

RESILIENCE AND/OR VULNERABILITY? RELATIONSHIPS AND ROLES IN RISK MITIGATION STRATEGIES

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Abstract

Resilience and vulnerability represent two core-concepts in the disaster field, widely invoked as basic means for supporting risk mitigation strategies. Vulnerability has been in-depth investigated since the Seventies; resilience has been largely widespread in the disaster field over the last two decades, although a shared theoretical and operative approach to this concept is still missing and the relationships between vulnerability and resilience are still a nebulous matter. This paper, based on a research work developed within the 7th FP Ensure Project, has been addressed to:

- in-depth investigate the concept of Resilience, in order to provide a conceptual model of its main components by integrating different disciplinary perspectives;
 - explore, grounding on both scientific literature and the proposed conceptual model of resilience, the relationships between vulnerability and resilience, and highlight common aspects and peculiarities, in order to better understand their respective roles in achieving risk reduction goals.
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Introduction

The concept of vulnerability has been largely widened over time, according to different disciplinary perspectives: from the Seventies, when it was generally used as a synonym of damage (AA.VV., 1979), up to the more recent definitions, focused on “the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard” (ISDR, 2009). Currently, grounding on the shared interpretation of vulnerability as “an internal side of risk” and “an intrinsic characteristics of a system or element at risk” (Birkmann, 2006), the concept has been characterized as a multifaceted one. It includes, indeed, not only physical features of buildings and infrastructures which make them susceptible to be damaged (which is usually the core of the engineering perspective to vulnerability analysis), but also other

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aspects, as well as social, economic or institutional features affecting the capacity of a community to withstand, cope with and adapt to a hazardous event. The inclusion of other concepts as coping and adaptive capacity within the vulnerability one has driven toward a growing mess referring to the differences and the relationships between vulnerability and resilience, which is going to be more and more widespread in the disaster field.

According to Villagràn de Leon (2006), “literature review regarding vulnerability reveals that the term has been used in many different contexts by many different authors, demonstrating the fact that the field is still unsettled”. Similarly, Rose (2007) states that, also due to the heterogeneity of approaches and to the different disciplinary perspectives, the concepts of resilience “is in danger of becoming a vacuous buzzword from overuse and ambiguity”.

Up to now, no further steps toward a deep understanding of meanings of and relationships between the two mentioned concepts have been made, although such understanding seems to be crucial for defining the potential roles of vulnerability and resilience in the reduction of the overall risk of communities dealing with natural, technological and na-tech hazards.

On the other side, in face of the growing rates of natural and technological disasters all over the world, the need for practical approaches to risk reduction has been more and more emphasized by the several actors in charge of risk prevention and mitigation at different levels (international agencies, national, regional and local governments, etc.), pushing toward a simplification of the scientific debate on vulnerability and resilience in favor of operational tools and effective guidelines to resilience and/or vulnerability assessment, as key-tools for developing risk mitigation strategies.

Therefore, this contribution focuses on the resilience concept and is addressed to provide a conceptual model of its main dimensions, as starting point for better understanding both the relationships between resilience and vulnerability and their roles in reducing the overall risk in face of different hazards.

In the last decades, indeed, a nourished scientific literature has been developed according to the idea that reducing vulnerability in face of a given hazard should have surely led to enhance resilience and reduce the overall risk. Nevertheless, the meanings of, and the relationships between, the two concepts are still nebulous and past disasters analysis clearly reveals that mitigation measures addressed to reduce vulnerability do not necessarily result in an enhancing of resilience and vice-versa.

In detail, this paper briefly presents the evolutionary path of the resilience concept, the reasons leading to its spreading into the disaster field and the most common interpretations of the debated relationship between vulnerability and resilience. Then, by integrating different disciplinary perspectives, the main components of resilience and their mutual influences have been singled out; then, in respect to the main phases of the disaster cycle, they have been arranged into a ring-shaped framework. This conceptual model of resilience underlines its dynamic features, provides a systematization of its main components and highlights that these components come on stage in different phases of the disaster cycle and most of them are largely time-related.

Starting from this conceptual model of resilience, the relationships between resilience and vulnerability have been unraveled, highlighting peculiarities and common aspects between the two concepts and, above all, the different roles they may play in risk mitigation strategies.

Roots and evolution of the Resilience concept

The term resilience, although initially adopted in physics to describe the resistance of a material to shocks, found wide room in Ecology in the first Seventies. In this field, Resilience was defined as a “measure of the persistence of systems and their ability to absorb changes and disturbance and still maintain the same relationships between populations or state variables” and it was clearly distinguished from the concept of stability, defined as “the ability of a system to return to an equilibrium state after a temporary disturbance” (Holling, 1973).

About twenty years later, Holling refined his theory by distinguishing two typologies of resilience: the engineering and the ecological one. In detail, he defined the ability to return to a stable steady-state following a perturbation as engineering resilience, which “emphasizes conditions far from any equilibrium steady state, where instabilities can flip a system into another regime of behavior” (Holling, 1996). Therefore, whereas the engineering resilience focuses on aspects such as efficiency, constancy and predictability, the ecological resilience focuses on aspects as persistence (maintaining the existence of functions) and robustness (preservation of the structure of the system in face of perturbations).

According to these definitions, engineering resilience can be measured “by a return time, the amount of time taken for the displacement to decay to some specified fraction of its initial value” (Pimm, 1991), whereas ecological resilience can be expressed by the magnitude of disturbance that can be absorbed before the system changes its structure by modifying variables and processes that control its behavior (Ludwig et al., 1996; Gunderson and Holling, 2001).

The aspects related to resistance and absorption of disturbance were more properly included in the “stability” concept by Berkes and Folke (1998), underlining that resilience is mainly referred to the opportunity for the recombination of modified structures and processes after a disturbance. The latter aspects became preeminent when discussion on resilience moved from the ecological to the socio-ecological field. Resilience has been officially introduced in the disaster field in 1994, within a UN document, namely the guidelines for the World Conference on Natural Disaster reduction. This document emphasized the need for strengthening “resilience and self-confidence of local communities to cope with natural disasters through recognition and propagation of their traditional knowledge, practices and values as a part of development activities”. A lot of documents published under the umbrella of relevant international institutions and NGOs followed the 1994 UN one. Starting from the Nineties and according to different disciplinary perspectives, a large variety of resilience definitions has been provided and the main properties, attributes or capacities able to make a system resilient in face of adverse circumstances have been identified. For example, Bruneau et al.

