in the following fields: human and economic geography, international development, regional economic development and strategic planning, environmental management, environmental planning, urban study and policy, urban and regional planning, urban governance, sustainable development, political and power dimensions of sustainability; government of complex social-ecological systems, social learning, and knowledge systems, etc. (reviewed in: Brand & Jax, 2007, p. 8; Davoudi, Brooks, & Mehmood, 2013; Folke, 2006; Folke, 2016; Meerow, Newell, & Stults, 2016). Over the past decade, the resilience concept has become widespread, in not only the academic field but also in practice, policy, and business (Folke, 2016, p. 1), where it is largely seen as a response to changes, crisis, and uncertainties. However, Davoudi et al. (2013, p.

307) assume that resilience has remained a vague concept, probably due to (or in spite of) its proliferation.

As an approach for understanding different types of complex adaptive systems, resilience serves as a platform for interdisciplinary and transdisciplinary research (Folke, 2016, p. 1). However, resilience has opened a lot of discussions and contestations among scientists and practitioners, which relate to its utility, application and measurement. Brand and Jax (2007, p. 9) see resilience as a *boundary object* (originally proposed by Star & Griesemer, 1989) that facilitates communication across different disciplines and diverse stakeholders, creating shared vocabulary and bridging the gap between science and policy. However, Simin Davoudi (2012) posed a question of whether resilience is a "*bridging concept* or a dead end"? Pointing to its overuse, she argues that resilience is in danger of becoming just another buzzword. Beyond the simple assumption that it is good to be resilient, there is a lack of clarity about what resilience really means and what are the opportunities and limitations of translating resilience from the field of ecology into planning theory and practice (Davoudi, 2012, p. 299). Nevertheless, she believes that it has "the potential to become a *bridging concept* between the natural and the social sciences and stimulate interdisciplinary dialogues and collaborations" (Davoudi, 2012, p. 306). Baggio, Brown, and Hellebrandt (2015, p. 2), in their comprehensive citation network analysis of resilience, made a distinction between resilience as *boundary object* - an entity shared by several different groups but viewed or used differently by each of them (e.g. resilient city), and resilience as a *bridging concept* that actively links different scientific fields, policy and practice, stimulates dialogue, and fosters inter- and trans-disciplinarity. Their research indicates that use of the term across different fields supports resilience as a *boundary object*, but only in a limited way as a *bridging concept*. Referring to Brown (2012), Baggio et al. (2015) suggest that resilience could be seen as the reframing of existing and conventional approaches, rather than one that is truly new and innovative. Therefore, they conclude that resilience is a *boundary object* that is able to foster interdisciplinary collaboration.

A lot of work on resilience has focused on the system capacity to absorb shocks and still maintain its function. However, resilience requires much wider observation on one hand, while deepening the detail of the research subject on the other. The origin and development of the resilience concept is best understood through the evolution of its definition. Furthermore, to fully understand resilience as a notion, concept, approach or theory, the explanation of a number of crucial concepts is necessary: the adaptive cycle, panarchy, complex adaptive system, resilience, adaptability, and transformability. For the sake of clarity, the next sections investigate the development path of resilience thinking/theory in more detail, and at the same time define the typology of resilience.

3 Engineering and Ecological Resilience

There is a lot of confusion in scientific literature related to the origin of resilience, as well as incorrect interpretation of its classification. Béné, Headey, Haddad, & Grebmer (2016) argue that although many scientists wrongly presented Holling as a founder of the original definition of resilience, the term had been actually first mentioned in the context of 19th century warship design through the 'modulus of resilience' when naval architect Robert Mallet introduced this concept as a means of assessing the ability of materials to withstand harsh conditions (Béné, Headey, Haddad, & Grebmer, 2016). In the 1960s and 1970s, the concept progressively emerged in engineering, where resilience was defined as the capacity of a material to absorb energy when it is elastically deformed and release that energy upon unloading (Callister & Rethwisch, 2012, pp. 216, 878).

Soon after, resilience appeared in the field of ecology through two main approaches; the first more focused on ecosystem dynamics near equilibrium – *engineering resilience,* while the other emphasised ecosystem conditions far from any steady state of equilibrium – *ecological resilience*. Although some authors wrongly interpret Holling's definition of resilience as one that belongs to the *engineering* view of concept, comparing engineering and ecological definition, he declares that his definition of resilience actually represents *ecological resilience* (Holling, 1996, p. 33). Referring to other authors, he explained that the *engineering* definition concentrates on the stability of the ecosystem near equilibrium, "where resistance to disturbance and speed of return to the equilibrium are used to measure the property" (Holling, 1973, p. 33). Contrary to *engineering* perspective, *ecological* resilience emphasises a system condition that is far from a single stable equilibrium, and acknowledges the existence of *multiple equilibria*, where instabilities could be seen as opportunity for flipping the system into another regime of behaviour – that is, alternative *stability domain* (Fig. 3.1.) (Holling, 1973, p. 4). Davoudi (2012, p. 301) points out that despite this difference "what underpins both perspectives is the belief in the existence of equilibrium in systems, be it a pre-existing one to which a resilient system bounces back (engineering) or a new one to which it bounces forth (ecological)".

By understanding that ecosystems are dynamic, with multiple stable states, Holling made a shift from the "stability" paradigm, previously applied in ecology. (Meerow, Newell, & Stults, 2016, p. 40). Even though Holling made a distinction from the engineering perspective, his early work had put the emphasis on the *persistence* and *absorptive/buffer capacity* of the system, so one may conclude that it still had something in common with the *engineering* view. According to his definition from 1973, *resilience* determines the "persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist" or in other words it is a measure of the ability of systems to absorb changes and still persist (Holling, 1973, p. 17). In parallel, exploring the behaviour and dynamics of the ecosystem, Holling

(1973, p. 17) contrasts another important property – *stability*, which represents the ability of a system to return to an equilibrium after a disturbance. Defining the speed by which the system bounces back to a state of equilibrium as an appropriate *measure of stability*, Holling (1973, p. 17) argues that the faster the system returns, the more stable it is. Distinguishing stability and resilience, Holling acknowledges *a measure of stability* as *engineering resilience,* but he rather applies *a measure of absorptive capacity*, labelling it as *ecological resilience* (Pisano, 2012, p. 11).

Therefore, one can conclude that resilience thinking in its early beginnings put emphasis on stability near an equilibrium, system persistence, and speed of return - return time, maintaining *efficiency* of system function, constancy and predictability (Davoudi, Brooks, & Mehmood, 2013, p. 308; Davoudi, 2012, p. 300; Holling, 1996, p. 33). This view may be termed *engineering resilience* (Fig. 3.1). In 1986, Holling (1986, p.76) reset his definition and defined resilience as the "ability of a system to maintain its structure and patterns of behaviour in the face of disturbance". A decade later, Holling (1996, p.33) offers third definition which builds on the first two, stating that resilience is "the magnitude of disturbance that can be absorbed before a system changes its structure by changing the variables and processes that control behaviour". He called this view *ecological resilience*. Equally, ecological resilience implies the ability to adapt to change by exploiting instabilities (Walker, Ludwig, Holling, & Peterman, 1981, p. 495) or the "ability to persist and the ability to adapt" (Adger, 2003, p. 1). Here, one may conclude that *ecological resilience* concentrates not only on the speed of return to equilibrium, but also on the extent of disturbance that it can endure and remain within its stability domain. Thus, ecological resilience focuses on maintaining the *existence* of system function and draws attention to "persistence, change and unpredictability" (Holling, 1996, p. 33) (Fig. 3.1).

types of resilience	key terms	dynamics	focus on	sources
	key characteristics			
engineering	stability persistence fail-safe design bounce back	single (stable) equilibrium	return time speed of return to equilibrium maintaining efficiency of function constancy and predictability	(Holling, 1996, p. 33; Davoudi, Brooks, & Mehmood, 2013, p.309; Walker, Holling, & Carpenter, 2004, p.2; Folke, 2006, p.259)
ecological	persistence adaptability tipping points safe-to-fail design	multiple equilibria stability landscape	absorptive/buffer capacity persistence, robustness maintaining existence of function withstand shock change and unpredictability	(Holling, 1996, p. 33; Davoudi, Brooks, & Mehmood, 2013, p.309.)
socio-ecological	dynamic interplay persistence adaptability transformability	non-equilibrium 'adaptive cycles' cross-scale dynamic interaction -'panarchy' multiple scales and timeframes	adaptive capacity transformative capacity dynamic interplay between persistence, adaptability and transformability people and nature as interdependent systems learning and innovation	(Folke, 2006, p.259; Folke et al., 2010, p. 21)
development path				

FIG. 3.1 Types of resilience

4 Socio-Ecological Resilience

Since late 1970s, resilience has been broadly extended and it marked a departure from previous paradigms: firstly, in the sense of understanding the system itself (components, parts, properties); secondly, in the sense of understanding the system behaviour and dynamics (complexity, (non) linearity); and thirdly in its conceptualisation - response to changes (short-term stress, long-term disturbances, external and internal changes, uncertainty).

