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Urban resilience: A framework for empowering cities in face of heterogeneous risk factors

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Abstract:
As remarked in the presentation of the special issue of the A|Z Journal - Cities at risk - the increasing losses due to natural hazards, often combined with technological ones, let arise the need for new approaches addressed to evaluate vulnerability and resilience of cities in face of hazard factors, in order to better drive disaster mitigation policies.

Tacking up this challenge, this contribution focuses on the "multifaceted" concept of resilience that, bridging different research fields (ecology, sustainability, risk, climate change), can play a key-role for enhancing cities' capacity to deal with the heterogeneous factors currently threatening them: climate change, individual and coupled hazards, from scarcity of resources to environmental degradation. In detail, based on the in-depth analysis of the capacities of a resilient system and of the different models of resilience up to now carried out, an interpretative model of Urban Resilience has been outlined. Such a model represents a methodological tool for driving planners and decision-makers in building up resilient cities, enabling them to frame, into a comprehensive approach, the currently fragmented policies addressed to tackle different issues: from the climate change to the complex chains of hazards; from the environmental decay to the scarcity of natural resources.

Keywords: *Resilience, complex urban systems, urban planning.*

1. Complex urban systems dealing with existing and emerging threats

In planning literature, cities have been recognized as systems since the early Seventies (McLoughlin, 1969), even though in the last decades the complexity thinking has largely modified the early principles of the General Systems' Theory (Morin, 1992, 2008): the notion of "dynamics" has become more and more important and cities are currently recognized as systems far from equilibrium, continually reinforcing the move away from equilibrium (Batty, 2007, 2008).

According to the complexity theory, cities - interpreted as complex, dynamics, self-organizing systems, continuously changing under the pressure of perturbing factors due to internal processes or external factors -

should be planned and managed as a whole, paying attention to the several links among their components (Sanders, 2008; Kanter and Litow, 2009).

At present, numerous “perturbing factors”, capable to damage or alter, sometimes irreversibly, human lives as well as anthropic and natural resources, threaten cities: climate change, individual and coupled hazards, environmental degradation, scarcity of resources are only some of these threats. They are different in nature and impacts: some of them may induce long-term changes in urban systems (e.g. scarcity of resources), others may provoke immediate shocks (e.g. earthquakes, tornadoes, etc.).

In the following, a brief description of the mentioned threats will be provided, trying to underline the main relationships among them.

Climate change is one of the main environmental issues that cities have to face in the 21th century (IPCC, 2011), since they are responsible for 60% to 80% of global energy consumption and greenhouse gas (GHG) emissions. According to the latest IPCC report (2013), GHG emissions represent the main causes of the change in climate conditions and “continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions” (IPCC, 2013). Climate change results in a large set of phenomena: from the slow-moving ones, such as the increase of air and ocean average temperature, the melting of snow and glaciers, the raise of the sea level, the change in the global precipitation amount (with significant increases in some regions and declines in others), to the quick-moving ones, such as flash floods, tropical cyclones, heat waves. Although these events cannot be directly linked to climate change, the IPCC (2007) has clearly highlighted that climate change contributes to the occurrence of more frequent, severe and unpredictable weather-related hazards, such as the mentioned ones.

Natural and technological hazards represent also relevant threats for urban areas, often built up in natural hazards prone areas and whose development has generally ignored or undervalued such threats. Starting from 2000, an increase in the number of reported disasters has been recorded: such an increase is mostly due to a rise in the number of hydrological (avalanches and floods) and climatological (extreme temperatures, drought and wildfires) disasters (Guha-Sapir et al., 2011, 2012) that might be interpreted, in turn, as a consequence, although not a direct one, of climate change. Finally, it is worth noting that while the number of victims is diminishing, the economic damage is increasing. In the last decades, indeed, whereas many countries have strengthened their capacity to reduce mortality associated to risks, the economic loss is growing, “as exposure of economic assets increases, outstripping reductions in vulnerability” (UN, 2011).

Moreover, it is worth noting that urban disasters are increasingly shifting from individual phenomena, due to a single hazard affecting a given area, towards complex events. Most of the disasters occurred in the last decades and characterized by large economic impacts (Figure 1) can be defined as “interactive mix of natural, technological and social events” (Mitchell, 1999). As stressed by McEntire et al. (2002), this is due to changes of hazards themselves, of exposure and vulnerability of territorial systems as well as to the interactive mix of such changes. Paradigmatic examples of complex events are, for example, the Katrina hurricane, which hit New Orleans in

2005, or the Fukushima disaster, occurred in Japan on 11 March 2011, characterized by a major earthquake, followed by a 15-mt tsunami that disabled the power supply and cooling of the three Fukushima Daiichi reactors, causing a nuclear accident.

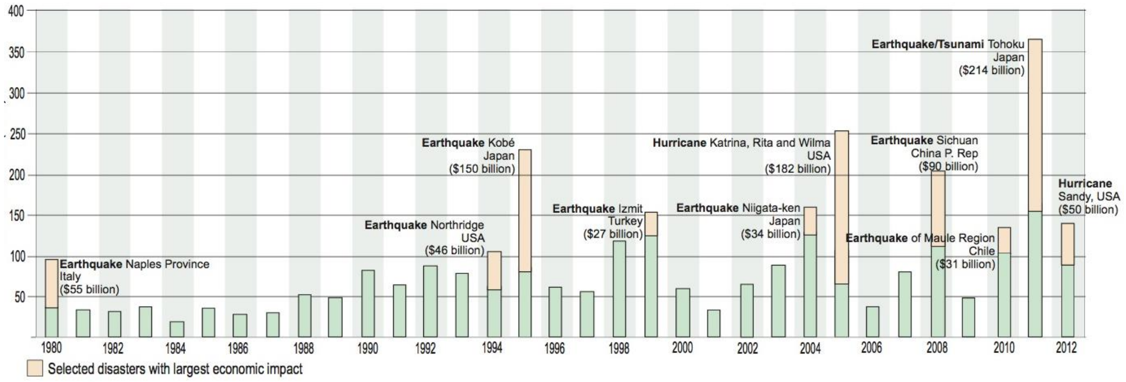


Figure 1. *Annual reported economic damages from natural disasters (1980-2012). (Source: http://www.preventionweb.net/files/31685_factsheet2012.pdf).*

Complex disasters pose a relevant threat to the safeguard of both human and natural resources, contributing to damage, sometimes irreversibly, natural ecosystems already severely altered by cities' development. Therefore, in the last years, numerous institutions and scholars have stressed the need for a better integration among disaster risk, environmental considerations and spatial planning processes (UNEP-ISDR, 2008; OECD, 2010; Galderisi, Profice, 2012) in order to drive urban development towards risk reduction and sustainability goals.

