Building resilience in times of new global challenges: a focus on six main attributes

Maurizio Indirli[a*], Ruben Paul Borg[b], Antonio Formisano[c], Lucia Martinelli[d], Anna Marzo[e], Francesco Romagnoli[f], Fabio Romanelli[g]

[a]*ENEA-SSPT-MET-DISPREV, Research Centre of Bologna, Bologna, Italy, maurizio.indirli@enea.it*
[b]*University of Malta, Msida, Malta, ruben.p.borg@gmail.com*
[c]*University of Naples Federico II, Naples, Italy, antoform@unina.it*
[d]*MUSE-Science Museum, Trento, Italy, lucia.martinelli@muse.it*
[e]*ENEA-SSPT-MET-DISPREV, Research Centre of Bologna, Bologna, Italy, anna.marzo@enea.it*
[f]*Riga Technical University, Riga, Latvia, Francesco.Romagnoli@rtu.lv*
[g]*University of Trieste, Trieste, Italy, romanel@units.it*

[*] corresponding author, *maurizio.indirli@enea.it*

Abstract

This work discusses the crucial concept of resilience in six specific paragraphs, starting from the grid of the main attributes (namely *safety*, *robustness*, *adaptive capacity*, *sustainability*, *governance*, and *anamnesis*) proposed by Indirli (2019). This study found that two views were particularly challenging, however conflicting: the *homeostatic* approach ('engineering resilience', e.g. oscillations around an initial steady state), or the *autopoietic* approach ('ecological resilience', e.g. irreversible shifts towards a new situation).
In fact, a reliable resilience's assessment is fundamental when geohazards affect the environment, urban habitat, building construction, lifelines, and heritage. The reason of this study is also due to the increasing ambiguity whereby the term is frequently used in multidisciplinary fields, as engineering, social-economical/social-ecological systems, disaster/risk assessment in case of catastrophic scenarios.
Therefore, considering the urgent need of analysis tools to prevent/properly govern future crises, the Authors intend to give a useful hint toward the adoption of resilient approaches. The original and captivating methodology developed here confirms and enhances the validity of the starting point cornerstones (modifying and fulfilling the initial definitions), in *primis* the relationship between the resilience's main concept and its attributes. Hence, the final goal is to provide an effective framework to study, without rigidity, complex questions in times of new global challenges, as the combination of natural and anthropogenic hazards, with particular reference to geohazards and global warming. Thus, successful actions focused on risk mitigation (with a tight link to communication, dissemination, and exploitation policies) can be implemented, aimed at enhancing consciousness about disasters, for a wide range of different organisations, from experts in risk management and preservation of environment/heritage to people and stakeholders concerned.
The investigation carried out here has been supported interlacing a theoretical discussion with the analysis of specific case studies (for example the behavior of buildings, infrastructure and heritage under earthquakes and volcanic eruptions). It is to be noted that this approach has been already adopted to evaluate the overall resilience of the Italian community during the first period of the COVID-19 pandemic. Such a tragic event has certainly been a very hard test, where resilience should be considered as a strategic indicator, proving that really short time to operate effective choices is available, being the humanity able or not to govern the next changes, hopefully towards enough resilient results.

Keywords:
Disaster Risk Reduction, geo-education, geohazards, resilience, risk prevention

1. Introduction

Nowadays resilience is a crucial word, widely adopted by scientists of several disciplines as well by exponents of public or private organizations. The term resilience originated from the Latin classic culture (rĕsīlīre: the act of rebounding, i.e. to rebound/recoil, from "re-" back + "salire" to jump, leap). Then, after passing almost forgotten through the Middle Ages, it was resumed in the modern times by intellectuals who were among the pioneers of the modern scientific method (as Francis Bacon), and, immediately later, by the positivist encyclopedists. Specifically, the term resilience is present in the English language since the 17th Century (Mcaslan, 2010; Indirli 2019), denoting a rebound or bouncing reaction. In the 20th century, its use spread out, starting from the Rankine's quantitative definition in engineering, until to other elaborations coming from psychology, anthropology, and ecology, the latter with the fundamental Holling's (1973) contribution. He proposed a key definition of resilience, referring to any biological systems as "*the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist*". By this definition, every biological system can be considered as an ideal example of resilient system. In the last decades, the concept expanded quickly into engineering, social-economical/social-ecological systems, disaster/risk assessment, sustainability, and adaptive capacity to cope catastrophic scenarios (Hassler et al., 2014; Mcaslan, 2010; Indirli 2019).