(2003) defined the community seismic resilience as the ability of social units (e.g. organizations, communities) to mitigate earthquakes, to contain the effects of disasters when they occur and to carry out recovery activities in ways that minimize social disruptions and mitigate the effects of future events. Moreover, they provided a framework for analyzing and measuring community seismic resilience, which has been considered a benchmark for numerous scholars and practitioners.

In 2004, resilience was introduced into the ISDR glossary on Disaster Risk Reduction and defined as “the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure” (ISDR, 2004). One year later, the Hyogo Framework for Action 2005-2015 (UN/ISDR, 2005) identified the goal of building resilience of nations and communities to disaster as the overarching one for achieving a substantive reduction of disaster losses by 2015.

In the last updating of the ISDR glossary on Disaster Risk Reduction the definition of resilience was refined as follows: “The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions” (ISDR, 2009). In such a way, the definition embodies both the ecological resilience meaning, by “the preservation and restoration of structures and functions”, and the engineering one, through the introduction of efficiency and time as key-variables to be taken into account in assessing resilience.

Thus, both institutional documents and the most recent approaches developed by scholars from different disciplinary fields seem to converge towards an interpretation of resilience as a set of interrelated adaptive capacities enabling systems to deal with both expected and unexpected changes (Norris et al, 2007; Paton and Johnston, 2008; Chapin et al. 2009).

Nevertheless, the overuse of the term resilience – probably related to its positive meaning in opposition to the negative one attributed to vulnerability – highlights that resilience is currently referred to as a “panacea” within the disaster field, even if some scholars stress on the fact that resilience should not be treated always as a desirable attitude (Sapountzaky, 2007).

Relationships between Resilience and Vulnerability in scientific literature

Resilience and vulnerability are linked core-concepts in the disaster field, as well as in the climate change one, although as mentioned above their relationships are still unclear. Thus, not surprisingly, in scientific literature it is widely accepted the idea that the reduction of losses due to hazards, which represents a primary goal for pursuing both risk mitigation and sustainable development, can be achieved through strategies aimed at reducing vulnerability and enhancing, in the meanwhile, resilience. According to this perspective, the two concepts seems to be two sides of the same coin even if this interpretation is only one among the different

ones provided up to now. The review of studies and researches devoted to this issue highlights at least three main schools of thought:

- resilience as the flip-side of vulnerability;
- resilience as a component of vulnerability;
- resilience and vulnerability as separate concepts.

For a deep understanding of the complexity of the issue, a brief snapshot of each mentioned approach is provided below.

Resilience as the flip-side of vulnerability

In 1981, Timmermann defined vulnerability as the level “to which a system acts adversely to the occurrence of a hazardous event. The degree and quality of the adverse reaction are conditioned by a system’s resilience, meant as a measure of the system’s capacity to absorb and recover from the event”.

Fortune and Peters (1995) provided a conceptualization of the vulnerability of a system as “the obverse of its ability to absorb disturbances, which in turn can be considered to be an indication of its resilience”.

Both examples, although referable to a flip-side approach, do not identify a clear direct and opposite relation between the terms.

More explicit and highly simplified is the flip-side perspective provided by the EVI Research Project, aimed at setting up an environmental vulnerability index, according to which resilience is defined as the “ability of an entity to resist or recover from damage”, underlining that “vulnerability and resilience are two sides of the same coin. Something is vulnerable to the extent that it is not resilient”. Moreover, the vulnerability concept as flip-side of resilience “applies equally well to physical entities (people, ecosystems, coastlines) and to abstract concepts (social systems, economic systems, countries)” (EVI Project, 1998).

The flip-side approach has widely spread in the socio-ecological field too. Folke et al. (2002) argue that “vulnerability is the flip side of resilience: when a social or ecological system loses resilience, it becomes vulnerable to change that previously could be absorbed” and, furthermore, “the antonym of resilience is often denoted vulnerability. Vulnerability refers to the propensity of social and ecological system to suffer harm from exposure to external stresses and shocks”.

Moreover, as stressed above, the flip-side approach seems to be related to the “desire to emphasize the positive side of things (enhancing resilience in opposition to reducing vulnerability)” (Klein et al., 2003).

According to Villagran (2006), the flip-side approach can be related to the definition of resilience as “an intrinsic ability of a system, an element, or a community to resist the impact of a natural or a social event”.

Resilience and vulnerability can be interpreted as “the two ends of a spectrum. High levels of vulnerability imply a low resilience, and vice-versa” (Cannon, 2008).

According to the flip-side approach, risk mitigation strategies, by decreasing vulnerability, would directly contribute to improve resilience in a given system.

Resilience as a component of vulnerability

Many authors refer to an “inclusive” relationship between the two terms, defining resilience as a component of the vulnerability concept. For example, McEntire (2001) identified the four variables which determine vulnerability as follows:

- risk, proximity or exposure to hazards, which affects the probability of adverse impact;
- susceptibility, proneness of individuals to adverse impacts of disasters, based on social, economic, political and cultural variables;
- resistance, the ability of physical systems to withstand the stress produced by hazards;
- resilience, the coping capacity and ability to recover quickly from impacts of disasters.

Moreover, in order to manage the relationships among these concepts and achieve a comprehensive risk reduction, he proposed a proactive holistic approach called “invulnerable development”, which involved “decisions and activities that are intentionally designed and implemented to reduce risk and susceptibility, and also raise resistance and resilience to disaster” (McEntire, 2001).

Similarly, Pelling (2003) recognized a priority role of vulnerability with respect to resilience and suggested an interpretation of vulnerability as result of exposure, resistance, and resilience: “exposure is related to the location of the system or element with respect to the hazard and the environmental surroundings; resistance is related to the economical, psychological, and physical health of systems of maintenance, as well as the capacity of individuals or communities to withstand the impact of the event and is related with livelihoods; while resilience is defined as the ability to cope with or adapt to the hazard stress through preparedness and spontaneous adaptations once the event has manifested itself”.