Environmental degradation, comprising the loss or the alteration of both natural resources (soil, water, air, etc.) and natural ecosystems, is one of the main consequences of human activities and, in the meanwhile, a significant threat for urban areas, increasingly forced to deal with air or water pollution. The latter may cause severe health problems, impacts on ecosystems and may have, in turn, an important influence on local and global climate (EEA, 2012) (Figure 2). It is worth noting that both the Millennium Ecosystem Assessment (2005) and the UN Global Assessment Report on Disaster Risk Reduction (2009) put large emphasis on the link between environmental degradation and disasters. Recently, the World Risk Report 2012 has clearly recognized the role of environmental degradation in increasing disasters and, on the opposite, the role of disasters in increasing environmental degradation (Welle, Beck, Muche, 2012).

Finally, next to the growing scarcity of natural resources (e.g. water), it is worth reminding the largely debated issue of the "peak oil" that, closely related to the climate change phenomena, is gaining more and more relevance in the last years. It refers to the shortage of oil, a key resource for current development model, at least in western countries. In detail, the peak oil refers to the "maximum rate of the production of oil in any area under consideration, recognizing that it is a finite natural resource, subject to depletion" (ASPO). The issue related to the peak oil has been largely debated and, although the amount of skeptics is large, some scholars (Minniear, 2009; Newman et al., 2009) emphasize that conventional oil is peaking and going to decline. This poses a serious question related to the urban development model and, namely, push scholars to develop new scenarios for cities – often designed only for cars – aimed at reducing their dependence on a limited resource as oil (Hopkins, 2008).

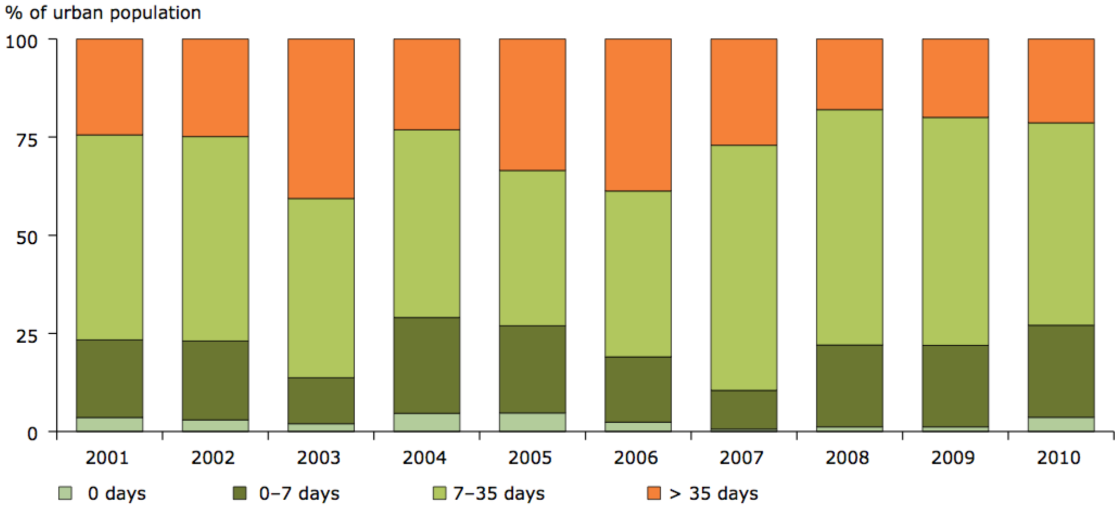


Figure 2. *Percentage of population resident in EU urban areas exposed to PM10 concentration levels exceeding the daily limit value, 2001–2010 (Source: EEA, 2012).*

In face of the different mentioned threats, cities seem to play a twofold role: on the one hand, they are significantly vulnerable in face of their impacts; on the other hand, they are often responsible, at least partially, for them, also due to land use policies that, frequently, ignore existing and potential threats, contributing to increase risk conditions.

Summing up, the features of the cities and of the main factors currently threatening them emphasize the need for looking at city as a whole and for managing the heterogeneous threats cities have to deal with grounding on a systemic approach, able to grasp complexity and interactions and to better understand how systems' components react to the different stress factors and to their interactions, on different spatial and temporal scales. At present, despite the awareness of the close relationships among the numerous elements and systems within a city and among the different risk factors, the many threats affecting cities are often faced separately, both by scholars and decision-makers that, also due to the lack of a reliable, shared and integrated approach to the heterogeneous risk factors, continue to implement sectoral and fragmented risk mitigation policies, often ineffective and poorly related to land use planning policies.

Grounding on these considerations and according to the main aim of the special issue of the A|Z Journal - Cities at risk - this contribution provides a focus on the resilience concept, which is more and more emphasized by institutions and scholars as the key concept for strengthening the capacity of urban areas to face sudden as well as slow-moving risks.

Despite the huge literature produced in the last decades on resilience and the numerous initiatives aimed at building up resilient cities undertaken by international organizations (UN-ISDR, ICLEI), it is still hard to find out a shared definition of the term and the different approaches are still struggling to find a common view. Therefore, based on the in-depth analysis of the capacities of a resilient system and on the different models of resilience up to now carried out, we will outline an interpretative model of Urban Resilience, which could support planners in developing a unitary, interdisciplinary and integrated approach, capable to empower cities in dealing with the numerous and heterogeneous risks they are prone to.

2. Resilience: A new "label" or a useful concept for empowering cities in face of old and emerging threats?

Resilience is a recent and fashionable term that in the last decade has gradually spread in different disciplinary fields, including land use planning. Nevertheless, the term is still controversial, in that different approaches and definition of 'resilience' are currently available and it is likely to become a new "label" for cities, difficult to translate in operational terms.

Some years ago, Rose (2007) highlighted that the concepts of resilience, also due to the heterogeneity of approaches and to the different disciplinary perspectives, was "in danger of becoming a vacuous buzzword from overuse and ambiguity". Similarly, Grünewald and Warner (2012) have recently remarked that resilience "seems to be going the way of sustainable development or governance, meaning all things to all people, and as a result, there is a risk that it will become an empty shell".

Referring to existing studies for an exhaustive review of the heterogeneous definitions and approaches to resilience (Galderisi et al. 2010a, 2010b; Sapountzaki, 2011), we will focus here on some key-steps of the long and complex evolution path of the concept, in order to explore if and why resilience - which is a recent addition to the repertoire of terms used by planners (Davoudi, 2012) - can be useful for empowering cities in face of the different factors currently threatening their future development.

The concept of resilience has been developed since the Fifties through different disciplinary fields, from physics to psychology, from ecology to management science, although it is hard to find out a shared interpretation of the concept in the different domains. The term comes from the physics: in this field, it was used to describe the strength of materials in face of external perturbations, their ability to elastically deform under load (Gordon, 1978).