In parallel with ecologists, some social scientists started to apply a resilience concept to social contexts, striving to facilitate and foster the resilience of groups, communities or society. Comparing social and ecological resilience, Adger (2000, p. 361) defines social resilience as the ability of communities to withstand external shocks and disturbances emerging as a result of social, economic, political, and environmental upheavals. Emphasising the institutional context of social resilience, he defines it at the community level, rather than the individual. Hence, social resilience is related to the social capital of societies and communities that have to cope with sudden shocks and large-scale changes or, in other words, it is related to social learning in social institutions (Adger, 2000, pp. 349,361). According to Magis (2010, p. 401), community resilience implies the "existence, development, and engagement of community resources by community members to thrive in an environment characterised by change, uncertainty, unpredictability, and surprise", that is - resilience refers to the ability of a system to respond to changes in such a way that it sustains, adapts and even occasionally transforms itself.

Drawing on these two parallel discourses of resilience (ecological and social) the concept of *social-ecological resilience* emerged in the late 1990s. In this approach, the *social* refers to people, communities, and society, through different aspects of their activity (political, institutional, economic, cultural), and the *ecological* to the biosphere where human life is embedded (Folke, 2016, p. 5). Conceptualising nature and society as an integrated, intertwined, co-evolving system, Berkes and Folke (1998) started to use the concept of *social-ecological systems* (SES) and related it to the concept of resilience. Since then, social-ecological systems have appeared as an interdisciplinary arena where resilience can effectively foster and facilitate collaboration related to dynamics of complex system within diverse groups of actors/stakeholders, in order to provide innovative theoretical and applied knowledge (Baggio, Brown, & Hellebrandt, 2015, p. 8).

Explaining Berkes and Folke's (1998) point of view, Béné et al. (2016, p. 124) argue that "social-ecological resilience was embedded in a new paradigm based in system thinking that was meant to overcome the separation of social from natural sciences, and create a new intellectual basis for responding to the 'environmental' challenges of the modern world". According to Folke (2016, p. 5), social-ecological approach, in essence, emphasises interdependence between society and ecosystem. Furthermore, he explains how people, communities, economies and

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cultures shape ecosystems through time and space, "from local to global scales, from the past to the future", and how, at the same time, society is substantially dependent on the capacity of biosphere to absorb pressures imposed by human development.

Other important characteristics of SES resilience theory are related to system dynamics, its complexity and responsiveness to the changes. Social-ecological system is not only an intertwined system of nature and society, but it also presents a *complex adaptive system* (CAS) (Levin, 1998, Levin, et al., 2013, p. 112), which "involves many components that adapt or learn as they interact" (Holland, 2006, p. 1). Understood as a system that is continually developing and evolving, CAS came increasingly into focus of natural and social sciences at the beginning of the 21th century (Abel, 1998; Gunderson & Holling, 2002; Berkes, Colding, & Folke, 2003; Holling, 2001; Holling, 2004; Walker, Holling, Carpenter, & Kinzig, 2004).

In ecology, theory of CAS has been developed through two main concepts that explain behaviour and dynamics of systems: *adaptive cycle* (Fig.7.2) and *panarchy* (Fig.7.3). *Adaptive cycle* was originally introduced by Holling in 1986 (1986, p. 95), when he, for the first time, presented the dynamic behaviour of the ecosystem through the sequential interaction of four system functions: exploitation, conservation, creative destruction, and renewal. It is a heuristic model that contributes to understanding of the dynamics of any complex systems (Holling, 2001, p. 93), and a useful metaphor that can generate testable explanations of SES dynamics and organise ideas in resilience theory (Carpenter, Walker, Anderies, & Abel, 2001, p. 766). A stylised representation in the form of an infinity curve suggests four phases through which ecosystem functions operate within adaptive cycle (∞, see Figure 7.2). According to Carpenter et al., complex systems do not tend toward equilibrium; instead, they pass through four characteristic phases of adaptive cycle: growth and exploitation (r), conservation (K), collapse or release (Ω), and renewal or reorganisation (α) (Carpenter, Walker, Anderies, & Abel, 2001). Three properties shape the adaptive cycle: 1) potential or wealth – determines the number of future possibilities; 2) connectedness or controllability – determines the degree of flexibility or rigidity between processes within system; and 3) resilience or adaptive capacity – is a measure of system vulnerability related to unexpected events, surprise or unpredictable disturbance (Holling, 2001, pp. 393-394). The adaptive cycle consists of two opposing trajectories: *front loop* (sometimes called the *forward loop*) and *back loop* (Gunderson & Holling, 2002, pp. 16-17; Holling, 2001, p. 395; Holling, 2004, p. 3; Walker, Holling, Carpenter, & Kinzig, 2004, p. 2). The *front loop* (from r to K) is a slow, predictable phase characterised by the accumulation of resources, growth, wealth and stability. The *back loop* (Schumpeter (2003, p. 83) – from Ω to α – "creative destruction" is more rapid, less familiar and unpredictable phase characterised by uncertainty, novelty, creativity, experimentation and innovation (Holling, 2001, p. 395; Holling, 2004, p. 3; Walker, Holling, Carpenter, & Kinzig, 2004, p. 2; Gunderson & Holling, 2002, pp. 16-17). In the *front loop*, the potential and controllability increases, but also vulnerability, while the resilience decreases, and vice versa. During the *back loop* period, the resilience is high and potential and controllability are low. That means that the system becomes more rigid in the sense of its functioning and more vulnerable to unexpected shocks during the period of the *front loop*, while during the *back loop* it is more flexible, more resilient to sudden more or less desirable changes, and has a high level of adaptive capacity.

Another important notion for understanding SES dynamics, introduced by Gunderson and Holling (2002), is the *panarchy* (Fig.7.3). Panarchy is a representation of a hierarchically nested set of adaptive cycles, as well as a representation of relations and connections between them that determine the sustainability of a system (Holling, 2001, p. 396). Using the Greek god Pan as a symbol for unpredictable change, Gundersone and Holling (2002, p.5) coupled it with the notion of the hierarchy trying to invent a new term that could represent complex structures of relationships within nested adaptive cycles across space and time scales. Thereby they opposed a hierarchically set system based on vertical (top-down) control, rigid nature, and fixed static structure in favour of the panarchical one that represents dynamic, adaptive systems, sensitivity to changes, disturbances and uncertainties which "sustain experiments, test its results and allow adaptive evolution" (Gunderson & Holling, 2002, p. 5)". A stylised representation of panarchy consists of three adaptive cycles: the small and fast, the intermediate size and speed, and the large and slow. Each level operates independently, but at the same time, it is protected by slower and larger levels from above, and stimulated by faster and smaller cycles of innovation from below (Holling, 2001, p. 390). Walker et al. (2004, p. 3) argue that the resilience of a system at a particular level will depend on the influences from dynamics at levels above and below. Besides the fact that the SES theory indicates a non-linear behaviour of CAS through the adaptive cycle model, it additionally emphasises the dynamics of the system that is far from a stable state of equilibrium through the panarchy model. Some scientists suggest that it is in the state of dynamic *non-equilibrium* that the system undergoes constant changes, thus it has no stable state (Meerow, Newell, & Stults, 2016, p. 43; Pickett, Cadenasso, & Grove, 2004, pp. 374-375). Trying to distinguish panarchically posed systems from hierarchical ones, Holling (2001, p. 397) points out the importance of interplay between cycles in the panarchy model, where he suggests two main connections that are critical for the adaptability and sustainability of systems: *revolt* and *remember*. *Revolt* refers to the impact of a small and fast cycle on a larger and slower one, while *remember* refers to the influence of a large and slow cycle on a smaller and faster one.