A key-element to better understand the “inclusive” approach is related to the different interpretations of the relationships among the concepts of coping capacity, adaptive capacity and resilience. The widening of the vulnerability concept implies, indeed, that coping and adaptive capacity are at present generally interpreted as components of vulnerability. Therefore, some authors have represented the three mentioned concepts as nested within the wider concept of vulnerability (Turner et al., 2003; Gallopin, 2006); others have stressed that, since resilience is totally included in the adaptive capacity, it is also a component of vulnerability (Adger, 2006; Birkmann, 2006; Folke, 2006; Cutter et al., 2008).

Villagràn de Leòn (2006) emphasized the temporal relationship between coping capacity and resilience; in detail, he defined the resistance as the “capacity of the system to remain unchanged for an interval of time after the event manifested itself”; the resilience as “the capacity of the system to recover to its state prior to the disaster” and the coping capacity as the combination of resistance and resilience.

Also according to this perspective, risk mitigation strategies, by decreasing vulnerability, would directly contribute to improve resilience in a given system.

Resilience and vulnerability as separate concepts

The “discrete or separate” approach has been supported by numerous scholars, who have proposed an interpretation of vulnerability and resilience as distinct, although connected, concepts.

According to Manyena (2006), “we can possess characteristics that can make us vulnerable and that can influence our capacity to adapt at the same time. Until it can be demonstrated the contrary, I think they should be viewed as discrete” and, therefore, “the absence of vulnerability does not make one resilient”.

Some scholars have clearly stressed that resilience and vulnerability are independent processes which do not necessarily lead to opposite outcomes even though sometimes one can clash with the other. For instance, in poor communities characterized by a strong social structure, sometimes the low access to resources produces a strong social cohesion and participation which, in turn, increases the community adaptive capacity. In such a case, as noticed by Paton (2008), vulnerability features coexist with other characteristics that improve the adaptive capacity. On the contrary, in disaster literature, it is often assumed that the higher is the resilience of a community, the lower will be their vulnerability in face of hazards. Paton (2008) highlights that hazard impacts cannot be reduced only to direct damage, but they have to be connected to the community features which “increase susceptibility to experiencing loss from exposure to a hazard (i.e. increase vulnerability) and those that facilitate the capacity to adapt or adjust (i.e. increase resilience)”. Thus, according to this perspective, adaptive capacity is included in the resilience concept, but is not included in the vulnerability one. Therefore, resilience and vulnerability are considered as independent factors, acting in different phases after the event (preparedness, response and recovery) at individual, community and institutional level in order to contribute respectively to improve adaptation and minimize disruptions (fig. 1).

On the opposite, within the wider interpretations of the vulnerability concept, “vulnerability and resilience have common elements of interest: the shocks and stresses experienced by the social and ecological system,

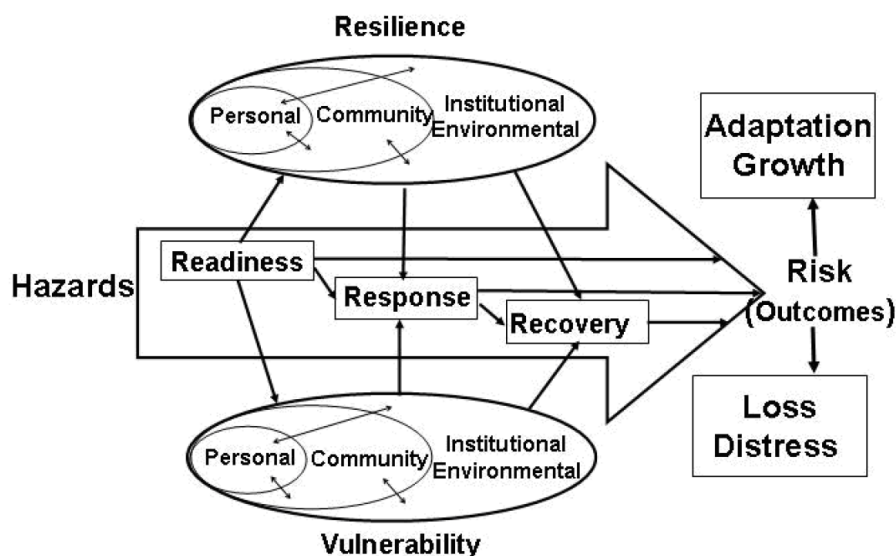


Figure 1: A Risk-Resilience-Vulnerability management model (Paton, 2008).

the response of the system, and the capacity for adaptive action”; consequently, “the points of convergence are more numerous and more fundamental than the points of divergence” (Adger, 2006).

Some scholars identify adaptability as the overlapping part between vulnerability and resilience (Chapin, 2009), highlighting that the two concepts can be interpreted neither as opposite nor as included one into the other, but as separate ones, although partially overlapping (fig. 2).

In both the mentioned interpretations (resilience and vulnerability as separate or partially overlapping concepts), it is clear that these concepts play a different role in risk mitigation processes and that strategies aimed at reducing vulnerability do not necessarily contribute to improve resilience in a given system and vice-versa.

The conceptual ring-shaped model of Resilience

Beside the different interpretations of the relationships between vulnerability and resilience, the multidimensional character of resilience makes even more unclear which features of a system effectively induce resilience or which variables have to be taken into account to assess it (Cumming et al., 2005).

Hence, it is also difficult to understand if actions aimed at reducing some aspects of vulnerability may contribute to enhancing resilience or on which variables it is possible to act in order to increase resilience and reduce, in the meanwhile, vulnerability.

As mentioned above, currently resilience is widely recognized as a set of interrelated capacities and numerous conceptual models have been carried out according to different disciplinary perspectives (Norris, 2008; Gibson and Tarrant, 2010).