Resilience found wide room in Ecology during the Seventies, although it was probably embedded in this field since the Fifties (Kelman, 2008). Holling (1973) was probably the first one to use the term for describing the behavior of natural systems in face of external perturbations, distinguishing resilience - interpreted as the "measure of the ability of a system to absorb changes of state variables, driving variables, and parameters, and still persist" - from stability, meant as "the ability of a system to return to an equilibrium state after a temporary disturbance". He emphasized that stability grounds on "an equilibrium centered view, is essentially static and provides little insight into the transient behavior of systems that are not near the equilibrium" (Holling, 1973).

In the mid-Nineties, still Holling pointed out the difference between "engineering" and "ecological" resilience. According to Holling (1996), the former, closely related to the concept of stability, is based on concepts as efficiency, constancy, predictability, return time to a previous state and, above all, on the idea of a single, stable equilibrium. On the opposite, the latter recognizes the existence of multiple equilibrium states, emphasizing the twofold possibility for a system to absorb changes, maintaining its main features, below a given threshold of disturbance, and, above such a threshold, to change its state, moving towards a different equilibrium state, not necessarily better than the previous one (Table 1 and Figure 3).

Table 1. *Engineering and ecological resilience (Source: Folke, 2006).*

Resilience concepts	**Characteristics**	**Focus on**	**Context**
Engineering resilience	Return time, efficiency	Recovery, constancy	Vicinity of a stable equilibrium
Ecological resilience	Buffer capacity, withstand shock, maintain function	Persistence, robustness	Multiple equilibrium states, stability landscapes

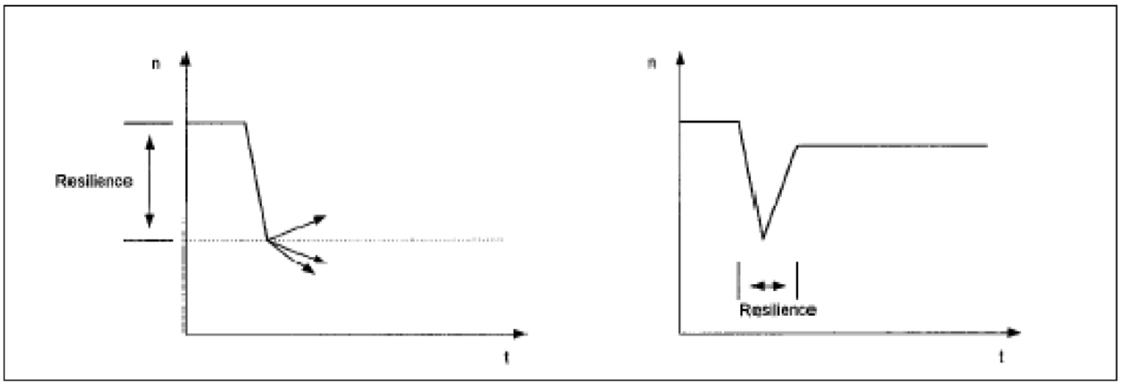


Figure 3. *Ecological (left side) and engineering resilience (right side) measures (Source: Adger, 2000).*

The “ecological” approach to resilience was further strengthened when the focus shifted from natural to socio-ecological systems – characterized by the close relationships between human and natural components – and the studies on resilience intertwined with those related to the complex adaptive systems, capable of learning from experience, processing the information, adapting and even transforming themselves in face to changes. By this perspective, resilience was less and less conceived as a bounce-back to a previous state and progressively adapted to the behavior of complex systems, that is non-linear, self-organizing, characterized by uncertainty and discontinuities (Berkes et al. 1998; Holling, 2001; Walker et al. 2004; Bankoff et al. 2004).

Closely related to the translation of resilience into the research field of complex adaptive systems, is the concept of 'panarchy', introduced by Gunderson and Holling (2001) to explain the adaptive nature and the evolutionary dynamics - nested one each other across different spatial and temporal scales - of these systems. Panarchy describes the evolution of systems through adaptive cycles characterized by four phases: a period of rapid growth and exploitation (r), leading into a long phase of accumulation, monopolization and conservation of structure (K); a rapid breakdown or release phase (V) and, finally, a relatively short phase of renewal and reorganization (α) (Figure 4).

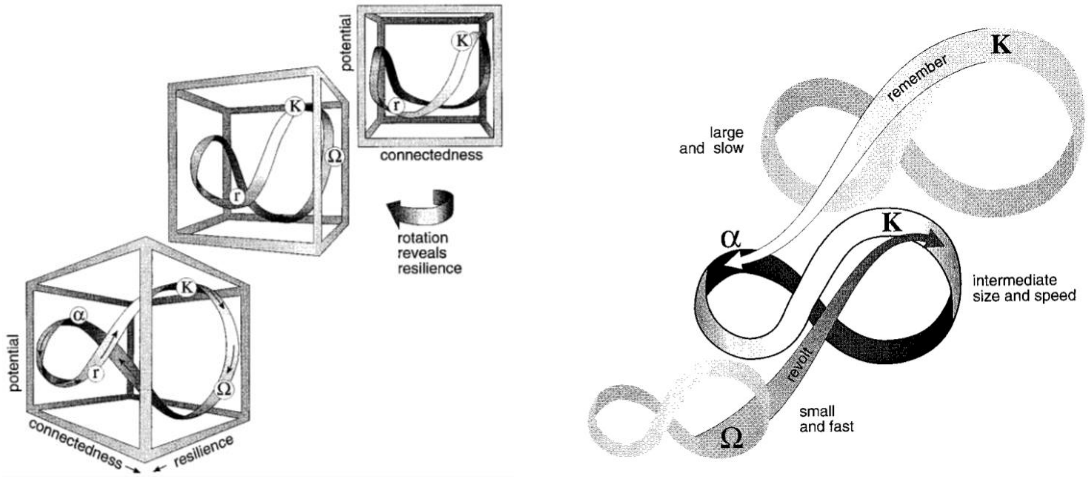


Figure 4. *The phases of adaptive cycles (Source: Holling, 2001).*

These cycles develop into a three-dimensional space, characterized by three axes: the potential or wealth, which includes the available ecological, economic, social and cultural capital; the connectedness, which represents the capacity of a system to control its own evolution or, on the opposite, its vulnerability in dealing with events exceeding its capacity for self-organizing; the resilience that is very low when the system is stable (conservation phase) and increase in the phase of release and reorganization, allowing the system to start a new cycle (Holling, 2001).