The common perspective was focused on identifying thresholds or limits to systematic changes and targets that a system encompasses if exposed to any external shocks (Donghyun and Seul-Ki, 2018). Based on this background, the concept of disaster resilience was proposed in the year 2009 according to the UN International Strategy for Disaster Reduction UNISDR (UNISDR, 2009; Rochas et al., 2014).

Bruneau et al. (2003) presented a conceptual framework to define seismic resilience of communities in addition to quantitative measures of resilience. The framework is based on complementary measures of resilience including the "*Reduced failure probabilities*", "*Reduced consequences from failures*", and "*Reduced time to recovery*". The framework also includes quantitative measures of the "*ends*" of robustness and rapidity, and the "*means*" of resourcefulness and redundancy, and integrates those measures into the four dimensions of community resilience (technical, organizational, social, and economic). These are useful in quantifying the resilience assessment for various types of physical and organizational systems.

Table 1: nuclei for a pluralistic but holistic view of resilience (definitions from Indirli, 2019).

attributes	description	target
safety	*Protection of life, heritage, and assets from natural/human-made disasters across climate/social changes.*	*multi-hazard combinations and maps*
robustness	*Adequacy of structural/infrastructural systems to withstand actions related to their function/exposure.*	*multilevel networks*
adaptive capacity	*Ability to respond successfully to new changes and recovery with acceptable consequences after catastrophic events.*	*social-ecological models*
sustainability	*Maintaining the natural/anthropogenic capital and fostering mature self-balanced environments.*	*sustainability models*
governance	*Consensual and shared management of conflicts towards a new equilibrium before/throughout/after traumas/disasters.*	*risk management*
anamnesis	*Safe-guarding and transmitting collective memory and cultural identity intact to posterity as a drop anchor for democracy.*	*preservation of tangible/intangible heritage*

Resilience can be summarized by three main definitions coming from different scientific fields: ecological, engineering and socio-ecological, sometimes also addressed as evolutionary resilience (Feofilovs et al., 2020). However, it is frequently used with increasing ambiguity about its properties and attributes. Indirli (2019) says about two views, particularly challenging but conflicting: the first, the 'engineering resilience', has been used to describe by quantitative means (i.e. with formulae) the behavior of structures and materials in engineering, for instance during a mechanical stress; later, the concept broadened to the measure of an infrastructure's seismic resilience under a hazardous event; oscillations around the initial steady state, and elasticity properties to 'bounce-back', are crucial features of this *homeostatic* approach. The second, the 'ecological resilience', has been used to describe the ability of natural systems to absorb changes, for instance the species persistence or probability of extinction; this approach (neither deterministic nor quantitative) points out the adaptive capability to challenge 'irreversible shifts' towards a new equilibrium, evolutionary and 'ductile' as *autopoietic*. Both these views are part of the ongoing debate; if embraced without rigidity, they are useful to study complex phenomena where the combination of natural and anthropogenic hazards is a crucial question, including global warming as well as epidemics/pandemics. The already cited starting point of Indirli (2019) considered indispensable a unifying framework regarding the resilience's assessment. Therefore, he proposed to investigate some "*nuclei for a pluralistic but holistic view of resilience*", which deconstruct the resilence concept into six main attributes, namely *safety*, *robustness*, *adaptive capacity*, *sustainability*, *governance*, and *anamnesis* (Table 1). The validity of the above said cornerstones, *in primis* the relationship between the resilience's main concept and its attributes, has been confirmed and enhanced here, modifying and fulfilling the relative initial definitions. Hence, this approach can be considered a valid tool to assess resilience. In this chapter, the authors discuss the suitability of adopting a step further analysis in six sections, where the resilience's cited attributes are analyzed and better defined. The investigation has been supported interlacing a theoretical discussion with the analysis of specific case studies (for example the behavior of buildings, infrastructure and heritage under earthquakes and volcanic eruptions). It is to be noted that this approach has been already adopted to evaluate the overall resilience of the Italian community during the first period of the COVID-19 pandemic (Indirli et al., 2021).