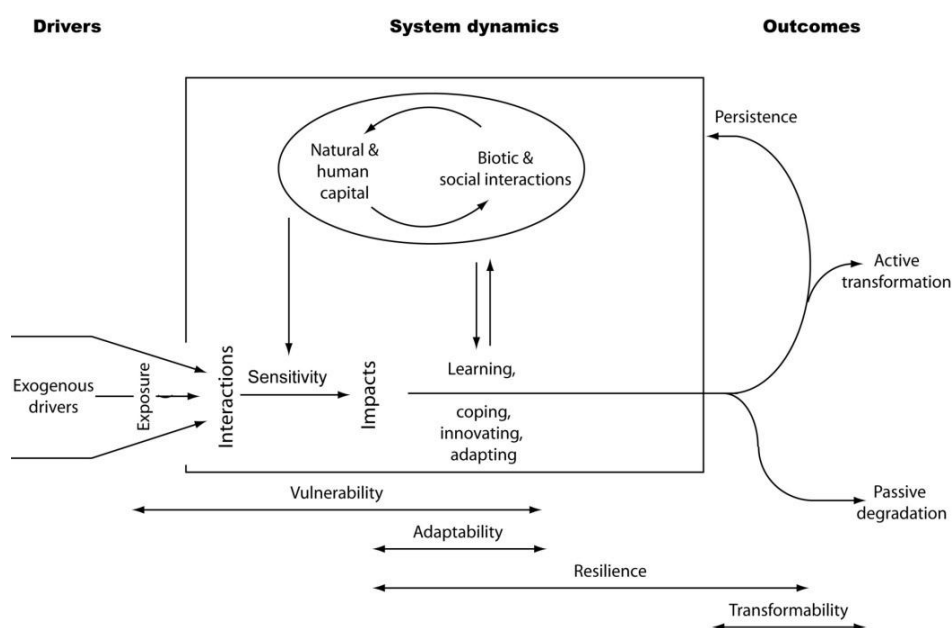


Figure 2: Vulnerability, adaptability and resilience (Chapin, 2009).

Nevertheless, these capacities/attributes/resources making a territory or a community resilient are still blurred and unshared.

To fill this gap, a careful review of current scientific literature has been carried out in order to better understand the concept of resilience and its key-components, as the starting point for defining the relationships between resilience and vulnerability and the roles that each of them might play in pursuing risk mitigation goals. In detail, the main studies developed in different scientific fields and focused on resilience have been analyzed and the main capacities or properties, which may influence the resilience of a given system, have been collected.

As shown in the table 1 – in which the main features stemming from scientific literature have been collected according to different typologies of systems – the ecological field and its extension into the socio-ecological domain offer fundamental remarks for singling out such characteristics (Folke et al., 2002; Walker et al., 2004). Fiksel's contribution (2003) grounds on a clear system perspective and couples the aspects of resilience with those referring to sustainable development. Godshalk's researches (2003), based on a planning perspective, provide some principles characterizing a resilient response of cities in face of natural hazards and terrorism.

In the same line, Chubarajan et al. (2006) investigate how the improvement of resilience can be a strategy to reach sustainability and provide implementable measures to achieve resilience and sustainability goals. Maguire and Hagan (2007) recognize resistance, recovery and resilience itself as the main properties of a resilient community. In fact, in an ongoing process, a resilient community predicts and anticipates disasters, absorbs, responds and recovers from the shock and improvises and innovates in response to disasters. According to an economic perspective, the concept of redundancy in terms of "ability to respond to a disruption" has been introduced with a clear reference to the resilience concept (Van der Veen and Logtmeijer, 2005) and the properties of efficiency, rapidity and flexibility have been singled out as core elements for economic resilience (Briguglio et al., 2008).

The Multidisciplinary Center for Earthquake Engineering Research (MCEER) has provided a relevant contribution on resilience too, by developing the R4 model (robustness, rapidity, redundancy, resourcefulness) related to the resilience of social system in face of earthquakes (Bruneau et al., 2003). Chang and Shinozuka (2004) refined the Bruneau's approach by reframing the measure in a probabilistic context. Davis (2005) explored the concept of resilience before, during and after disaster impact and presented numerous case studies to highlight how resilience operates or fails.

Tierney and Bruneau (2007) reaffirmed the validity of the R4 framework in order to provide a range of strategies to enhance resilience, including mitigation-based ones, such as the development of a robust organizational and community capacity to respond to disasters, and the improvement of the coping capabilities of households and businesses.

AUTHORS	CAPACITIES/PROPERTIES	SYSTEMS
Folke et al. (2002)	Diversity, redundancy, adaptability, self-organization, transformability	Complex Adaptive Systems
	memory, experience and knowledge, innovation, learning capacity	
Fiksel (2003)	Diversity, adaptability, cohesion, efficiency	Systems
Godshalk (2003)	Diversity, redundancy, strenghts (resistance), adaptability/flexibility	Cities
	collaboration, interdependence, autonomy, efficiency	
Bruneau et al. (2003)	Redundancy, robustness, resourcefulness, rapidity	Communities
Chang et al. (2004)	"	
Davis (2005)	"	
Tierney & Bruneau (2007)	"	
Adger et al. (2005)	Diversity, redundancy, spatial pattern	Ecosystems
Van der Veen et al. (2005)	Redundancy (including substitutability and transferability)	Economic systems
Chuvarajan (2006)	Diversity, redundancy, self-organization, memory, networks	Communities
	innovation, individual capacity, spatial scale interaction	
	temporal scale interaction, self-reliance, feedback	
Maguire and Hagan (2007)	Resistance, recovery, creativity	Social systems
UNESCAP (2008)	Redundancy, robustness, resourcefulness	Socio-ecological and economic systems
Briguglio et al. (2008)	Efficiency, rapidity, flexibility	Economic systems
McDaniels et al. (2008)	Robustness, rapidity	Infrastructures

Table 1: The "Capacities/Properties" of Resilient Systems

Based on the MCEER's framework, the United Nations Economic and Social Commission for Asia and the Pacific took into account only robustness, redundancy and resourcefulness as key-factors, coupled with resource efficiency, for strengthening efforts aimed at improving economic growth sustainability (UNESCAP, 2008). They excluded rapidity due to the fact that it largely depends on the degree of shock experienced. Finally, McDaniels et al. (2008), focusing on the infrastructural systems, developed a conceptual framework for understanding both the factors that influence resilience and the type of decisions that can be pursued to foster them.