According to them, these cross-scale interactions are very important in times of change and renewal. Once a *creative destruction* (Ω phase) is started at the smaller and faster level, the collapse can cascade to the next larger and slower level and trigger a crisis, particularly if this level is in the K phase where resilience is low and system is quite vulnerable and rigid. At the same time, opportunities for renewal within the focal cycle are strongly influenced by wisdom, maturity, and potentials (accumulated in K phase) of the slower and larger level (*remember*)

(Holling, 2001, p. 398). Although *revolt* connection primarily emphasises negative impacts, it also opens up the possibility of the appearance of small-scale novelties (during the back loop) that are transmitted to higher levels (Holling, 2004, p. 4). Hence, in complex adaptive systems, there are ongoing interactions between slow and fast systems and small and large ones. Some authors interpret this dynamic non-linear view of system behaviour as self-organising (Berkes & Folke, 1998; Levin S. A., 1998; Walker, Holling, Carpenter, & Kinzig, 2004), where self-organisation implies such patterns of behaviour within the system that result in the feedbacks that influence further interactions and their development (Folke, Carpenter, Elmqvist, Gunderson, Holling & Walker, 2002, p. 438). Arguing that a complex system is self-organising, Folke et al. give further explanation, wherein the context of "continuous change and facing discontinuities and uncertainty (...) self-organization creates systems far-from-equilibrium, characterized by multiple possible outcomes of management" (Folke, Carpenter, Elmqvist, Gunderson, Holling & Walker, 2002, p. 438). Similarly, Berkes and Folke (1998, p. 12) see socio-ecological systems as complex, multi-equilibrium, non-linear, and self-organising, pervaded by discontinuities and uncertainty.

Therefore, Holling (2001, p.390) argues that whole panarchy is *creative and conserving* because it fosters learning, innovation, and continuity through interactions between different levels. Explaining the terms *sustainabilit*y and *development*, he pointed out that panarchy helps to clarify meaning of the phrase *sustainable development*, which, according to him, refers to "the goal of fostering adaptive capabilities (sustainability) while simultaneously creating opportunities" (development) (Holling, 2001, p. 390).

5 Adaptability and Transformability – Toward Definition of Resilience

Summing up the above-elaborated notions and concepts, one can say that socio-ecological resilience, with accompanying ideas of adaptive cycle and panarchy, provides a completely new lens for understanding socio-ecological systems as complex adaptive systems. However, the understanding of its dynamics and responsiveness to changes and disturbances was additionally deepened by the work of Walker, Holling, Carpenter, and Kinzig (2004). Through considering the system's dynamics and its response to disturbances, their paper "Resilience, Adaptability and Transformability in Social–ecological Systems" largely explained possible future trajectories and three related attributes of SES: resilience, adaptability, and transformability. In order to explain system behaviour, they use two key visual concepts/metaphors: *basin of attraction* and *stability landscape*. The first represents the symbolic spatial model within which the system operates and in which it tends to remain, while the second represents the wider perspective, which includes the various basins that a system may occupy and the thresholds that separate them (Walker, Holling, Carpenter, & Kinzig, 2004, p. 3). Walker et al. argue that the system state in *basin of* *attraction* - i.e. its resilience - is determined by four key variables: 1) latitude (L - extent to which a system can be changed before losing its ability to recover); 2) resistance (R - resistant to being changed); 3) precariousness (Pr - nearness of threshold); and 4) panarchy (cross-scale interactions). Furthermore, they assume that: "SESs are moving within a particular basin of attraction, rather than tending directly toward an *attractor*" (Walker, Holling, Carpenter, & Kinzig, 2004, p. 3), understood as the state of equilibrium for which systems strive. According to them, both the *basin of attraction* and *stability landscape* are changeable categories within which systems operate, alter, adopt or even transform. Based on their work, the system's behavioural theory is further developed, and thereby, so too are the key concepts of resilience, adaptability, and transformability (buffer capacity, adaptive capacity, transformative capacity).

Adaptability (*adaptive capacity*) of a system is the capacity of people to learn, combine experience and knowledge, innovate, maintain certain system processes, and adjust them, despite changing internal demands and external drivers, as well as the capacity of a SES to continue operating and developing within the current *basin of attraction* (stability domain) (Berkes, Colding, & Folke, 2003; Davoudi, 2012, p. 4; Folke, Carpenter, Walker, Scheffer, Chapin, & Rockström, 2010, p. 2, Walker, Holling, Carpenter, & Kinzig, 2004). Arguing that adaptability of the SES is mainly a function of the social component, Walker et al. (200, p. 3) determine it as a capacity of actors in a system to unintentionally influence, or intentionally manage resilience, in order to avoid crossing into undesirable system trajectories or succeed in crossing back into a desirable ones. Adaptive capacity that addresses the ability of SES to cope with change is closely related to learning (Gunderson L. H., 2000; Gunderson & Holling, 2002) and helps turn surprises into opportunities. Some authors distinguish *adaptation* (*adaptedness*) from *adaptability* (*adaptive capacity*), arguing that the first is highly specialised, while the second is more generic (Meerow, Newell, & Stults, 2016, p. 44; Nelson, Adger, & Brown, 2007). This delineation led to the further classification of resilience, i.e. the emergence of *general (normative)* and *specified (descriptive)* resilience, which will be elaborated upon below.

On the other side, *transformability* (*transformative capacity*) of a system is the "capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable", i.e. the capacity to create entirely new stability landscape with new state variables or the old supplemented by new ones (Walker, Holling, Carpenter, & Kinzig, 2004, pp. 3,5). Walker et al (2004, p. 5) also argue that the transformations occur mainly due to the trapping of a system in an undesirable basin where restructuring is extremely difficult. It is a state in which crisis can open up space for new ways of thinking and operating. Folke (2016, p. 4) defines the transformability in a more general way, arguing that it does not only imply the creation of new stability landscape, but rather it is also about having the capacity to cross thresholds and move the systems to new basins of attraction. Walker et al. (2004, p. 2) argue that the major distinction between adaptability and transformability is in their focuses. While the first concentrates on the dynamics and function of an existing system, the second refers to fundamentally altering the nature of a system or creating a new one.

To sum up, all of the above (key ideas, concepts, classification) have led to the current definition of *socio-ecological resilience* that follows. In the context of research of non-linear complex adaptive systems, interpretation of resilience has been more elaborated upon in recent years. Thus, resilience is "no (longer) simply about resistance to change and conservation of existing structures" (the *engineering* definition) (Folke, 2006, p. 259), nor it is about a *buffer/absorptive capacity*, *persistence,* and *robustness* of systems to withstand a wide array of disturbances while maintaining function (Folke et al., 2002, p. 13). In other words, "preserving what we have and recovering to where we were" (the *ecological* definition) (Davoudi, 2012, p. 332; Folke, Carpenter, Walker, Scheffer, Chapin, & Rockström, 2010, p. 6). Instead, resilience (the *socio-ecological* definition) has been viewed as an emergent system property that includes three key dimensions: "*absorptive capacity* - leading to persistence, *adaptive capacity* - leading to incremental adjustments/changes and adaptation and *transformative capacity* - leading to transformational responses" (Béné, Headey, Haddad, & Grebmer, 2016, p. 3).

The most cited definition of socio-ecological resilience determines it as: "the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks" (Walker, Holling, Carpenter, & Kinzig, 2004, p. 2). Drawing from Carpenter et al. (2001), resilience can be best described by three crucial characteristics: a) the amount of disturbance a system can absorb while still remaining within the same state or basin of attraction; b) the degree to which the system is capable of self-organisation; and c) the degree to which the system can build and increase the capacity for learning and adaptation (Carpenter, Walker, Anderies, & Abel, 2001, p. 766; Folke C. , 2006, pp. 259-260; Walker, et al., 2002, pp. 5-6).