The adaptive cycles do not develop as isolated cycles; they are characterized as a series, developing at different scales - from small to large – with different times and speeds - from slow to fast - interacting each other through feedback mechanisms that induce cross-scale effects. Thus, the dynamics of change can be triggered at a given scale and reflect to a larger or lower scale. The links between phases at one level and phases at another level are labeled as “revolt” and “remember”. These links are critical in creating and sustaining adaptive capacity. When a level enters in the α phase, the collapse can cascade to the next larger and slower level, triggering a crisis. Such an event is likely if the slower level is at its K phase, since in this case resilience is low and the system is particularly vulnerable. On the other side, remember connection facilitates renewal, by drawing on the potential that has been accumulated and stored in a larger, slower cycle (Holling, 2001). Revolt and remember connections are typical examples of cross-scale interactions.

More recent studies, closely related to the metaphor of panarchy, have further expanded the concept of resilience, providing an interpretation of the term as a “dynamic interplay of persistence, adaptability and transformability across multiple scales” (Folke et al. 2010). Persistence refers to the system's ability to withstand an impact, preserving its own characteristics and structure, except for a temporary departure from the ordinary functioning conditions. Adaptability refers to the capacity of socio-ecological systems of learning, combining experience and knowledge, in order to “adjust its responses to changing external drivers and internal processes, and continue developing within the current stability domain or basin of attraction” (Folke et al. 2010). Transformability can be defined as “the capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable” (Walker et al. 2004, Folke et al. 2010).

Thus, along the evolution path of the concept, the focus of resilience has largely shifted from a stability perspective, which emphasizes the ability of a system to maintain or to bounce-back to a previous state, towards a multiple equilibrium perspective, focusing on processes and dynamics rather than on status and structures, and emphasizing, on the opposite, the ability of a system to adapt and change in face of internal or external pressures.

Current approaches to resilience concept focus on the ability of a system to deal with different threats - being consistent with the current trends in risk research that highlight the need for an all-risk approach (Berkes, 2007) - and extend the focus beyond resistance to shocks to include adaptive responses and long-term transformation in face of different threats. Moreover, the metaphor of panarchy has largely stressed the importance to recognize that the different processes within a complex adaptive system may occur simultaneously, across multiple temporal and spatial scales (Fekete et al., 2009; Garmestani et al., 2009), while some scholars have pointed out the importance of “continual learning” (Cutter et al., 2008), providing an idea of resilience as ‘bouncing forward’, which includes the idea of anticipation and ‘improvement’ of systems’ essential structures and functions (IPCC, 2012).

According to such an evolution, the concept of resilience seems currently to be the most appropriate to grasp both the complex dynamics of urban systems - depending on social and biophysical ecological patterns and processes and continuously changing under the pressure of internal and external drivers (Pickett et al., 2004; 2010) - and the increasingly variable, dynamic and uncertain impacts of the numerous risk factors currently threatening urban areas (Tyler, Moench, 2012). In detail, current approaches to resilience seems to be suitable for framing urban policies in face of a large set of slow-moving and sudden phenomena, from the ones related to climate change till the ones related to environmental degradation or to scarcity of resources, counterbalancing current fragmentation of approaches and policies. In some cases, indeed, the concept of persistence, addressed to improve the capacity of a system to withstand instantaneous impacts and to rapidly and effectively recover previous conditions after a disturbance, can be significant. In other cases, being current conditions unsustainable or inadequate, novelty and innovation become crucial to drive the systems’ transition towards new development pathways.

3. An integrated approach to urban resilience

Despite the long debate on resilience and the numerous on-going institutional initiatives aimed at promoting and supporting the process for “making resilient cities” (ICLEI, 2010; UN-ISDR, 2012), an interdisciplinary and integrated approach to urban resilience is still missing, and both the characteristics that define resilience and the analytical units for its measurement are still far from being defined (Leichenko, 2011).

Hence, in order to move towards an integrated approach to urban resilience - supporting planners and decision-makers in framing into a comprehensive and resilience-based framework, the heterogeneous urban policies addressed to tackle the different threats mentioned above - further steps have to be undertaken.

First of all, the main features that make a city resilient have to be identified. To this aim, an in-depth review of the multidisciplinary literature on resilience has been carried out: in detail, numerous research works published in the last decade (2002-2013) and addressed to identify the capacities of resilient systems have been collected and analyzed.

As noticed by Leichenko (2011), “looking at the diverse array of literatures on resilience currently available, it is clear that, while there is much overlap and cross-fertilization among these different sets of literature”, each of them focuses on different facets of resilience. Then, the collected studies have been classified in respect to four different disciplinary fields, mirroring different approaches to resilience and focusing on different systems, and the capacities common to more than one field have been singled out (Figure 5).