In times of new global challenges to face various catastrophic events, a reliable resilience's assessment is fundamental when geohazards (geomorphological, geological, or environmental processes potentially dangerous for human life, health, and property; see Bobrowsky, 2013) affect the environment, urban habitat, infrastructure, and heritage. In this case, it is very useful to develop and deploy the concept of multi-hazard (past/future) disaster scenarios (impact, occurrence, relationship, hierarchy and combination, from regional to local scales), considering their full range and avoiding omissions, finding common languages/tools to identify, profile, quantify hazards; this diagnosis should evaluate and combine all the different hazards, distinguishing short-term (earthquake, tsunami, landslide, volcanic eruption, flood, etc.) and long-term (maintenance, decay, tourism pressure, climate change effects, etc.) events. Therefore, both multi-hazard and resilience approaches can provide an effective and comprehensive description of the selected sites of interest, on the basis of an appropriate storage, classification, overlay and elaboration of the huge amount of information coming from multi-disciplinary investigations (Indirli, 2007).

Moreover, successful actions devoted to risk mitigation (with a tight interaction with communication, dissemination, exploitation activities) can be implemented, with the aim to increase consciousness about disasters striking prone areas, for a wide range of various organisations, from experts in risk management and preservation of environment/heritage to people and stakeholders concerned.

2. Analysis of resilience attributes

2.1 Safety

In general terms, given a system (intended as a set of complex interacting components in a dynamic equilibrium), its ability to prevent or adapt to perturbations in order to maintain its attributes reflects its resilience. In this section, the attribute we are concerned about is safety. To ensure safety, the system must avoid failures and losses, as well as responding appropriately after an (hazardous) event. Thus, the safety of a "resilient system" could be measured by a metric based on a Performance Based Design (PBD) approach. This approach is usually adopted in earthquake engineering for the design of structures, where a system has to meet specific performance levels according to different demand levels, and possess the following features (e.g. Bruneau et al. 2003): (a) reduced failure probabilities; (b) reduced consequences from failures, in terms of lives lost, damage, and negative economic and social consequences; (c) reduced time to recovery (restoration of a specific system or set of systems to their "normal" level of performance).

Following the "seismic" side, lessons learnt from the largest earthquakes worldwide occurred during the last decade (e.g. the 2011 Tōhoku earthquake, 11/03/2011, M>9) show that the performances of the standard probabilistic seismic hazard assessment (PSHA) are unsatisfactory, underestimating the magnitude of seismic events and their possible impacts. Therefore, the need for an appropriate hazard assessment is a pressing concern for seismologists, geologists, seismic engineers, etc.; it appears preferable to refer to a complementary scenario-based method based on a better integration of the available information (i.e. seismological, geological, geophysical, and geotechnical data) about the site of interest with updated physical modelling techniques. A possible operative solution in a resilient oriented framework has been suggested by Rugarli et al. (2019), who tackled and discussed the seismic hazard case in detail, and worldwide examples of its application can be found in the volume recently edited by Panza et al. (2021).

In addition, we wish to develop, for an area or for selected sites, the concept of multi-hazard scenarios, also in relationship with global warming (impact, occurrence, relationship, hierarchy, combination), by finding/utilizing common languages/tools. This evaluation should select and combine both short-term events (e.g. earthquakes, volcanic eruptions, floods, landslides, tsunamis, atmospheric pollution effects, war damage, anthropogenic accidents, mass events, acts of terrorism, etc.) and long-term events (e.g. extreme climate change effects, large-scale super eruptions and earthquakes, maintenance, decay, tourism pressure, etc.), which affect urban habitats, environment, and heritage. Therefore, it is necessary and urgent to move towards multi-hazard analyses, since single hazard assessment methods need to be critically studied and implemented.

A first overview on risk assessment procedures for natural hazards was developed in Indirli (2007), with a discussion about hazard identification and profile, inventory assets, estimate losses, and mitigation options. A comparison of damage assessment methodologies for different natural hazards can be found in Rossetto et al. (2010) and Vamvatsikos et al. (2010).

A vivid example of multi-hazard analyses was carried out in the framework of the COST Action C26 'Urban habitat constructions under catastrophic events' (COST Action C26, 2010a-b), where the peculiar risky situation of the Neapolitan volcanic complex Summa-Vesuvius was taken as a paradigmatic reference case, with the following main objectives: to define qualitatively and quantitatively the exceptional volcanic actions due to a strong eruption (earthquake, pyroclastic flow and surge, tephra, lava flow, bombs and missiles, lahar and mudslide, tsunami) producing a combination of accelerations, vertical loads, horizontal dynamic pressure, and impact on construction; to evaluate their effects on the urban environment (in the pilot area of Torre del Greco, Naples); to propose mitigation interventions (Mazzolani et al., 2009).