Through the SES theory, a new sub-classification of resilience has been developed. Thus, some authors distinguish two key approaches, called *general or normative resilience* and *specified or descriptive resilience*. According to Folke (2016, p. 2), *general resilience* is a wider type of resilience for building the capacity of SES to deal with true *uncertainty* and *complexity*, i.e. *unknown* and *unknowable*. On the other hand, *specified resilience* concerns resilience *of what to what* (Carpenter, Walker, Anderies, & Abel, 2001), *for whom* (Cretney, 2014; Lebel, et al., 2006) and *for when, where, and why* (Meerow et al., 2016, Pike et al. 2010, p.66). According to Carpenter et al., specified resilience identifies "what system state is being considered (resilience of what) and what disturbances are of interest (resilience to what)" (Carpenter et al., 2001, p.777). Likewise, Brand and Jax (2007, p. 10) point out that "resilience must be possible (a) to specify the particular objects the concept refers to, (b) to decide whether particular states of a system are resilient or non-resilient, and that it should be possible (c) to assess the degree of resilience of a certain state". Questions *for whom, for when,* and *for where* refer to social, temporal, and spatial scale at which the measurement is made (Carpenter, Walker, Anderies, & Abel, 2001, p. 767; Meerow & Newell, 2016). With regard to this, Brand and Jax (2007, pp. 7, 10) see descriptive concept as a quantitative, measurable approach to resilience and foundation for its operationalisation and application. In descriptive concept, resilience could be understood as a property of socio-ecological systems, where humans have to search for metrics and indicators of resilience, while on the other hand, in normative concept resilience could be seen as an approach for analysing, understanding, and managing change in social-ecological systems (Folke, 2016, p. 8). In that sense, resilience is a theory of change (Baggio, Brown, & Hellebrandt, 2015, p. 2). It is a more metaphorical and more generic approach. It provides flexibility over the long term, and by dealing with ongoing gradual change it could turn a crisis into an opportunity (Folke, 2016, p. 12). Folke et al. (2003, p. 355) defined four key factors of general resilience for building adaptive capacity that interact across temporal and spatial scales: "1) learning to live with change and uncertainty; 2) nurturing diversity for reorganization and renewal; 3) combining different types of knowledge for learning; and 4) creating opportunity for self-organization toward social-ecological sustainability".

6 Adaptive Management for Building Resilience

Adaptive management emerged and developed as useful tools for resilience-building in social-ecological systems. It is a systematic, multidisciplinary approach to dealing with uncertainty, a model that, on the basis of knowledge gained through decision-making, monitoring and evaluating, improves the management itself. The concept has attracted attention due to establishing a connection between the learning process and the process of making policies in the course of their implementation (Stankey, Clark, & Bern, 2005). The term simply means "learning by doing" and adapting based on what has been learned (Walters & Holling, 1990). In other words, learning in an adaptive model occurs through the management process, i.e. through adaptations that occur simultaneously as the level of understanding of the management process improves (Fig. 7.6) (Williams & Brown, 2012). Although the roots of the idea can also be traced through other scientific disciplines, the original concept of adaptive management, understood as a strategy for the management of natural resources, was introduced by Holling in 1978 (Folke, 2016). By publishing Holling's (1978) book *Adaptive Environmental Assessment and Management*, the potential of adaptive management, as a framework for solving complex problems in the field of natural environment, has become recognised. Subsequent publications such as *Adaptive Management of Renewable Resources* (Walters, 1986), *Compass and Gyroscope: Integrating Science and Politics for the Environment* (Lee, 1993), and *Barriers and Bridges to the Renewal of Ecosystems and Institutions* (Gunderson, Holling, & Light, 1995) have further improved and developed the concept and promoted its potential. The growing interest in this area is reflected in the extensive scientific literature and diverse application of the adaptive model in practice (Stankey, Clark, & Bern, 2005, p. 6). According to Holling (1995, p.8), this growing interest in adaptive management arises from three interconnected elements: non-resilient and vulnerable (eco)systems, rigid and inefficient management activities, and more dependent society. It seems that, through these three elements, Holling defines the factors that lead to paralysis and the irrecoverable collapse of the system, which society must find a strategy to forestall.

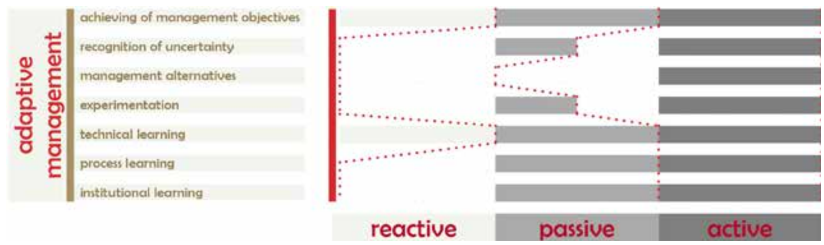

FIG. 6.1 Characteristics of reactive, passive and active adaptive management *(Vujičić, n.d.)*

In the context of the adaptive management model, there are four key approaches: reactive, passive, and active adaptive management (Fig. 6.1) (Walters & Holling, 1990, p. 2060), and adaptive co-management (Folke, Carpenter, Elmqvist, Gunderson, Holling, & Walker, 2002). The basic differences between the first three types are defined by the level of importance that each of the approaches gives to learning, achieving management goals, and reducing possible uncertainties in the process of management. The fourth type is a newly derived form of management model that introduces a social (institutional) dimension in management, connecting it to the specific spatial context (local, national, regional).

Reactive (incremental (Kusel, Doak, Carpenter, & Sturtevant, 1996)) *adaptive management* (RAM) is based on "trial and error" (Williams, Szaro, & Shapiro, 2009), and the basic focus is on achieving management goals, while the role of uncertainty in the overall process is minor. Monitoring and evaluating are primarily focused on the state of resources, while much less importance is given to the understanding of processes inside the system, i.e. learning (Williams, Szaro, & Shapiro, 2009). *Passive adaptive management (PAM)* is an approach in which managers are dealing with uncertainties through the implementation of a single 'best' model, optimised to enable achievement of the set goals (MFR, 2012), where the model and management policies are adjusted and modified in relation to monitoring results (Arthur, Garaway, & Lorenzen, 2002). In contrast to the reactive approach, passive model monitoring and evaluating are directed not only towards recording and evaluating the state of resources, but towards other characteristics of the system that can contribute to a better understanding of the processes within the system, as well as improving the overall knowledge (Williams, Szaro, & Shapiro, 2009). Indicating the learning characteristics within a passive model and approach linearity, Bormann et al. (1999) use the term *sequential learning*. *Active adaptive management* (AAM) differs from other approaches in its relevant integration of experimenting in the process of making policies and management strategies and their implementation (Kusel, Doak, Carpenter, & Sturtevant, 1996). In other words, policies and management activities are treated as experiments and opportunities for learning (Lee, 1993). Instead of focusing on the single 'best' solution, an approach is designed to give feedback on the effectiveness of several implemented models and policies. Bormann et al. (1999) see active adaptive approach as a form of parallel learning through comparison and evaluation of a number of alternative policies that are simultaneously implemented. In contrast to RAM and PAM, an active model directs monitoring and evaluating of both the recording and evaluating of the state of resources, as well as other characteristics of the system that can contribute to improving the overall knowledge and better understanding of the processes within the system (Williams, et al., 2009). On the other hand, in the model of active adaptive management, learning significantly expands its context. AAM shifts focus from strictly technical learning (about the system, its function, structure, and dynamic characteristics) that is advocated by RAM and PAM, toward learning about the processes and structure of management, changes in the institutional arrangements, changes in perspectives, and in the system of values of the actors involved (Williams et al., 2009).

Adaptive management inevitably implies socio-political activities and technical-scientific ventures. By emphasising the social dimension of adaptive management, in terms of a relationship between scientists, managers, and the public, Kusel et al. (1996, p. 612-613) claim that an adaptive approach, in comparison to traditional management, basically changes the relationships between these three groups of actors. Buck et al. add that this occurs in a way that builds partnership, and a collegial and active working relationship (Buck, Geisler, Schelhas, & Woll, 2001). In this context, there is a concept of the *adaptive co-management,* which is a combination of active adaptive and collaborative approaches, an improved concept of the adaptive model, which supports involvement and collaboration of different interest groups in all phases of management. It spans from the definition and assessment of a problem, through development of management strategies, to monitoring and evaluation (Ruitenbeek & Cartier, 2001). Adaptive co-management represents a flexible, collaborative management system adapted to a specific spatial and institutional context, i.e. dynamic, ongoing, self-organised process of "learning by doing" (Folke, Carpenter, Elmqvist, Gunderson, Holling & Walker, 2002).