The mentioned capacities and properties are clearly not exhaustive and other researches providing similar components in respect to different systems could be mentioned (Norris, 2008; Gibson and Tarrant 2010; Bahadur et al., 2010). Nevertheless, the main question to be faced here seems to be which role each capacity or property might play in enhancing systems' resilience and how they are linked together. To answer these questions, the mentioned capacities have been in-depth analyzed (ENSURE Project, del. 2.2): some of them – being very similar to, or included in others – have been left out; others have been synthesized in one concept; then, the selected ones have been sorted into a ring-shaped model, articulated in three concentric rings, following the main phases of the disaster cycle (preparedness-impact-response-recovery).

Resilience has been placed in the core of the ring-shaped model, since it represents the final aim of the process addressed to enhance capacities, properties and resources that make a given system resilient.

Thus, in order to drive and support strategies and actions for enhancing resilience, the selected capacities and properties have been placed into the three rings according to a hierarchical structure – widely applied in planning – which links goals, objectives and strategies or actions. In other words, starting from the inner ring, capacities and properties placed in each ring represent a specification of the ones placed in the previous ring (fig. 3).

The inner ring includes robustness, adaptability and transformability: they represent, in our view, the main components of resilience, mirroring the end point of the evolutionary path of the concept itself. These components, related to different phases of the disaster cycle, can be also viewed as the main goals to pursue for enhancing the resilience of a system.

The intermediate ring includes capacities related to one or more of the three main components: these capacities can be interpreted as objectives to be achieved for enhancing the resilience components.

Finally, the outer ring includes properties or capacities which can be interpreted as strategies to be implemented for achieving the different objectives and enhancing resilience.

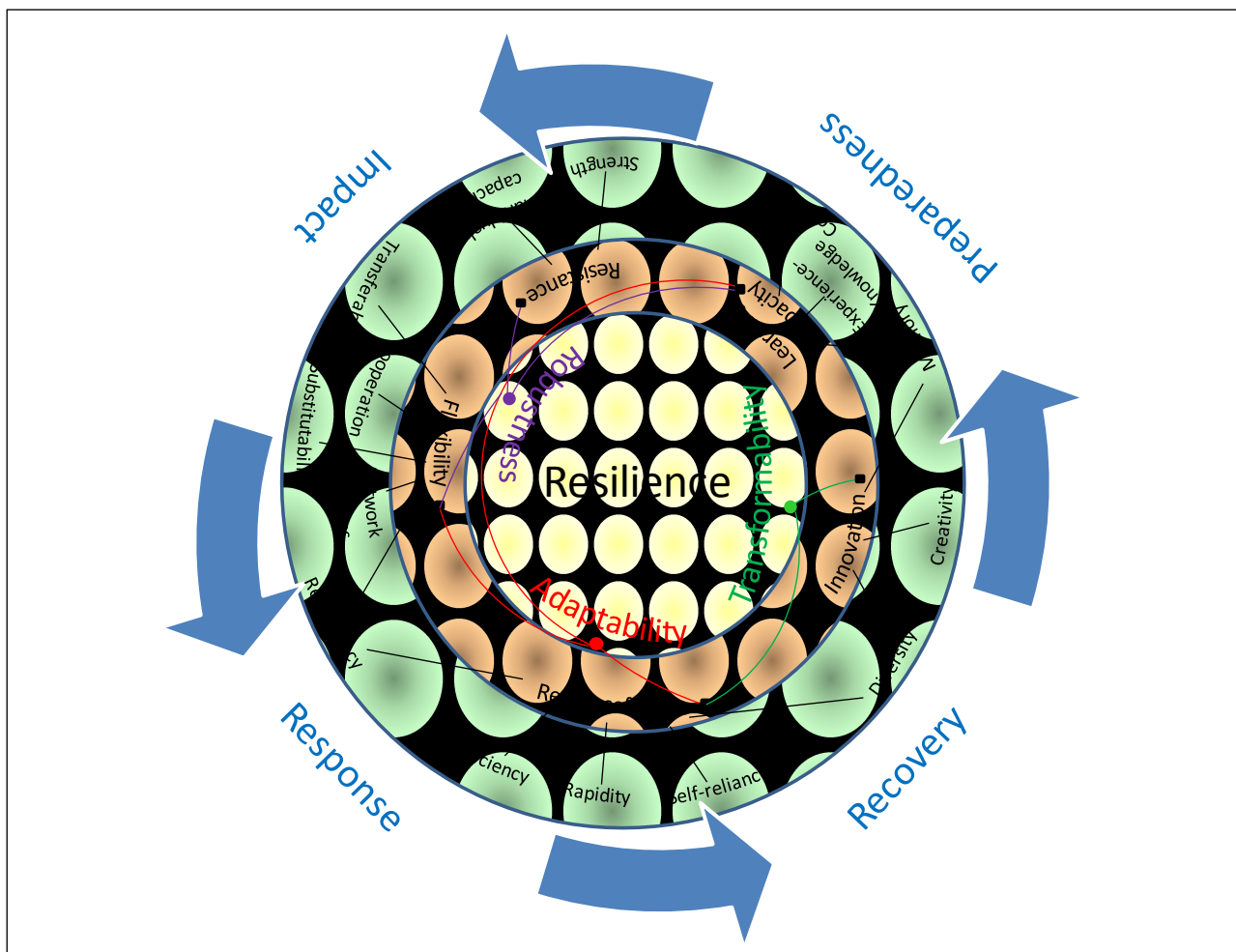


Figure 3: The ring-shaped model of resilience

The inner ring

The meaning of resilience has evolved, as mentioned above, from an interpretation fairly close to the ability of a systems to withstand a given level of stress without suffering losses or failures (robustness), toward the capacity of a system to adapt in face of the consequences (in terms of losses or failures) of a hazardous event (adaptability), up to the possibility to turn a disaster into an opportunity, by creating new conditions, different and sometimes more desirable in respect to the pre-impact ones (transformability).