About multi-hazard scenarios, the research should provide modern and standardized procedures as an effective progress in the field. Unfortunately, the lack of a well-structured theoretical approach to the resilience assessment is undeniable, based on punctual quantitative data and widely accepted among the scientific community. Specifically, an emphasis should be put on safety measures also including the evaluation of the cultural/historical contest using various approaches (e.g. humanities/hard sciences, in situ/laboratory survey/testing etc.), towards the realization and employment of specific procedures.

Existing safeguard methodologies of heritage assets, exposed to multiple hazards, must be carefully investigated for developing cutting-edge integrated tools. Despite several years of research, current procedures/technologies still suffer from comprehensive validation and integration; this is the gap that a proper approach should aim to fill, focusing on preservation and safe fruition of a common good in the framework of resilient communities. A priority step towards safety is upgrading of local traditional consolidation/rehabilitation techniques with innovative/cost-effective materials/devices already available in various field of restoration (Best Available Technologies, BAT). Then, sustainable development should be indispensable for a wider application in any intervention (on systems/ utilities) of goods/services that are: safe, non-polluting, ecologically sustainable throughout their life cycle; conserving of energy/natural resources; conceived to be durable, repairable, readily recycled, compostable, easily biodegradable; economically efficient, using the lowest amount of material/energy; healthful for workers, communities, and consumers.

The implementation of safe management models/governance systems for cultural heritage should involve a wide amount of subjects (both public entities and private actors) and population in general, interfacing with local cultures and their sense of belonging/identity. A major challenge in post-catastrophe/post-crisis scenarios is the integration between what was there and is no longer there, what was there and is still there, identical or changed, and what is rebuilt to replace what is lost. Citizens and local stakeholders can make significant contributions to the setting up of a priority agenda. Therefore, the reconstruction process should include effective participatory mechanisms and multi-stakeholder governance structures. Moreover, because responses to disasters correlate to culture, culture must anticipate/prepare responses to catastrophes and raise awareness of local communities with regard to policies, plans, programmes and architectural interventions.

In conclusion, we can update the definition of *safety*, always as an autonomous attribute of resilience (see Table 1), with the following sentence: it is related to the *protection of life, heritage, and assets from natural/human-made disasters across climate/social changes in the framework of multi-hazard scenarios, reducing failure probabilities, consequences from failures, and time to recovery.*

2.2 Robustness

In the recent times, natural and human-made disasters often causes extensive casualties and socio-economic losses, in particular in the developed countries and built-up territory. Therefore, the attention of the scientific community on the concept of robustness significantly increased when a resilience analysis of the urban areas is tackled.

Robustness is a fundamental structural prerequisite to survive without failure over a time period (Beer and Liebscher, 2008). It can be defined as the insensitivity of a structure to undergo local failure independently from the causes and probabilities of initial local failures (EN 1991-1-7, 2006). In the past years, the structural robustness was assessed under either exceptional or normally random conditions. According to the first case, a construction can be considered as robust when either collapse is not sudden, or the resistance is not substantially lost, although the deformations exceed the serviceability level. Instead, in the second case, a robust system can withstand occasional or frequent changes of environmental conditions without noticeable effects on its serviceability limit state behavior (Formisano et al., 2009; Formisano, 2019).

The structural robustness is achieved when the response is commensurate to different types of applied actions, i.e. loads exceeding the design ones, accidental loads or damage to members. New and existing structures can be exposed during their lifetime to extreme actions, due to both anthropogenic and natural hazards, often unaccounted or underestimated in the design phase, like: earthquakes in non-seismic areas, large eruptions, unpredictable fires, great storms, weighty snow, explosions, terrorist attacks, vehicular collisions, accidental overload, aircraft impact, and design/construction mistakes (Formisano, 2019). Structural robustness can be achieved by: (a) either preventing the action or increasing the occurrence probability; (b) protecting the building; (c) reducing the sensitivity to disproportionate collapse (Blockey et al., 2002). This last case must be taken into account in the design process and designers must certify that the crisis of any structural building component does not produce a total collapse. Moreover, any resulting local damage must be confined within the floors above and below that interested by the component failure. More in detail, a robust structure can redistribute loads when a load-bearing member suffers a loss of strength or stiffness, but exhibiting a ductile, rather than brittle, failure mode. A robust structure is not over-designed, but it can withstand damage thanks to its global structural behavior and failure modes. In fact, the localized failure can be mitigated by the construction capability to redistribute the load elsewhere (Formisano, 2019).