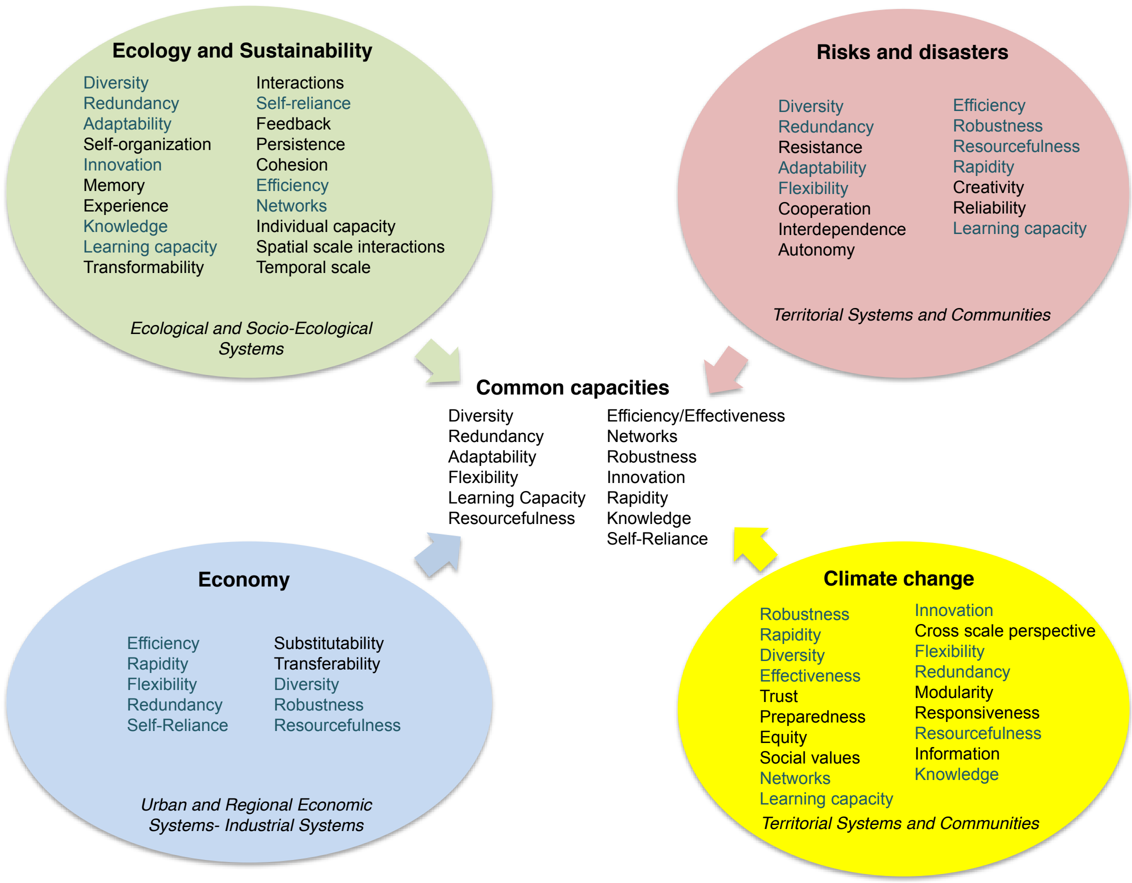


Figure 5. *The capacities of a resilient system according to different disciplinary approaches and the set of common capacities.*

In detail, the first group of capacities comprises the studies developed in the field of ecology and sustainability and focused on ecosystems and socio-ecological systems; the second one stems from the hazard and risk community and focuses on resilience of territories and communities in face of hazardous events; the third one, based on an economic perspective, is addressed to investigate resilience of economic systems at urban and regional scale or of productive systems; the last group roots in the more recent field of climate change and focuses on resilience of cities and communities in face of climate-related phenomena.

The large set of capacities stemming from the different disciplinary fields, although not exhaustive, may be useful to develop a multidisciplinary and integrated approach to urban resilience. Cities are, indeed, complex systems characterized by a variety of dimensions (environmental, social, physical, economic, etc.) currently affected by heterogeneous threatening factors - from climate change, to individual and coupled hazards, from scarcity of resources to environmental degradation - which require to be managed as a whole.

Referring to the next paragraph for a brief description of each capacity and to previous studies for a more exhaustive one (Galderisi et al., 2010a), we will focus here on some key points, important to understand differences and commonalities among the four sets of capacities. First of all, in respect to three facets of resilience singled out by Folke et al. (2010) (cfr. pr. 2) and largely recurrent in the research works developed in the field of ecology and sustainability - persistence, adaptability and transformability - it is worth noting that adaptability and persistence are common to most of the different approaches, even though the term robustness is generally preferred to that one of persistence.

On the opposite, transformability finds scarce attention out from the field of ecology and sustainability. The majority of the research works carried out by the risk community as well as in the economic field is based, indeed, on the engineering approach to resilience, which emphasizes the capacity of cities, communities as well as of infrastructural and economic systems to quickly and effectively “bounce back” from the adverse impacts of natural or technological hazards (Bruneau et. al. 2003; Chang, Shinozuka, 2004; Davis, 2005; Tierney, Bruneau, 2007). Hence, in these fields, large attention is paid to capacities as efficiency, rapidity, redundancy, resourcefulness, flexibility and diversity, recognized as key factors for enhancing system’s ability to withstand and recover from an impact.

Quite widespread in the studies developed by the climate change community is the concept of innovation, closely related to transformability, since it is generally referred to the capacity of a system to reorganize its variables following a disturbance (Chuvarajan et al., 2006). The concept is also invoked in the theory of panarchy (Holling, 2001), being crucial to the phase of renewal and reorganization. Moreover, the concept of innovation has been largely emphasized, in the last decade, by the numerous studies that have been developed under the umbrella of the Transition Movement - founded in 2005 in Ireland by Rob Hopkins - addressed to promote a bottom-up “transition”, capable to transform external pressures (e.g. climate change, oil scarcity) into opportunities for redesign the development path of a community, changing the way of life as well as the modes of production (Hopkins, 2005, 2008; Brunetta, Baglione, 2013).

Also learning capacity and knowledge are common to most of the considered fields: these capacities are recognized as key factors for enhancing communities’ ability to foresee and cope with future events, contributing, in this way, to improve communities’ preparedness in face of adverse events. Recent studies suggest “that in the face of either sudden or slow burning disturbances, complex adaptive socio-ecological systems (…) can become more or less resilient depending on their social learning capacity for enhancing their chances of resisting disturbances (being persistent and robust), absorbing disturbances without crossing a threshold into an undesirable and possibly irreversible trajectory (being flexible and adaptable) and moving towards a more desirable trajectory (being innovative and transformative)" (Davoudi, et al., 2013).

Finally, it is worth noting that some capacities, although common to different approaches, might be more properly referred to concepts different from resilience. According to the theory of panarchy (Gunderson and Holling, 2001), in fact, resilience, potential and connectedness are the three factors influencing adaptive cycles (Figure 6). Hence, resourcefulness, common to most of the considered approaches, might be more properly attributed to the concept of potential that refers to the availability of ecological, economic, social and cultural capital; similarly, self-organization, interdependence and autonomy could be attributed to the concept of connectedness that refers to the capacity of a system to control its own evolution. In the same line, spatial and temporal interactions as well as cross-scale perspective - identified as resilience capacities in the ecological and sustainability as well as in the climate change field - might be properly referred to the systemic approach to cities (Batty, 2008). In detail, they are crucial for understanding the features and dynamics of a city interpreted as a complex system, whose knowledge cannot fail to consider cross-scale interactions between elements and systems, occurring at different geographical scales and in different time spans.

Once the capacities of a resilient system have been identified and selected, the focus has been shifted to the review of the conceptual models of Resilience up to now developed (Figure 7). Most of them are based on specific disciplinary approaches or addressed to specific goals: thus, they take into account only some of the identified capacities. However, they shed light on some relevant aspects. First of all, some of them highlight that resilience can be interpreted as the result of different capacities/factors mutually interrelated. For example, some scholars identify resilience as a set of networked adaptive capacities (Norris et al., 2008). Moreover, in the majority of the models, capabilities/factors are placed into a circular model and influenced by some basic factors (e.g. equity, context, etc.). Finally, some of them refer to the idea that the building up of resilience is the result of a continuous process that, as well as the land use planning process, is characterized by different phases and involves different actors.