7 Toward Conceptualisation of Urban Resilience and Climate Resilience

Understanding the concept of *urban resilience*, *resilient city,* and *climate resilience* requires, first and foremost, clarification of the notion of *resilience* with regard to notions of *urban - city* and *climate change*. The proliferation of the term 'resilience' in urban and climate-related studies indicates that it serves as not only *boundary object* within this scientific milieu, but also as a *bridging concept* between urbanism and other disciplines that applied a resilience framework (Fig. 7.1). However, the sudden popularity of a notion or concept in the field of urban studies has led to ambiguities, and, sometimes, an incorrect interpretation of the resilience concept. Therefore, this section deals with conceptualisation of resilience in context of urban research based entirely on the author's views and interpretations of the concept/s of resilience described above. For more profound research, readers are called to consult the following sources: Davoudi, 2012; Davoudi, Brooks, & Mehmood, 2013; Eraydin & Taşan-Kok, 2013; Leichenko, 2011; Meerow & Newell, 2016; Meerow, Newell, & Stults, 2016; Otto-Zimmermann, 2010; Resilience Alliance, 2007.

The conceptualisation of *urban resilience* and *climate resilience* aims to connect *resilience theory,* originated from ecology sciences, with *urban theory*. More precisely, the goal is to introduce the resilience concept into the field of urban planning through: 1) defining key terms and concepts; 2) creating relationships and links among key concepts; 3) classification and typology of resilience in the context of urban studies; and 4) opening the key research topics and questions applicable to further research in urban planning.

Boundary object	urban / city / climate / resilience	
Bridging concept	among different	
	disciplines	stakeholders
'urban resilience' 'resilient city' 'climate resilience'	ecology sociology economy management planning engineering psychology	urban planners ecologists sociologists economists politicians authorities (nacional/local) scientists engineers (different profiles) NGOs citizens

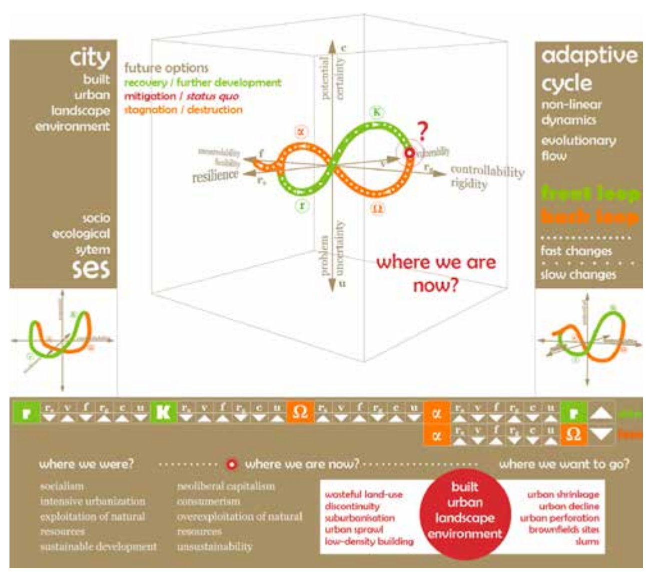

FIG. 7.1 Resilience as boundary object and bridging concept

FIG. 7.2 Evolutionary adaptive pathway of a city *(Vujičić, n.d.) (Note: modified representation of adaptive cycle created according to Gunderson & Holling, 2002, p. 34, 41)*

Conceptualisation starts with the assumption that a city is a *complex adaptive urban system* (CAUS). In order to understand the meaning of this catchword/phrase, further explanation of the terms *complex* and *adaptive* is needed. With regard to this, the concept of *socio-ecological resilience* will serve as a foundation for defining the research base of resilience in the urban context. Key notions, assumptions, research questions, and principles will be developed according to four crucial resilience concepts: *socio-ecological system* (Berkes & Folke, 1998), *adaptive cycle* (Holling, 2001, p. 394; Gunderson & Holling, 2002, p. 34), *panarchy* (Gunderson & Holling, 2002, p. 75), and *stability landscape* (Walker, Holling, Carpenter, & Kinzig, 2004, p. 4). A comparison between SES and the city helps to clarify the multilayer, complex structure of an urban system. *Adaptive cycle* refers to the evolutionary path of a city and helps to determine its current state, i.e. its position on the infinity curve (Fig. 7.2). *Panarchy* links different levels/dimensions of a city with its evolutionary flow (Fig. 7.3). Furthermore, panarchy explains interrelations and interactions between these levels. The concept of *stability landscape* helps to explain possible future evolutionary trajectories of a city i.e. it helps to conceptualise dynamic and behavioural patterns of a city in the face of uncertainties (Fig.7.6). On the other hand, four key approaches developed through resilience theory – *socio-ecological resilience* (Walker, Holling, Carpenter, & Kinzig, 2004), *general resilience* (Folke, 2016), *specified resilience* (Carpenter, Walker, Anderies, & Abel, 2001) and *adaptive management* (Holling, 1978) – suggest possible directions for future development and improvement of methods and tools in urban planning and design (Fig.7.5, Fig 7.6). Each of these terms opens up the set of research questions that present the basis for future scientific and empirical research (Table 7.1).

RESEARCH QUESTIONS RELATED TO KEY RESILIENCE CONCEPTS	
SES	Can the city be considered as a socio-ecological system?
	Does the city consist of the same components as SES?
	What are the main differences between the SES and the city?
	What are key components/dimensions of the city?
adaptive cycle	Is the adaptive cycle applicable to the city?
	Is the evolutionary path of the city comparable with the pathway of the SES?
	Can the evolutionary path of city be perceived, followed, and explained through the adaptive cycle?
	Where was the city? Where is the city now? Where is the city going to be?
panarchy	Is the panarchy model applicable to the city / urban context?
	Which elements/components make the city complex, multi-layered, panarchical?
	What kinds of levels exist within the city (large, medium, small)?
	Does each of levels follow dynamic patterns of adaptive cycle in sense of pathway and speed?
	What kind of relations and impacts exist between different levels?
stability landscape	Is the stability landscape model applicable to the city?
	Can the city be in equilibrium or is it in endless non-equilibrium?
	What does the stable state of a city imply? Is it utopia or the future of a city?
	Is there non-linear stability of a city and what does it imply?
	What does attractor imply in the context of city?
	What do a basin and its bottom imply in the context of city?
	What do a hill and its top imply in the context of city?
	What does crossing the thresholds mean for a city and what are the thresholds?
	Is movement toward the hilltop (un)desirable?
	Is movement toward the basin bottom (un)desirable?
	What does variable resistance imply?
	What are the relations between the concepts of stability landscape and adaptive cycle in context of a city?
	What is the optimal state of a city and should a city strive for it?
	What is the future of a city? What are possible future pathways of a city?
adaptive capacity	How does a city react to negative changes and disturbances?
	What are the consequences of these changes in human environment/city?
	How does society withstand sudden shocks and how does it cope with gradual changes?
	Does the local community have enough capacity to deal with complexity, uncertainties, and surprises that affect the city and how to develop them?

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RESEARCH QUESTIONS RELATED TO KEY RESILIENCE CONCEPTS	
resilience / approach	What does it mean to be resilient in the context of city? What does urban resilience mean?
	What does resilient city mean? What should society do to reach resilient city?
	What is the city / society striving for?
	What should society do in order to reduce uncertainty and mitigate the negative effects of perturbations in the city context?
	What does the concept of resilience offer to city/urban planning?
	Why is the resilience concept useful in urban planning?
	Is the focus on general or specified resilience in urban planning/design?
	How will society address the unknown and the unknowable?
	What city state is being considered – resilience of what?
	What disturbances are of interest – resilience to what?
	For whom is the resilience concept useful? Which target groups will benefit from the resilience concept?
	When and in what spatial context (where), is the resilience approach useful?
	Is the focus on short term disturbances or long-term stresses?
	Is the focus on short-term or long-term resilience?
	What are the criteria, parameters, indicators, metrics, and thresholds of resilience in an urban system/subsystem?
	Is the model of adaptive management applicable in urban planning?
	What kind of adjustments of the adaptive management model should be done in order to meet the needs and requirements of urban planning / planners?
	What does it mean to be climate resilient in context of a city?
	What are the criteria, parameters, indicators, metrics, and thresholds of climate resilience?