Part 1-7 of Eurocode 1 (2006) defines robustness as "*the ability of a structure to withstand events like fire, explosions, impact or the consequences of human error without being damaged to an extent disproportionate to the original cause*".

This definition was later incorporated within other codes, such as the recent Italian technical standards (M. D., 2008; M. D., 2018), but lacking effective criteria either in measuring robustness or assessing whether the structure robustness level is acceptable or not. Therefore, robustness is a structural property which mitigate the susceptibility of structures towards progressive collapse, which is caused by the disproportion between the initial damage and the resulting huge breakdown of either the structure or its large parts (Formisano, 2019). When structural robustness is lacking, the final failure state, disproportionately greater than that originating the crisis, leads to the so-called progressive collapse; it can be defined as "*the spread of an initial local failure from element to element resulting, eventually, in the collapse of an entire structure or a disproportionately large part of it*" (ASCE, 2002). Therefore, the progressive collapse mechanism, originated by the propagation of local damages, interests either a large percentage or the entire construction, which is so that the structural system cannot withstand the main structural loads. It occurs when possible abnormal loads trigger a disastrous mechanism like that of a row of dominos.

A typical progressive collapse event was the failure of the Ronan Point apartment tower (year 1968); after this tragic circumstance, the UK Building Regulations introduced in 1970 the "Fifth Amendment", providing indications to avoid progressive collapse. Later on, the terrorist attack on the Murrah Federal Office Building (year 1995), together with the World Trade Centre collapse (year 2001), gave a new interest towards this subject. In general, there are three alternative approaches to disproportionate collapse resistant design: improved interconnection or continuity, notional element removal and key element design. Nowadays, a general standard code theory regarding the study of robustness and progressive (or disproportionate) collapse topics does not exist at all. About structural robustness, although qualitative study approaches are diffused, no general quantitative recommendations and criteria have been yet implemented to quantify structural assessment approaches under extreme or unforeseen events.

Thus, in structures susceptible to progressive collapse, small events can have catastrophic consequences. For such reasons, the degree of "progressivity" of a collapse can be defined as the collapsed volume (or area) over the same quantity directly destroyed by the event (Formisano et al., 2015).

More in detail, the term "progressive" refers to the type of the structural collapse behavior. It can be propagated horizontally, from a structural bay to the adjacent ones, or vertically, i.e. when the collapse of a column interests the upper floors, leading to the so-called "pancake" collapse. The observer judges a collapse disproportionate when it is incongruent with the initial damage cause. This is merely an evaluation based on observations of the damage consequences resulting from the originating events, but does not describe the characteristics of the structural behavior. For example, a collapse may be progressive, but not necessarily disproportionate, if it stops after an evolution through several structural bays. On the other hand, a collapse may be disproportionate, but not necessarily progressive if it is limited to a single structural bay. Starting from the above said statements, the research within this field should establish as a first step a reliable methodology for evaluating the performance of construction subjected to exceptional actions. In fact, the interest on the robustness assessment has been increasing a lot especially in the structural design field, firstly by solving an optimization problem. All variable parameters are commonly considered random quantities, used to evaluate the structural robustness in a probabilistic way. The optimization problem generally aims at achieving both an optimum mean and a minimum variance of the structural response with respect to input variations. Nevertheless, probabilistic approaches are often complicated to be used by designers. For this reason, a new procedure for robustness assessment has been conceived and applied to new structures in a semi-probabilistic manner, and then deterministically to evaluate the seismic resistance of existing gravity-load designed buildings (). Such a method, framed within a performance-based approach, allows for the achievement of direct and indirect damages of buildings starting from their capacity curves evaluated through the pushover analyses (Formisano et al., 2015 and 2019).

Finally, based on these analyses, appropriate robustness matrices of structural systems can be defined according to pre-determined performance targets.