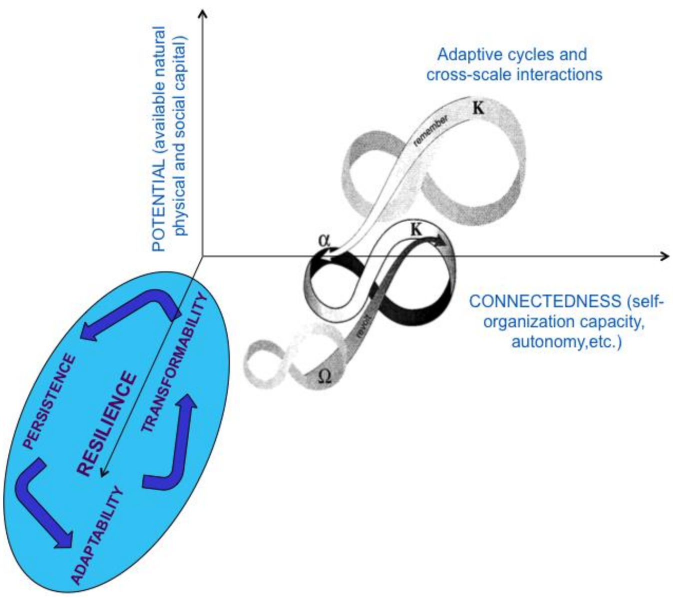


Figure 6. *The three axes of adaptive cycles.*

4. Towards resilient cities: A conceptual framework

Based on the in-depth analysis of the resilience capacities stemming from literature and taking into account the main hints arising from the available models, the selected capacities have been arranged into a conceptual framework, able to represent their importance and roles in the different stages following a perturbation. Such a framework embraces an idea of resilience as a process, characterized by a network of interrelated capacities and is addressed to support planners and decision-makers in moving cities towards “a more resilient state” (Jabareen, 2013).

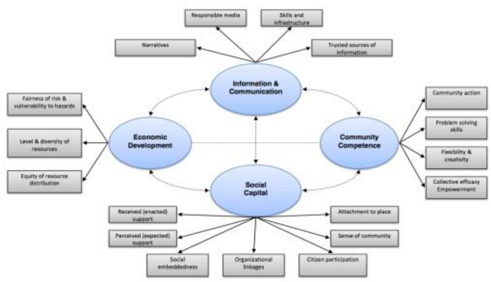
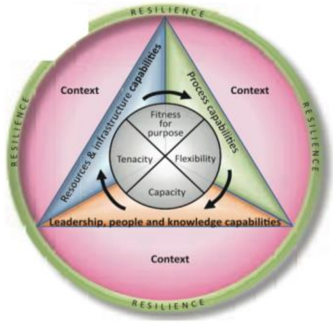
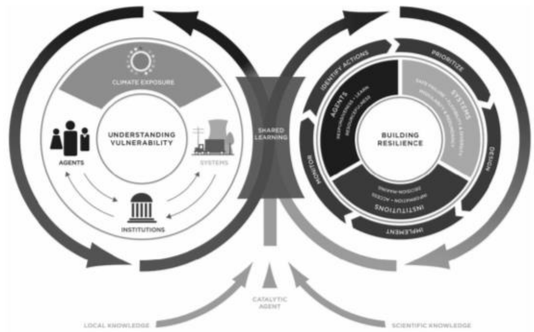
	
Resilience as a set of networked adaptive capacities (Norris et al., 2008).	The triangular model of Resilience (Gibson and Tarrant, 2010).
	
The factors influencing Resilience (Turnbull et al., 2013).	A framework for resilience planning (Tyler and Moench, 2012).

Figure 7. *Models of Resilience: Examples.*

The framework is structured as a cyclical process formed by three stages, mirroring the response of an urban system to an external stress (Figure 8): the pre-event stage, in which the capacities of an urban system to anticipate, prevent, mitigate and prepare in face of the potential impacts of a stress factor play a key role; the emergency phase, in which the capacities of an urban system to resist and absorb the impacts of a sudden event are crucial; the recovery/transition phase, in which the capacities of an urban system to reconstruct after the impact of a catastrophic event or to change in face of slow moving phenomena find place. The significance of these stages depends on the type of stress factor: the prevention and mitigation phase has a key-role in face of both instantaneous and slow-moving phenomena; response and emergency phase gains importance in face of instantaneous phenomena (floods, avalanches, fires) and it is generally followed by a long-term reconstruction phase. On the opposite, in case of slow-moving events (droughts, raise of the sea level), prevention and mitigation phase is generally followed by a slow phase of transition, characterized by the adaptation or transformation of the system in order to deal with changing conditions.

Since the selected capacities are very heterogeneous - some of them represent general concepts related, for example, to the different facets of resilience, others refer to more specific contents - the model has been structured into three levels. Each level provides a specification, in operational terms, of the previous one, recalling the structure goals-objectives-actions largely used in the urban planning decision-making processes.

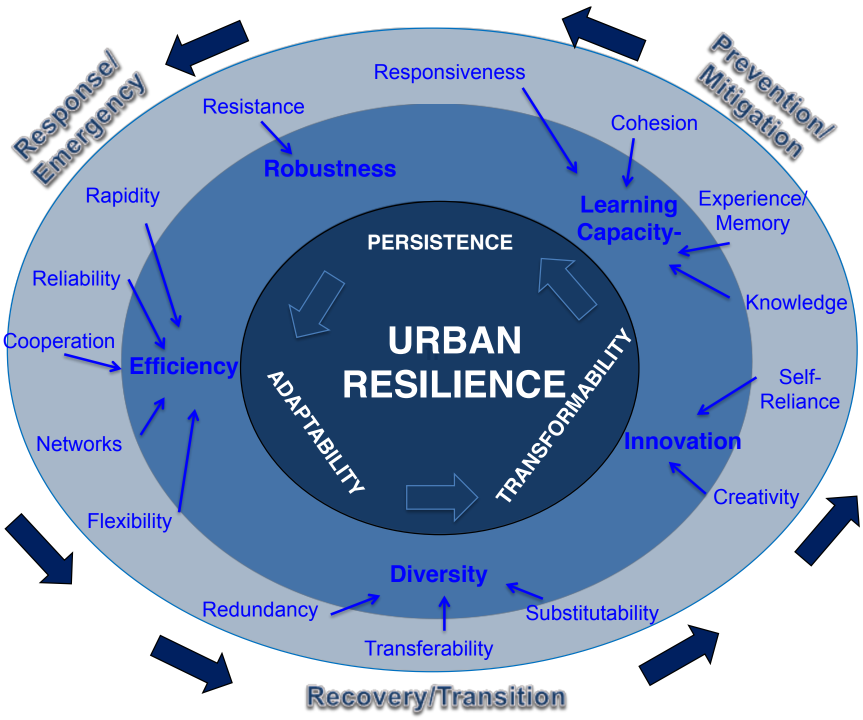


Figure 8. *The integrated model of Urban Resilience.*

The first level, the most internal one, represents the core, the main goal of the process addressed to enhance urban resilience. Thus, according to the interpretation of resilience as “dynamic interplay of persistence, adaptability and transformability across multiple scales” provided by Folke et al. (2010), at this level resilience and its three main facets have been placed. According to this interpretation, the concept of resilience helps us to extend the focus beyond resistance to shocks to include adaptive responses as well as long-term transformation in face of emerging threats.