TABLE 7.1 Framework for further scientific and empirical research in the field of urban planning (Note: For more research questions related to urban resilience see: Meerow & Newell, 2016, p. 9 and Resilience Alliance, 2007)

Considering the city as a *complex* urban system, it can be defined by applying three key approaches: *administrative*, *morphological,* and *functional* (Fig.7.3) (Vujičić & Đukić, 2015, p. 523).

The administrative approach defines the city as a territorial unit of local governance (municipality), which consists of one or more urban settlements and which ensures a framework for different types of social networking in order to meet the basic needs of community and individuals. Here, the city is labelled through political, economic, and social dimensions of organising, networking, and governance, i.e. through 1) governance institutions - local and national (administration, public services), 2) economy (industry, services), and 3) nongovernmental organisations. In order to justify the introduction of a dimension of human needs into the definition of a city, a recall of Bruntland's definition of sustainable development is needed. According to this report, sustainable development strives to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 41). According to the *morphological approach*, the city is regarded as a physical object composed of built and natural environments (buildings, utilities, transportations, green spaces).

What is missing in these approaches is functional interrelations between social and natural worlds in order to meet the human needs. Therefore, the *functional approach* defines the city as an *economic* and *social* entity integrated in a *spatial context*, i.e. a system labelled by a complex structure of interrelations between these levels. Returning to the *human needs* and relating them to the three key approaches for defining the city, two main levels of needs are recognised: 1) basic physiological needs (food, water, shelter, energy, consumer goods, materials); and 2) safety, psychological and self-fulfilment needs (security, health, education, work, equity, justice) (Fig.7.3). The first set is closely related to the physical / spatial environment (morphological approach), while the second set adds social and economic (administrative approach) to spatial dimension. As can be seen, there are many interrelations between different dimensions, levels, and scales of a city that make it extremely complex. However, if one puts a city in the same plane as SES, particularly in the context of development of SES as a concept, the main differences between these two types of systems will be pointed out. The city is, in the first instance, the *system dominated by humans*, while SES is, primarily, the system dominated by biocenosis (plants and animals). Furthermore, the most important characteristic of the city, which separates it from the nature and socio-ecological view of system, is its *built environment*. Even the nature of the city is mainly artificial. Finally, the city is determined by four key pillars deriving from previous definitions and comparisons: *society, economy, built environment,* and *natural environment* (Fig. 7.3).

Resilience, understood as an approach for facing and dealing with uncertainties, requires identification and analysis of different types of changes that affect a city and increase uncertainty. Given that a city is system dominated by humans, most consequences, particularly the negative ones, have been caused by the growing needs of humanity. What the repercussions of these growing human needs are is best seen in (Fig.7.4). In contemporary urban studies, the biggest interests for research are climate resilience and climate changes, mainly associated with global warming. Due to emission of carbon dioxide and other greenhouse gases (GHG) our planet's atmosphere is now like a "thick heat-trapping blanket" (The David Suzuki Foundation, 2017, para. 5). Increased energy stored in the warming atmosphere has disrupted the balance that keeps the climate stable. Consequently, we are now seeing extreme weather events around the globe. Floods, droughts, storms, hurricanes, and fires are only some of the consequences of large-scale climate change. On the other hand, climate changes result not only in abrupt disturbances, but also in slow changes such as balmier winters, intense summers, changing rain patterns, freshwater shortages, environmental pollution, etc. Besides these events caused by climate change, there are also other abrupt changes such as volcanic eruptions, earthquakes, and tsunamis that take human lives and cause devastation of natural and built environments. These geological (tectonic and magmatic) activities are not influenced by humans, but they could radically affect human environment.

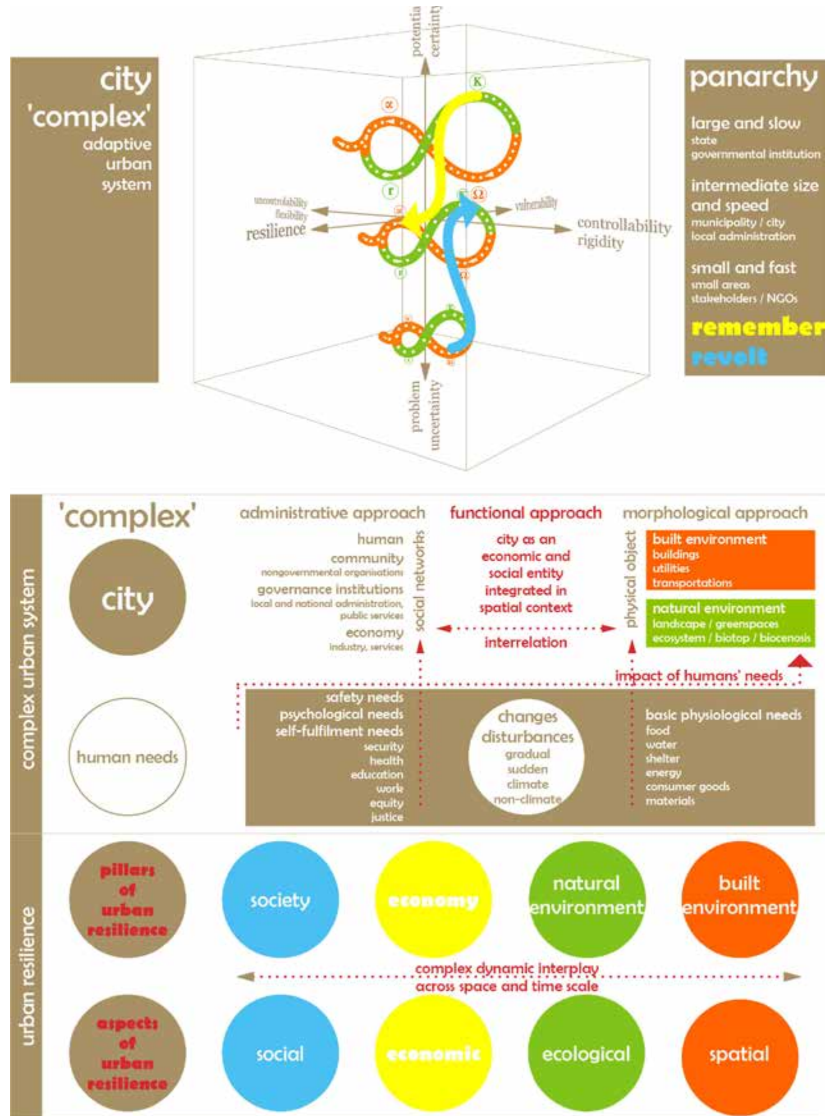

FIG. 7.3 Complex urban system *(Vujičić, n.d.) (Note: Panarchy model modified and adjusted to urban context according to Gunderson & Holling, 2002, p. 75)*

All these changes caused by natural factors have severe impacts on the human environment, and the task of society is to overcome the consequences of its own actions and reduce uncertainty. Furthermore, the paper recognises other type of crisis caused by human (non-natural) factors such as structural or systemic changes, security crisis, social crisis, negative demographic trends, and economic decline. More importantly for urban planners, all these changes led to imbalance in human habitats (built environment). Consequently, we are now seeing: 1) devastation of the built environment as a consequence of natural disasters; 2) urban shrinkage as a consequence of negative demographic trends; 3) brownfield sites as a result of economic loss and structural changes (Đukić, Simonović, & Vujičić, 2014); 4) slums and substandard housing as a result of poverty; and 5) wasteful land use, urban sprawl, discontinuity, and low-density building as a result of bad urban policies and local governance. To sum up, there is a large body of changes that can make the community and human environment more or less vulnerable. This is a place where the resilience approach could make a great contribution in the process of dealing with consequences of these perturbations.