Studies on structural robustness under a Vesuvius large eruption can be found in De Gregorio et al. (2010), Faggiano et al. (2010), Zuccaro, Cacace, and Nardone (2010), and other papers of the COST Action C26 (2010a-b).

In conclusion, we can update the definition of *robustness*, always as an autonomous attribute of resilience (see Table 1), with the following definition: it is related to the *adequacy of structural/infrastructural systems to withstand actions, under exceptional or normal conditions, related to their function/exposure, mitigating the susceptibility towards disproportionate or progressive collapse and surviving without failure over a time period.*

2.3 Adaptive capacity

The concept of adaptive capacity has been defined in different ways to cover many factors, referring to a wide amount of attributes and processes, without a general agreement among the researchers. Furthermore, there are contradictory definitions of vulnerability, exposure, sensitivity and adaptive capacity (Adger et al, 2004), which are frequently interdependent. Jakku and Lynam (2010; and references therein) illustrated several definitions of adaptive capacity in the literature (see Table 2). An updated ICCP's definition of adaptive capacity is the following: it represents "*the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences*" (IPCC, 2014).

Similar shocks can have different impacts in different environments. Therefore, adaptive capacity depends on several factors. Availability, access, and distribution (from national to local level) of resources (natural, economic, social and human capital) and technological options are fundamental to face hazardous situations and cope response strategies. Changes over time and across space, variations from country to country, from community to community, among social groups and individuals are evident.

The structure of institutions, effectiveness of decision criteria, and ability of decision makers to manage information are also critical. Adaptive capacity is dynamic and context specific. In addition, it is shaped by interdependent scales, occurring at various levels (geographic, ecological, social, political, and economic), because different places are exposed to different hazards and climate change impacts. Moreover, adaptive capacity is a latent potential, because it can be explicated into actual adaptation only after the push of hazards and impacts; even if it has been developed at a certain level, still uncertainties in the response can still be seen.

Table 2: different definitions of adaptive capacity (adapted from Jakku and Lynam, 2010).

approach	*definition*	*reference*
resilience framework	Adaptive capacity is "a component of resilience that reflects the learning aspect of system behavior in response to disturbance".	Carpenter et al. (2001)
	Adaptive capacity relates to a system's "ability to reorganize and renew itself in the face of change".	Fazey et al. (2007)
	Adaptive capacity is treated as synonymous to adaptability, which is defined as "the capacity of any human system from the individual to humankind to increase (or at least maintain) the quality of life of its individual members in a given environment or range of environments".	Gallopin (2006)
	Adaptive capacity is "the preconditions necessary to enable adaptation, including social and physical elements, and the ability to mobilize these elements. […]. "It is represented by the set of available resources and the ability of the system to respond to disturbances and includes the capacity to design and implement effective adaptation strategies to cope with current or future events".	Nelson et al. (2007)
	Adaptability is defined as "the capacity of actors in a system to influence resilience". The "collective capacity" of actors "determines whether they can successfully avoid crossing into an undesirable system regime, or succeed in crossing back into a desirable one".	Walker et al. (2004)
vulnerability assessment	Adaptive capacity is "the ability or capacity of a system to modify or change its characteristics or behavior so as to cope better with existing or anticipated external stresses".	Adger et al. (2004)
	"Adaptive capacity is a vector of resources and assets that represent the asset base from which adaptation actions and investments can be made".	Adger and Vincent (2005)
	The IPCC defines adaptive capacity as "the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences".	IPCC (2001), Section 2.3
	The IPCC also views adaptive capacity as "the potential, capability, or ability of a system to adapt to climate change stimuli, their effects or impacts".	IPCC 2001), Section 18.5.1
	Adaptive capacity is "the ability of a system to change in a way that makes it better equipped to manage its exposure and/or sensitivity to climatic influences".	Preston and Stafford-Smith (2009)
community-based approach	Adaptive capacity is "a critical aspect of resource management that reflects learning and an ability to experiment and foster innovative solutions in complex social and ecological circumstances".	Armitage (2005)
	Adaptive capacity is "a specific application of community capacity to achieve a certain outcome". In the context of climate change, adaptive capacity is "the collective ability of a group to adapt to and cope with climate change over time in a way that maximizes well-being".	Mendis et al.(2003)
	Adaptive capacity is "a set of characteristics that allows a given system to perceive change or threatening circumstances, evaluate them, decide on a solution path and both develop and adopt processes and tools to manage the risk, thereby maintaining itself throughout".	Wall and Marzall (2006)

Adaptive capacity goes beyond the concept of coping ability. The latter is referred mainly to short-term adjustments (recovery measures), while the first is related to long-term effects (structural changes), differentiating recovery from mitigation (Jakku and Lynam, 2010; Lorenz and Dittmer, 2016; Yohe and Tol, 2006; and references therein).