At the second level five capacities, common to all the analyzed sets of literature on resilience, have been placed: robustness, efficiency, diversity, innovation and learning capacity. These capacities represent the main objectives of the process addressed to enhance the three facets of urban resilience, even though each capacity gains prominence in one stage of the process. In detail, two of them (robustness, efficiency) come from an engineering approach to resilience and play a key-role in guaranteeing the persistence of an urban system in face of stress factors. The others (diversity, innovation, learning capacity), arising from the socio-ecological approach to resilience, are crucial for shaping the response of the system in the medium-long term in that they directly influence the capacity of an urban system to adapt or move towards a new state.

In the disaster field, robustness has been generally referred to the ability of elements or systems to withstand a given level of stress without suffering degradation or loss of functionality (Bruneau et al., 2003). In the climate change studies, it has been defined as “the ability of a system to continue to perform satisfactorily under load” (UKCIP, 2003). Thus, robustness is strongly linked to the concept of persistence and can be interpreted as the capacity of an urban system to withstand external threats, preserving its physical, environmental and social capital without significant reductions in its ordinary level of functioning.

Efficiency can be interpreted as the capacity of a system to guarantee its performances in a resource-limited setting. Therefore, this capacity is crucial both in the immediate post-event phase, enabling urban systems to optimize available resources, and in the medium-long term, for ensuring the adaptation of the system in face of slow-moving phenomena, such as climate change or scarcity of resources. For example, nowadays efficiency is considered crucial in the European strategies addressed to meet the 20-20-20 targets: the thermal insulation of existing buildings as well as the rules for guaranteeing high energy performances of the new ones; the improvement of urban infrastructures for energy distribution (smart grids or district heating) are only some examples of the numerous measures currently addressed to enhance efficiency of urban systems in face of climate related problems.

Diversity crosses most of the approaches to resilience and is crucial for ensuring the capacity of an urban system to adapt in face of different threats. In the field of ecological and sustainability studies, diversity has been recognized as an important capacity for coping with uncertainty and surprise, facilitating redevelopment and innovation following a crisis (Folke et al., 2002). In the field of risk, spatial and functional diversity are recognized as important capacities for guaranteeing the preservation of the key assets as well as the key functions of an urban system in case of impacts of adverse events. Furthermore, some authors highlight that a diverse economy ensures that there is overall economic viability if one economic activity fails (Berkes et al. 2002). According to a long-term perspective, both economic and land use planning can largely contribute to enhance diversity in urban systems, for example, reducing their over-dependence on economic activities placed in hazard prone areas (Davoudi et al., 2013).

Innovation represents the ability of a system to reorganize its variables in response to an external change: although scarcely considered by the engineering approach to resilience, it has been largely emphasized in the last decade by the Transition Movement as a key capacity to go beyond adaptation, transforming the external pressures into opportunities for new and more desirable development paths for communities (Hopkins, 2005, 2008). Strategies addressed to enhance innovation require long-term visions based on innovative technical solutions as well as on community involvement and political will.

Learning capacity, typical of complex adaptive systems, has been recognized as crucial for enhancing resilience both in the field of ecology and sustainability and in the climate change community. The capacity of an urban system to learn from past events is a key-step for anticipating, foreseeing and coping with the future ones (Folke et al., 2002). Therefore, it plays a fundamental role in the pre-event phase, being crucial for enhancing urban systems’ capacity to persist, adapt or change in face of stress factors (Davoudi et al., 2013).

At the third level, the most external one, the five capacities previous described have been further specified through a set of capabilities.

Resistance - which refers to the ability of systems to withstand perturbing factors, maintaining their features – is closely related to the robustness of urban systems. Strategies addressed to enhance resistance of an urban system may include, for example, the retrofitting of existing buildings as well as the definition or the updating of building and planning codes in hazard prone areas as well as in areas affected by climate-related phenomena.

Rapidity, reliability, cooperation, networks and flexibility have been identified as the main capacities to improve the efficiency of a system. In the disaster field, rapidity has been interpreted as the capacity to meet priorities and achieve goals in a timely manner in order to contain losses and avoid future disruptions.

Rapidity of urban systems in face of instantaneous phenomena can be enhanced, for example, through measures addressed to improve forecasting and early warning systems, allowing a prompt response of the hit urban system in case of emergency.

Reliability is generally referred to the ability of systems and their components to ensure that key functions continue to be available, accessible and fit for purpose following a perturbing event (Gibson and Tarrant, 2010). Strategies aimed at increasing reliability of an urban system may include, for example, the setting up of emergency plans as well as of continuity plans for economic activities, capable to guarantee an effective response of a city in case of hazardous events.

Cooperation among different systems/actors is crucial for ensuring efficiency of urban systems in face of sudden and slow-moving threats. Numerous initiatives at European level, for example, are currently addressed to encourage cooperation among organizations, cities and communities for preventing/mitigating climate change impacts (e.g. the Climate Action Network-Europe). Furthermore, the recent Document "Elements for a National Strategy for Adaptation to Climate Change Strategy", issued in 2013 by the Italian Ministry of the Environment, recognizes that adaptation to climate change requires cooperation among institutions at different spatial levels (multilevel governance) and among different stakeholders (Ministero dell'Ambiente, 2013).

Closely related to the concept of cooperation is the capacity to establish formal and informal networks within organizations, institutions and communities. Adger (2003) argues that environmental management and climate adaptation are strongly dependent on "networks and flows of information between individuals and groups" and an increasing number of studies highlight the key role of social networks in the post-disaster recovery (Nelson et al., 2007). The capacity of establishing social as well as institutional networks is crucial to facilitate the exchange of information, the collaboration across different institutions at different scales, the sharing of resources, improving the efficiency/effectiveness of urban systems both in the emergency and in the recovery phase following a hazardous event (Buckle et al. 2000; Chuvarajan et al., 2006; Coyle, Meier, 2009). The capacity to develop formal and informal networks can be largely improved through measures addressed to improve "smartness" of cities: Information and Communication Technologies (ICTs) currently available (wireless sensor networks, internet, mobile communication network, private network, internet of things) can significantly increase the capacity to collect, elaborate and share information at different levels, enhancing the ability of urban system to effectively withstand and react in case of adverse events.