Thus, the three mentioned components – which are not linked together since they can be considered as three distinct sides of the resilience concept, gaining relevance in different stages of the disaster cycle – represent the main goals to be pursued for making a system resilient in relation to a wide variety of external stresses.

In detail robustness – which according to Gallopin (2006) can be interpreted as the flip-side of vulnerability – is particularly relevant at the impact “time”: a system can resist to the impact without showing any mark of weakening or suffering, at most, a temporary gap from its ordinary structural or functioning conditions.

Adaptability gains prominence in the short-medium term after the impact (response phase): according to its different levels of adaptability, a system can bounce back to the previous state or shift toward new ones. Finally, in the long term and namely during the recovery phase, there is room for change and innovation: hence, transformability comes on stage.

The intermediate ring

Some of the capacities included in this ring are related only to one of the components mentioned above, others to more than one. In detail, closely related to robustness is resistance, which represents the capacity of a system to withstand a given stress or pressure or, in other words, how much a system can be displaced (or disturbed) by a given physical force. Resistance has been recognized as an important dimension of resilience by different authors; nevertheless, although it surely represents a positive feature at the occurrence of a hazard, it might also represent a negative feature during the response or recovery phases. For example, the resistance of an institutional system to adapt or change in face of an un-expected large size event may largely frustrate quick decisions and actions, as it happened during the emergency following the Kobe earthquake (Menoni, 2001).

Flexibility is recognized as crucial both for enabling a system to bounce back after being adversely affected by a shock (Briguglio et al., 2008) and for ensuring the adaptive capacity of a system (Godshalk, 2003). Thus, it contributes to increase, on the one hand, the adaptability and, on the other hand, the robustness of a system, by limiting the loss of functioning resulting from the impact. In this sense, it might include the concept of reliability, interpreted as the capacity of system to maintain its key-functions after a disturbance, which is clearly crucial for adaptation.

Resourcefulness has been identified as a key property for improving both adaptability, in the response phase, and transformability, during the recovery one. Moreover, transformability has been also related to the

innovation, which represents the ability of a system to reorganize itself in face of a disturbance. Innovation – arising over a long time span after the impact of a hazardous event – mainly characterizes the recovery phase. Finally, the capacity of learning from past events in order to foresee and cope with the future ones (Folke et al., 2002) has been recognised as a key-capacity, in relation to the preparedness phase, for increasing both robustness and adaptability.

The outer ring

Each of the above mentioned capacities has been specified through a set of properties and capacities included in the outer ring. In detail, strength and individual capacity represent the main properties that might be improved for enhancing resistance. The former refers to the strengthening of the built environment in face of hazards, the latter to the strengthening of individual actors within a system: from a social perspective, indeed, if individuals are healthy and have good individual resources, they will better deal with hazardous circumstances.

Flexibility can be enhanced through different properties or mechanisms aimed at overcoming dependency. Among them, transferability and substitutability (Van der Veen et al., 2005), relevant mainly to economic activities; spatial and organizational network patterns – designed or spontaneous – which can be singled out as properties ensuring a higher flexibility in respect to the hierarchical or monocentric ones; cooperation among the different actors within a system, especially by an institutional perspective; redundancy, relevant mainly to strategic activities and infrastructures. It is worth noting that cooperation can be also interpreted as a form of redundancy, in that it provides a multiplicity of opportunities that are very useful, especially in the immediate aftermath of a disrupting event.

Redundancy is widely recognized as key-property not only for increasing flexibility and reliability of a system but also for improving resourcefulness. Other key-properties to improve resourcefulness have been recognized in rapidity, viewed from an organizational perspective; efficiency, aimed at optimizing the available resources, making a rational use of them and self-reliance, which implies autonomy, satisfaction of needs through local resource, lack of dependency linkages.

Diversity is another property to strengthen for enhancing resourcefulness; it supports the richness and the variety of available resources. Diversity has been widely recognized as a crucial property of a system for coping with uncertainty and surprise, facilitating redevelopment and innovation following a crisis (Folke et al., 2002). Therefore, diversity has been also linked to the capacity for innovation. The latter depends also on another intangible resource, the creativity, which gains prominence after the end of the emergency phase, namely in the period generally defined as “window of opportunity” (Christoplos, 2006). Creativity plays an important role in the preparedness phase too: it should favor, indeed, the design of anticipatory scenarios taking into account events or synergies among them and among their impacts, characterized by a low probability of occurrence.

Memory and experience have been recognized as key properties for improving learning capacity; these properties are relevant both for the re-organization of a system after a disaster and for preventing future events, and largely contribute to increase knowledge (of events, damages, mitigation measure, best practices, etc.) which is crucial for an effective learning process too. Finally, learning capacity is also influenced by the level of cohesion existing within the community: in case of a good cohesion level, indeed, experience is more easily communicated and memory more easily preserved.

Conclusions

Based on numerous studies and researches on resilience, the set of capacities and properties that make a system resilient in face of hazardous events and their mutual relationships have been identified and systematized into a conceptual model, aimed at driving and supporting strategies and actions for enhancing resilience. Such a model allows also to highlight common features and main differences between the two concepts under investigation in this contribution: resilience and vulnerability. In detail, the conceptual model of the main capacities and properties which determine the resilience of exposed systems allows to overcome the widely shared interpretations of resilience as the flip-side or as a component of vulnerability, by highlighting their overlapping and distinct aspects and the consequent relevance of both vulnerability and resilience in the different phases of the disaster cycle.

Thus, even though the flip-side approach is currently the most widespread one, the in-depth analysis of resilience interpreted as a set of interconnected capacities and properties lead us to conclude that resilience concept, since it includes the opportunity for change and transformation after hazardous events, goes far beyond the vulnerability concept. Therefore, elements and systems may be vulnerable to a given event and, in the meanwhile, they can be resilient in that they can turn disasters into opportunities for future developments.

In detail – as it clearly arises from the work carried out – some of the capacities and properties which make a system resilient, namely the ones coming on stage in the first phases of the disaster cycle, partially overlap to some aspects of vulnerability. These capacities refer to the potential of a system to withstand the impact of a hazardous event, in terms of capacity both of preventing or mitigating damage (robustness) and of reducing losses through an effective management of the emergency phase (coping capacity which is part of the wider concept of adaptation). Hence, capacities and properties enabling a system to resist change can be investigated in terms of vulnerability or, at the opposite, in terms of robustness.