A key category about adaptive capacity is the participation at local, regional, and global processes; the lower it is, the lower prevention activities and adaptation developments to disasters are evident (Lorenz and Dittmer, 2016; and references therein).

Finally, in the way of Carpenter (2001) and others, we prefer to define *adaptive capacity* as an autonomous attribute of resilience (see Table 1), with the following definition: it is *the ability of systems, institutions, humans and other organisms to modify themselves in order to recovery (short term) with acceptable consequences after catastrophic events and respond successfully to new global changes (long term).*

2.4 Sustainability

Sustainability and resilience represent complex concepts with different definitions depending on the areas of applicability. Their interrelationship is still widely discussed and the hierarchy among them not very well investigated (Indirli, 2019). Dealing with disaster risk management, several points of convergence and divergence are evident, sometimes creating uncertainties towards the decision-making process (Lizarralde et al., 2015) within urban planning and infrastructural design (Roostaie et al., 2019). This aspect is critical for urban scale policy makers to implement sustainable development pathways, facing the increase of severity of natural hazards events driven by climate change and world population growth (Feofilovs et al., 2020). This is the underlined reason why methodological approaches and strategic tools for sustainability and resilience assessment rose during the last decades (Roostaie et al., 2019), with a particular focus on urban policy planning, which is certainly a critical issue. Therefore, reasoning about an inclusive "Smart cities" approach is nowadays essential. It is in line with the UN's Sustainable Development Goals-*SDGs* (Visvizi et al. 2021), with the aim to enhance sustainable and resilient strategies against climate changes within the urban context. We might describe this approach as a combination of "*networks of physical systems and human communities, capable of managing extreme events and able to survive and function under extreme stress*" (Rus et al., 2018).

The concept of sustainable development and sustainability relies on The Brundtland report discussed by the Prime Minister of Norway in 1987 at the United Nations' Commission for Environment and Development. It is defined as the *"… development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (United Nations, 1987). Such definition drafted the roadmap towards the 17 *SDGs* that the UN General Assembly agreed on in September 2015 (United Nations, 2015). In addition, redefinitions of sustainable development concepts and sustainability were proposed depending on the type of emphasized research subject, e.g. human well-being, preservation and maintaining of natural and cultural resources, mitigating changes in biodiversity, heritage artifacts, and intangible cultural traditions (Leach et al., 2010; Lew et al., 2016).

By definition, we might say that the central idea of sustainability aims to reduce negative environmental impacts to avoid changes, while resilience is more connected to adaptation to change and thus including adaptive capacity. In this light, such concepts are also embedded within the Panarchy approach, which considers a series of interconnected (and thus complex) adaptation cycles at different scales (Garmestani et al., 2009). The Panarchy concept often relies to disasters science. Based on this approach, it is interesting the vision proposed by Colocci (2020). He describes sustainability as *"… the overall endeavour of human communities to promote a sound coexistence with the bio-physical systems, where flux of resources and information is bi-directional, addressing human needs while never exceeding natural capacities*"; on the other hand, the same author defines resilience as a concept from which "*… social-ecological systems should learn from the processes of the natural dynamics as well as they should prepare in advance in case of severe hazards*".

It may be agreed that increasing the resilience of communities against disasters became paramount for sustainable development goals. In this way, resilience and sustainability ca be considered complementary properties necessary to jointly enhance urban development (Feofilovs et al., 2020).

Sustainability and resilience deal with a multidimensional/multifunctional evaluation depending on the defined objectives of specific disciplines. According to Roostaie et al. (2019), the tricky relationship between sustainability and resilience might be defined by four different relationships (Figure 1). They can be considered as: synonyms; a component embedding the other; separate and/or complementary conceptual objectives.