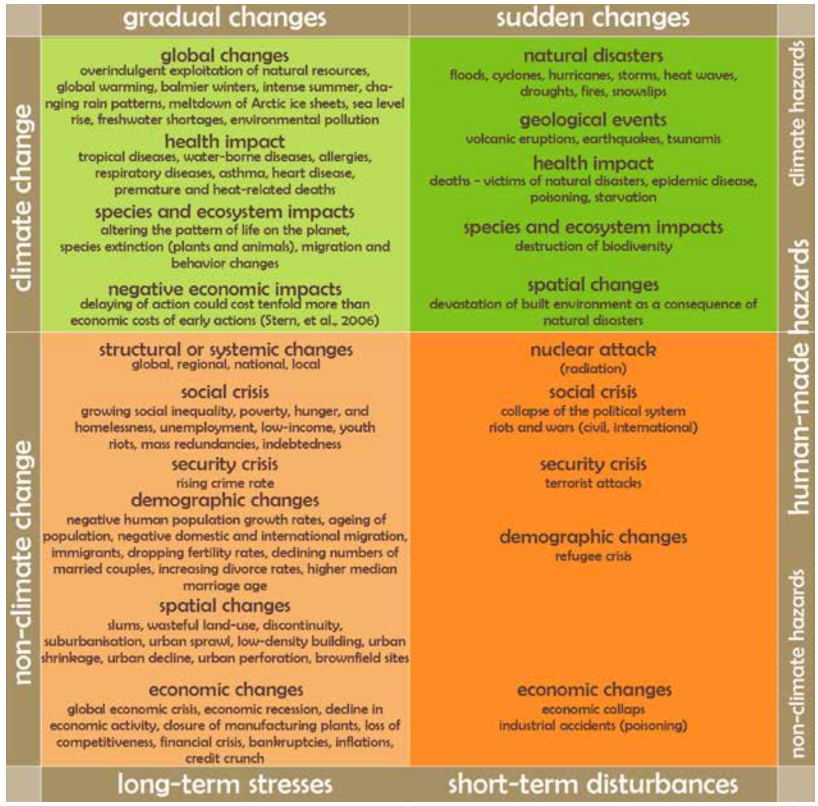

FIG. 7.4 Human-made hazards and changes

Withstanding of shocks and dealing with uncertainty is equal to *being resilient*, having capacity to persist, adapt, or transform following disturbance. Does a community have sufficient capacity to deal with complexity, uncertainties, and surprises that affect the city and how it is developed? What should society do in order to reduce uncertainty and mitigate the negative effects of perturbations? More precisely, what the scientific community do in order to improve the governance of human settlements - built environment - faced with uncertainties, i.e. what should urban planners do to realise a *resilient city*? Here are some recommendations:

– translating the term *resilience* into the mother tongue / local languages;

– defining the concept of *urban resilience* in accordance with the theoretical framework developed by ecologists and the adjustment of the definition for urban research purposes;

– defining *general urban resilience* as well as different types of *specified urban resilience*;

– developing general methodologies based on principles of resilience theory is a crucial prerequisite for redefining urban planning in the face of uncertainty;

– adjustment and application of resilience concept/s in the urban planning/design and specific spatial context - developing of methods and tools, as well as criteria, parameters and indicators of urban resilience;

- particularly, definition of an operational model of *climate resilience,* which implies climate sensitive urban planning and design, impact assessment, and measurement, as well as risk management;

- guidelines and recommendations for the reframing of the national/ local legislation framework of urban planning.

Simultaneously, governance institutions (national and local) should build *adaptive governance*, i.e. foster and support flexible multilevel institutions, participation and collaboration, self-organisation and networking, and capacity building for learning and innovation (Djalante, Holley, & Thomalla, 2011, p. 1). Adaptive governance should help to build urban resilience, i.e. absorptive, adaptive, and transformative capacities of a complex urban system at all levels in order to withstand not only sudden upheavals, disturbances and shocks, but also gradual, long-term stresses. The best way to achieve this goal is the application of an *adaptive management* model (Fig.7.6), developed in the field of natural resource management, and its adjustment for urban planning and management/governance purposes. Although *adaptive co-management* represents state-of-the-art and the most developed type of adaptive management, application of less advanced models into field of urban planning and governance is more likely, particularly at the beginning of reframing.

Adaptive co-management (Fig. 7.6) represents a flexible, collaborative management system adapted to a specific spatial context, implemented by cooperation with the institutions and organisations at different levels. It implies the process by which the institutional arrangements and technical knowledge are tested and reviewed, i.e. dynamic, ongoing, and self-organised process of "learning by doing" (Folke, Carpenter, Elmqvist, Gunderson, Holling & Walker, 2002). The main characteristics of adaptive co-management include: 1) focus on learning by doing; 2) synthesis of different systems of knowledge; 3) cooperation and division of powers among local, regional and national level; and 4) flexibility of management (Resilience Alliance, 2006). These characteristics promote improvement and development of locally adapted management approaches in which strategies are sensitive to feedback and oriented to the resilience of the urban system and sustainability.

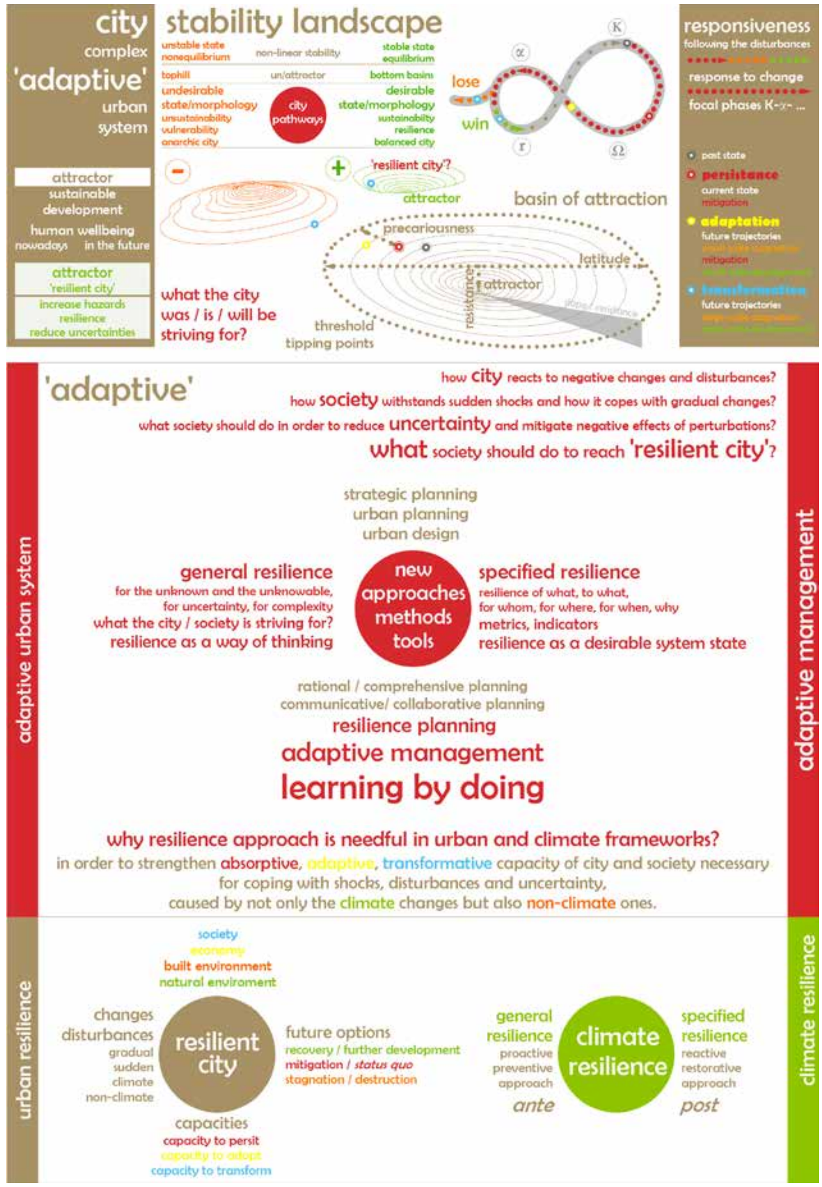

FIG. 7.5 Adaptive urban system *(Vujičić, n.d.) (Note: Stability landscape modified according to Walker, Holling, Carpenter, & Kinzig, 2004, p.11., Fig.1a-1b.)*