Other capacities and properties, specifically related to the potential of a system to innovate itself after a disaster and to learn from experience in order to be prepared in face of change, can be better investigated in terms of resilience, since they are specifically related to the capacities or properties of systems allowing them, even though hit and damaged by a hazardous event, to adapt or change according to new conditions, modifying and sometimes improving their previous state. These capacities and properties are not directly

related to the vulnerability of the system itself but to general features of systems – such as the available territorial and social capital or the reliability of institutions, or the trust of communities in the institution themselves – which make them more or less capable to rebuild themselves after a calamitous event and to improve their capacity to withstand or cope with future events (Vale and Campanella, 2005). As stressed by Lynch (1990), “a city is hard to kill, in part because of its strategic location and its persisting stock of physical capital, and even more because of memories, motives and skills of its inhabitants”.

Transformability and the related capacities and properties come on stage, as mentioned above, in the recovery phase. Nevertheless, according to the features of the disaster cycle, they can influence vulnerability of a community to future hazardous events, in that reconstruction processes may facilitate the arising of new vulnerabilities or also the transfer of vulnerability from one area to another or from one group to another (Sapountzaki, 2007). Moreover, learning capacity – which represents a key feature of a resilient system, mainly in respect to the pre-event phase (preparedness) – may influence both robustness and adaptability and, consequently, all the aspects of vulnerability (from physical, to social and systemic ones).

Thus, resilience and vulnerability should be separately investigated over the different phases of the disaster cycle, even though – due to the fact that vulnerability can be largely influenced by some aspects of resilience – the influences that some capacities or properties of a resilient system might have on vulnerability facets (physical, economic, institutional, etc.) should be taken into account.

The choice to analyze the overlapping aspects of resilience and vulnerability under the lens of vulnerability is mainly due to the fact that relevant progress toward an effective assessment of the different facets of vulnerability has been done - even though an integrated assessment of vulnerabilities is still matter of ongoing researches (e.g. Ensure Project) - whereas methods and tools for an effective resilience assessment are still at an early stage. Nevertheless, the choice to widen the focus from vulnerabilities to resilience is in line with the choice to shift policies “from an attempt to control change and create stability to managing the capacity of a system to cope with, adapt to, shape change” (Bahadur et al. 2010).

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References

- Adger, W. N. (2006), *Vulnerability*, Global Environmental Change, 16: 268-281.
- Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., Rockstrom, J. (2005), *Social-Ecological Resilience to Coastal Disasters*, Science, 309, 1036.
- AA. VV. (1979), *Natural Disasters and Vulnerability Analysis*, Report of Expert Group Meeting, Office of the United Nations Relief Coordinator.
- Bahadur V. A. Ibrahim M., Tanner T. (2010), *The resilience renaissance? Unpacking of resilience for tackling climate change and disasters*; Strengthening Climate Resilience Discussion Paper 1, available at <http://www.crid.or.cr/digitalizacion/pdf/eng/doc18119/doc18119-contenido.pdf>
- Berkes, F., Folke, C. (1998), *Linking social and ecological systems: management practices and social mechanisms for building resilience*. Cambridge University Press, Cambridge, UK.
- Birkmann, J., ed. (2006), *Measuring vulnerability to natural hazards. Towards resilient societies*, UNU-EHS.
- Briguglio, L., Cordina, G., Farrugia, N., Vella, S. (2008), *Economic vulnerability and resilience. Concept and measurements*, research paper No. 2008/55. United Nations University.
- Bruneau, M., Chang, S.E., Eguchi, R.T., Lee, G.C., O'Rourke, T.D., Reinhorn, A.M., Shinozuka, M., Tierney, K.T., Wallace, W.A., von Winterfeldt, D. (2003), *A framework to quantitatively assess and enhance the seismic resilience of communities*, Earthquake Spectra, 19 (4): 733-52.
- Cannon, T. (2008), *Reducing People's Vulnerability to Natural Hazards Communities and Resilience*, Research Paper No. 2008/34, UNU-WIDER.
- Chang, S.E., Shinozuka, M. (2004), *Measuring improvements in the disaster resilience of communities*, Earthquake Spectra, Volume 20, No. 3: 739-755.
- Chapin, T. (2009), *Concept and strategies to address sustainability in a changing world*; Presentation, available at www.alaska.edu/epscor/living-on-earth/Terry-Chapin.ppt
- Chuvarajan, A., Martel, I., Peterson, C. (2006), *A Strategic Approach for sustainability and resilience planning within municipalities*. Thesis submitted for completion of Master of Strategic Leadership towards Sustainability, Blekinge Institute of Technology, Karlskrona, Sweden.
- Christoplos, I. (2006), *The elusive 'window of opportunity' for risk reduction in post-disaster recovery*. ProVention Consortium Forum 2006 Strengthening global collaboration in disaster risk Reduction Bangkok, February 2-3.
- Cumming, G.S., Barnes, G., Perz, S., Schmink, M., Sieving, K.E., Southworth J., Binford, M., Holt, R.D., Stickler, C., Van Holt, T. (2005), *An exploratory framework for the empirical measurement of resilience*, Ecosystems, 8: 975-987.
- Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans E., Tate, E., Webb, J. (2008), *A place-based model for understanding community resilience to natural disasters*, Global Environmental Change, 18: 598-606.
- Davis, I. (2005), *Observations on Building and Maintaining Resilient Buildings and Human Settlements to withstand Disaster Impact*, Proceedings International Conference, "Built Environment issues in small island states and territories", August 3-5, Faculty of the Built Environment, University of Technology, Jamaica.
- Ensure Project, 7th Framework Programme, presentation available at <http://www.ensureproject.eu/>
- EVI Project, "What is vulnerability?/What is Resilience?", available at http://www.sidsnet.org/docshare/other/20030910171306_Vulnerability_for_dummies.pdf
- Fiksel, J. (2003), *Designing resilient, sustainable systems*, Environmental Science and technology 37 (23).
-

- Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., Walker, B., et al. (2002), *Resilience and sustainable development: building adaptive capacity in a world of transformations*, Scientific Background Paper on Resilience for the process of The World Summit on Sustainable Development on behalf of The Environmental Advisory Council to the Swedish Government.
- Folke, C. (2006), *Resilience: The emergence of a perspective for social–ecological systems analyses*, *Global Environmental Change*, 16: 253-267.
- Fortune, J., Peters, G. (1995), *Learning from Failure. The System Approach*, John Wiley & Sons Ltd, England.
- Gallopín, G.C. (2006), *Linkages between vulnerability, resilience, and adaptive capacity*, *Global Environmental Change*, 16: 293-303.
- Gibson, A.C., Tarrant, M. (2010), *A ‘conceptual models’ approach to organizational resilience*, *The Australian Journal of Emergency Management*, vol. 25, N°02, April.
- Godschalk, D. R. (2003), *Urban Hazard Mitigation: Creating Resilient Cities*, *Natural Hazards Review*, ASCE, August.
- Holling, C.S., (1973), *Resilience and stability of ecological systems*, *Annu. Rev. Ecol. Syst.* 4:1-23.
- Holling, C.S. (1996) *Engineering resilience versus Ecological resilience*, in P. Schulze, ed., “Engineering with ecological constraints”. National Academy, Washington, D.C., USA.
- Klein, R.J.T., Nicholls, R.J., Thomalla, F. (2003), *Resilience to Natural Hazards: How Useful is this Concept?*, *Environmental Hazards*, 5:35-45.
- ISDR (2004), *Living with risk. A global review of disaster reduction initiatives*, United Nations Publications
- ISDR (2009), *UNISDR Terminology on Disaster Risk Reduction*, <http://www.unisdr.org/eng/terminology/terminology-2009-eng.html>
- Lynch, K. (1990), *Wasting Away*, Sierra Club Books, San Francisco, CA.
- Ludwig D., Walker B., Holling C.S. (1996), *Sustainability, stability and resilience*, *Conserv. Ecol.* 1:1–27
- Maguire, B., Hagan, P. (2007) *Disasters and communities: Understanding social resilience*, *The Australian Journal of Emergency Management*, Vol. 22, No. 2.
- Manyena, S.B. (2006), *The concept of resilience revisited*, *Disasters*, 30 (4): 433-450.
- McDaniels, T., Chang, S., Cole, D., Mikawoz, J., Longstaff, H. (2008), *Fostering resilience to extreme events within infrastructure systems: Characterizing decision contexts for mitigation and adaptation*, *Global Environmental Change* 18: 310-318.
- McEntire, D.A. (2001) *Triggering Agents, Vulnerabilities and Disaster Reduction: Towards a Holistic Paradigm*, *Disaster Prevention and Management*, 10 (3): 189-196.
- Menoni, S. (2001), *Chains of Damages and Failures in a Metropolitan Environment: Some Observations on the Kobe Earthquake in 1995*, *Journal of Hazardous Materials*, 86: 101-119.
- Norris F., Stevens S., Pfefferbaum B., Wyche K., Pfefferbaum R. (2008) , *Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness*, in “*American Journal of Community Psychology*”, vol. 41.
- Paton, D. (2008) *Community Resilience: Integrating Individual, Community and Societal Perspective*, in Gow, K., Paton, D., eds., “*The Phoenix of Natural Disasters: Community Resilience*”, Nova Science Publishers Inc.
- Pelling, M. (2003), *The vulnerability of cities: natural disasters and social resilience*, Earthscan, London, UK.

- Pimm, S.L. (1991), *The Balance of Nature? Ecological Issues in the Conservation of Species and Communities*, University of Chicago Press, Chicago.
- Rose, A. (2007) *Economic resilience to natural and man-made disasters: Multidisciplinary origins and contextual dimensions*, *Environmental Hazards* 7: 383-398.
- Schoon, M. (2005), *A Short Historical Overview of the Concepts of Resilience, Vulnerability, and Adaptation*, Workshop in Political Theory and Policy Analysis, Indiana University, Bloomington, IN, 29 January, Working Paper W05-4.
- Tierney, K., Bruneau, M. (2007), *Conceptualizing and measuring resilience. A key to disaster loss reduction*, TR news 250, May- June.
- Timmerman, P. (1981), *Vulnerability, Resilience, and the Collapse of Society*, Institute of Environmental Studies Research Paper, Toronto.
- Turner, B.L., Kasperson, R. E., Matson, P. A., McCarthy, J. J., et al. (2003), *A Framework for Vulnerability Analysis in Sustainability Science*, *Proceedings from the National Academy of Science*, 100 (14):8074-8079.
- UNESCAP (2008), *Sustainability, resilience and resource efficiency: Consideration for developing an analytical framework and questions for further development*, paper prepared by the Environment and Development Division, UNESCAP, to stimulate discussion at the UNESCAP Expert Group Meeting: Sustainability of economic growth, resource efficiency and resilience, UN Conference Centre, Bangkok, 22-24 October.
- UN/ISDR (2005), *Hyogo framework for action 2005-2015. Building the resilience of nations and communities to disasters*, World Conference on Disaster reduction, Kobe, Japan, 18-22 Jan.
- Vale, L.J., Campanella T.J. (2005), *The resilient city. How modern cities recover from disaster*, New York, Oxford University Press.
- Van der Veen, A., Logtmeijer, C. (2005), *Economic Hotspots: Visualizing Vulnerability to Flooding*, *Natural Hazards* 36 (1): 65-80.
- Villagràn de Leòn, J.C. (2006), “Vulnerability. A methodological and conceptual review”, in *SOURCE* n° 4, UNU-EHS.
- Walker, B., Holling, C. S., Carpenter, S. R., Kinzig, A. (2004), *Resilience, adaptability and transformability in social–ecological systems*, *Ecology and Society* 9(2): 5.
- Sapountzaki, K., (2007), *Social resilience to environmental risks: A mechanism of vulnerability transfer?* *Management of Environmental Quality: An International Journal*, Vol. 18, No. 3: 274-297.