Flexibility is a key aspect of adaptability, crucial when unexpected events occur (Godshalk, 2003). The lack of flexibility that often characterizes disaster management systems - rigidly organized and designed according to a probabilistic approach to risk assessment and management - may frustrate quick decisions and actions in face of events “beyond” the expected (Menoni, 2001). Therefore, in order to improve flexibility, strategies addressed to enable institutions and organizations to cope with sudden and unforeseen shocks should be promoted. For example, training exercises for extreme meteorological events as well as practicing decision-making in vacuum could be useful to increase flexibility both of institutions and citizens (Gibson and Tarrant, 2010).

Redundancy, transferability and substitutability can be identified as the main capacities to improve diversity in urban systems. These capacities are addressed to ensure a satisfactory level of performance following a perturbation, providing continuity to a given system through the availability of different elements or agents performing the same function. They are also crucial to deal with uncertainty that is a key feature both of urban systems and of the different threats at stake (natural hazards, climate related phenomena, etc.). According to Berkes (2007), indeed, our knowledge of complex systems “and our ability to predict their future changes will never be complete, even after a great deal of research”. Similarly, scholars and practitioners recognize that “uncertainty looms high in the area of natural hazards” (Berkes, 2007) and that greater uncertainty is currently added to hazard and risk assessment by climate change (IPCC, 2012).

In detail, redundancy refers to the availability within a system of several elements/actors performing the same function, ensuring continuity in case one element/actor fails (Chuvarajan et al., 2006). In the disaster field, redundancy has been defined as the availability of elements or systems that can be activated when hazard-related disruptions occur (Bruneau et al., 2003). Closely related to the concept of redundancy, and according to a functional and economic perspective, transferability and substitutability refer to the degree to which an activity, a good or a service can be moved, relocated or replaced by another when the need arises (Van der Veen and Logtmeijer, 2005). Thus, redundancy, transferability and substitutability are all addressed to ensure the continuity of urban performances - namely of lifelines, emergency facilities, economic activities - in the emergency phase.

Creativity gains relevance in the recovery/transition phase, which marks the transition of the system towards a different state. It is a key feature to cope with uncertainty and surprise as well as to adapt to new circumstances (Maguire and Hagan, 2007), achieving different and better conditions after a perturbation. Therefore, creativity should be larger encouraged, by investing in research as well as in the ICTs, in order to provide spurs for innovating cities in face of complex and unpredictable events.

Self-reliance refers to the ability of satisfying basic needs locally, reducing dependence on imported resources (Chuvarajan et al., 2006). In economy, self-reliance refers to the capacity of strengthening local economies, making them less vulnerable to global economy fluctuations (James and Torbjorn, 2004). Currently, numerous studies emphasize the need of encouraging self-reliance at urban scale in face of the “peak oil” as well as of the scarcity of available resources (water). According to Morris (2008), “the increased cost and decreased availability of raw materials, including but not limited to fossil fuels, pushes us (…) to recycle our scrap products, to process materials at the local level, and to generate energy nearer the final customer”. Thus, strategies for a self-reliant urban development could be addressed, for example, to promote the use of renewable energy sources or of natural building materials, to develop effective rainwater harvesting systems as well as to promote recycling.

Finally, knowledge, experience, cohesion and responsiveness are all addressed to improve the capacity of a system to learn from past events and to disseminate such learning within a community.

In detail, knowledge of past events as well as of the best available tools for preventing or mitigating risks is crucial for fostering awareness among local institutions, citizens, associations, improving cities’ ability to withstand and adapt in face of adverse events. Knowledge can be improved through strategies addressed, for example, to develop research programs involving local Authorities (INTERREG) or creating exchange and learning programs enabling local Authorities to work together and to develop common solutions to major urban challenges (URBACT).

Memory and experience are closely related each other: memory refers to the ability of a system to preserve knowledge and information (Chuvarajan et al., 2006) and, very often, experience is decisive for building up memory. Numerous scholars have considered knowledge and experience as key features for supporting preparedness activities as well as for enhancing the re-organization after a disturbance (Folke et al., 2002) and the anticipation of future disasters (Gunderson, 2009).

The level of cohesion within a community largely affects both the communication and sharing of experience and the preservation of memory. It can be significantly increased through policies aimed at promoting an active participation of citizens, notably of minorities and most vulnerable groups, to community life and to decision-making processes. Responsiveness - referred to the capacity to identify problems, anticipate, plan and prepare for a disruptive event or an organizational failure and to respond in the aftermath of such events - largely depends on knowledge as well as on experience and memory of past event.

Finally, it is worth noting that the blue arrows in the Resilience model (Figure 8) point out the direct links among the capacities placed at the third and the second level, whereas the links among capacities placed at the same level have been here neglected. For example, the capacity to establish networks has been identified as a key capacity for improving the efficiency of urban system in case of adverse events. Nevertheless, such a capacity could be crucial to increase social cohesion and, thus, might indirectly contribute to enhance learning capacity.

5. Conclusion

Resilience has been here interpreted as one of the three factors influencing adaptive cycles of urban systems, together with the potential and the connectedness (Holling, 2001), resulting from the “dynamic interplay of persistence, adaptability and transformability across multiple scales” (Folke et al. 2010), bridging and above all overcoming the dichotomy between engineering and ecological resilience.

Some authors have defined this interpretation of the resilience concept as “evolutionary resilience”, in that it “is understood not as a fixed asset, but as a continually changing process; not as a being but as a becoming” (Davoudi, 2012).

According to such an interpretation, some steps for moving from a theoretical approach to resilience towards an operational level have been outlined. First of all, an in depth review of research works and institutional documents, published in the last decade and addressed to identify the capacities of a resilient system, has been carried out. The available literature has been collected and classified in respect to four different disciplinary fields, mirroring different approaches to resilience. Then, the capacities arising from each field have been analyzed, selected and organized into a framework, the Urban Resilience Model, structured as a cyclical process and capable to take into account environmental, social, economic, functional and spatial aspects of urban systems’ resilience.

Summing up, according to the main aims of the special issue of the A|Z Journal “Cities at risk”, the suggested resilience-based approach could allow planners and decision-makers to overcome some of the weaknesses of current disaster mitigation strategies based, in most cases, on a sectoral perspective and often focused on physical failures. The proposed Urban Resilience Model represents, indeed, a tool for enabling them to frame, into a comprehensive approach - capable to look beyond physical failure and to take into account the different stages mirroring the response of an urban system to external stresses - policies addressed to tackle the different threats currently affecting cities (climate change, natural and technological hazards, environmental degradation, etc.).

Nevertheless, starting from the Urban Resilience Model, a further step should be undertaken in order to provide cities with effective tools enabling them to withstand, adapt or change in face of heterogeneous risk factors. In detail, in order to fill the persisting gap among theory and practice, the provided Urban Resilience Model should be calibrate on specific urban systems, in order to: prioritize the capacity placed at different levels of the model according to the real problems of the city at stake; define tailored on the context actions and measures to be implemented in order to achieve each capacity.

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