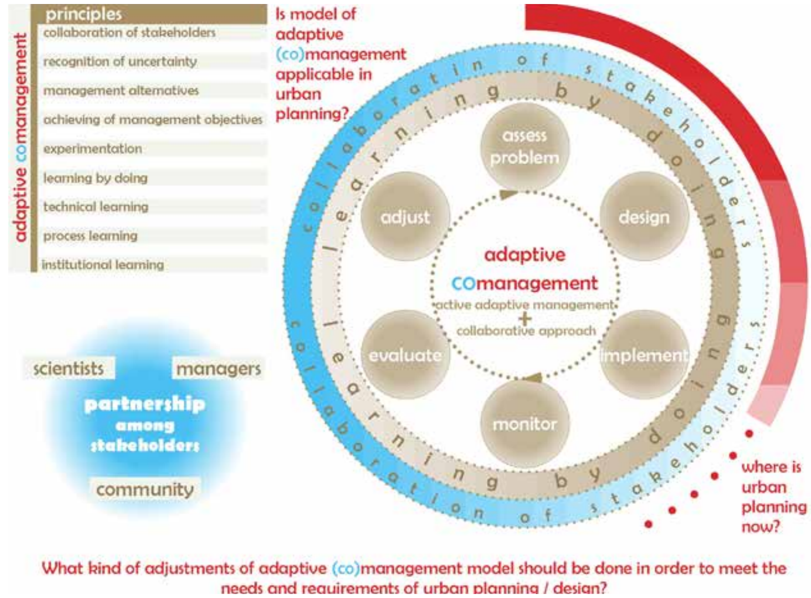

FIG. 7.6 Adaptive co-management process diagram *(Vujičić, n.d.)*

8 Conclusion

This paper gave both a concise and comprehensive review of the resilience theory, i.e. it defined key terms, concepts, classifications and approaches. Based on the review, a conceptualisation of *urban resilience* (and *climate resilience* as its constituent part) has been proposed. The main contributions of the paper are:

- comprehensive review of a large body of literature related to resilience;
- explanation of key terms/concepts and its interpretation from the urban perspective;
- proposal of classification of resilience applicable in urban studies' context; and
- opening of the key topics and questions for further research in the field of urban planning.

As such, the paper can serve urban planners, researchers, authorities, and decision-makers to understand better the key principles of resilience theory originating from ecology, and thereby facilitating the application and integration of a resilience framework into the field of urban planning/design and urban governance. Considering the large body of notions embedded in the term *resilience*, one can ask whether it is concept, theory, approach, discourse, or philosophy. Whatever it is called, resilience framework offers the answers to many of today's questions.

Regarding the translation of term resilience in Serbian/Croatian/Bosnian, the author of this paper recognises some difficulties and limitations. Even though, *otpornost* (understood as resistance) presents the most appropriate translation, it excludes other related connotations, not only within the meaning of the term itself, but also in terms of other essential principles embedded in the resilience concept / theory such as adaptability (*adaptabilnost / prilagodljivost*) and transformability (*transformabilnost / promjenljivost*). Due to positive connotations, acceptance of the notions of *adaptabilnost* and *transformabilnost* by the general public (especially by politicians) is more likely than of *otpornost. Otpornost* suggests *reactive* response to changes, while *adaptabilnost* and *transformabilnost* put more emphasis on *proactive* approach in management of changes. More precisely, *otpornost* is associated with the ability of a system to *withstand* the negative effects of *past changes* (reduction of the vulnerability of a system), while *adaptabilnost* and *transformabilnost* refer more to the capacity of a system to *respond* to changes and imply *future actions* (an increase of adaptive and transformative capacity). Furthermore, in the literature, the term resilience is often equated with *adaptive capacity* or adaptability (*adaptabilnost*) (Holling, 2001, p.394). Regarding this, *adaptabilnost* could be seen as a synonym for resilience/*otpornost*. Therefore, it can be concluded that there are three main terms embedded in resilience concept: *otpornost* / resilience, *adaptabilnost* / adaptability and *transformabilnost* / transformability. Each of them indicates a certain reaction to changes that are more or less radical, and either past or future oriented. Relying on the etymological root of the resilience (Latin - *resilio*, meaning bounce back), it can be concluded that *otpornost* is the most appropriate translation whose use is recommended especially among professionals and researchers (Fig.9.1). Nevertheless, the wider public will be likely accept other forms of translation because of their positive connotations: *adaptabilnost* / adaptability, *transformabilnost* / transformability, *elastičnost* / elasticity, and even the Anglicism, *rezilijentnost* / resilience. Finally, depending on type of research (focus, content, goal) and type of target audience, different forms of translation can be used.

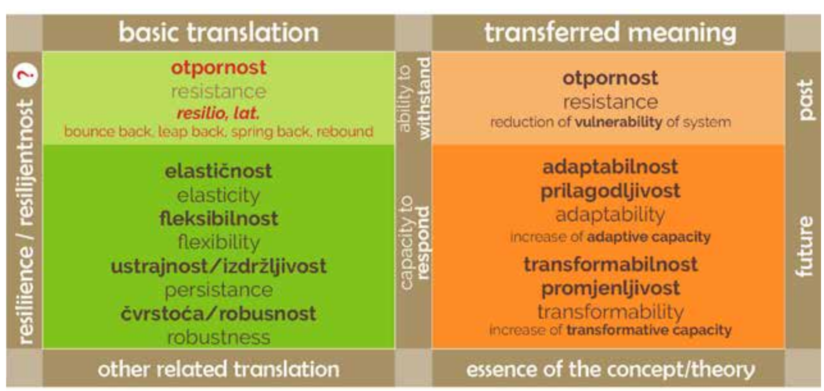

FIG. 8.1 Resilience: a non-existing word in SCB

Summing up the conceptual framework from Section 7, it can be concluded that the *city* is a *complex* urban system labelled by complex dynamic interplay between different components - society, economy, natural and built environment (see Chapter 3, section 3) - across multiple space and time frames (Fig. 8.3). To become an *adaptive* urban system, the city, that is, the society, should build its adaptive capacities through the application of a resilience framework in planning and governance (Fig. 8.5).

With regard to that, *urban resilience* could be considered as:

- the capacity of an urban system (a socio-economic entity embedded in the built and natural environment) to persist and adapt during and following disturbances, maintaining its processes, structure, identity, and feedbacks, i.e. remaining in the same *basin of attraction – stability landscape*;

- the ability to transform structure and processes, and change identity in order to survive and overcome disturbances, surprises and uncertainties - i.e. ability to shift onto another desirable *basin of attraction* or to create a completely new *stability landscape*; and

- the ability of society to anticipate the unknown and comprehend the unknowable, that is, the ability to learn and innovate through a process of management/governance in order to successfully confront with sudden perturbations and long-term stresses.

Key aspects of urban resilience in the city context are social, economic, ecological, and spatial (for more information related to the application of resilience concepts to the built environment see Chapter 3). General and specific urban resilience represent two main types of approaches, suitable and applicable in urban research. The first is more generic and comprehensive - it ensures the integrity of approach and wider perspective. The second is narrower and more focused. It operationalises the approach through the specification of a particular object, the measurement/evaluation of its (non)resilient state, and then it focuses on problem solving, the incensement of hazard resilience, and the reduction of uncertainty.

There is no panacea for urban resilience, however, *adaptive (co) management*, as an approach for managing uncertainties, creates a favourable framework for learning, innovation, and governance through collaboration and partnership of leaders, decision-makers, urban planners, scientists and other stakeholders (Fig.8.6.). With regard to this, redefinition of approaches of urban planning/design, in accordance with the principles of resilience theory, should be encouraged. Such an advanced approach should primarily be focused on the building and strengthening of the city or society's capacity for facing and dealing with uncertainty, and, later, on activities focused on overall development. This implies shifts in:

- *approach* - from planning toward (adaptive) management;
- *discourse* – from sustainable development toward building (hazards) resilience;
- *focus of planning* – from achieving predetermined results toward open-ending process; and
- *vision of future of city* – from development toward any kind of possibilities (development, mitigation, stagnation).

This also entails the shift in governance from *conventional* toward *adaptive*. In order to achieve this transition, the first step is the creation of a new educational profile that will produce educated experts capable of applying and transferring gained knowledge in practice.

In the world of constant, ongoing changes, where surprises and stresses are ubiquitous, uncertainties are more and more likely, and the urban system is more and more complex, *resilience* and *adaptive* approaches appear as outstanding opportunities for reframing urban theory and practice, while at the same time the concept of the *complex adaptive urban system* appears as an emerging arena for interdisciplinary research. The task of scientific community is to adopt, adjust, and develop resilience/adaptive framework in the urban field, i.e. to develop *resilience/adaptive* methodologies, approaches, methods, and tools. Finally, the main research hypothesis has been partially proven. The *city* of the present-day is a *complex* but still not *adaptive* urban system. Whether this will be achieved in the future is very uncertain. However, the *building of adaptive capacity* of a city, i.e. achievement of the vision of a *resilient city* should be the ultimate goal for which contemporary society should strive.

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