Towards the implementation of risk reduction strategies coping climate change and the increase of the magnitude and frequency of natural disasters, it is essential to promote a consistent yet integrated approach in order to: (1) conserve future resources; (2) protect investment in sustainable structures and infrastructure; (3) ensure that sustainable developments continue to function for their design life and continue to reap the benefits of sustainable design, and (4) preserve the stability of social and economic networks within communities (Matthews et al., 2014; Roostaie et al., 2019).

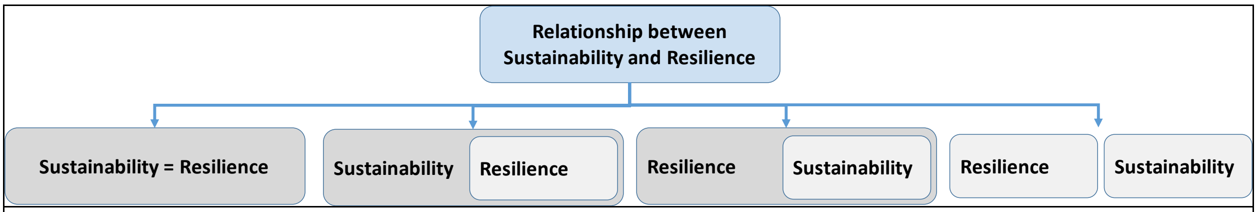

Figure 1. Different relationships between sustainability and resilience (reedited from Roostaie et al., 2019).

This background becomes essential to consistently integrate resilience assessment methods into building sustainability assessment frameworks to support strategic thinking and planning within the built environment. This way can be made by providing policy - or decision makers - qualitative, semi-quantitative, and quantitative tools capable of describing and optimizing the interrelationship between sustainability and resilience.

Many research attempts started to face a comprehensive sustainability and resilience assessment (Jabareen, 2013; Zanotti et al., 2020; Keith et al., 2020). Several researchers defined the link between sustainability and urban resilience by Environmental Adaptation (Zanotti et al., 2020). Specifically, the UK government merged the sustainability concept within urban resilience and adaptability strategic planning (Thompson and Beck, 2014). The assessment method proposed by Roostaie and Nawari (2021) aims to incorporate each concept's most common principles to more effectively coping against natural hazards and climate change effects. This method defines design indicators and sustainable design principles to explore and identify the interdependence of sustainable and resilient design factors. The study of Mallick et al. (2021) integrates the Prediction-Adaptation-Resilience (PAR) approach with SDGs for better urban resilience and sustainable urban management using an indicator-based conceptual framework. The conceptual approach proposed by Feofilovs and Romagnoli (2021) is based on complex system theory (i.e. System Dynamics). Such approach provides a dynamic assessment of urban resilience to natural hazards by defining an urban resilience index embedding the sustainability aspect more in improving environmental performances within the urban system.

There are several ongoing discussions on how to consider the concept of sustainability, embedded within a larger resilience definition. Sustainability is usually defined through tree main pillars: environmental, social and economic considerations. On the other hand, resilience is generally described as the ability of a system to absorb impacts, recover and adapt following persistent stress or a disruptive event. Based on the latest conceptualization, resilience can be considered as a property of a complex system and indeed may be counter to sustainability goals (Borg, 2019); for instance, efficiency reduces diversity and redundancy; therefore, both of these are key features of resilience. High-density urban areas are suitable to promote more efficient energy distribution, waste management, and communications, but are more vulnerable to extreme actions, such as flooding, because they are less diverse and have less redundancies (Elmqvist, 2017). The differences and synergies between sustainability and resilience need to be explored first to be further applied in resilient policy and practice.

In conclusion, given the complexity of the different definitions of sustainability and resilience, their assessment methodologies, and potential applicability, it is challenging to define a one-size-fits-all framework that can fully integrate the two concepts. When incorporating resilience standards into the sustainability agenda, there is a need to tailor and customize the potentially applicable strategies based on the nature of development scenarios, location, climate, and natural hazards to which the area is prone.

It is of utmost importance to actively integrate and engage different stakeholders to create a consistent roadmap towards sustainable and resilient urban planning and development in light of the 2030 Agenda for SDGs. In this way, the synergetic cooperation among urban planners, policy makers, urban researchers and local administrators could be enhanced for better urban resilience and sustainable development. This process is essential to provide local administrators and policy makers the key for sustainable and affordable smart city development (Mallick et al., 2021).

Finally, we prefer a certain dependence of the first (sustainability) on the second (resilience), as an attribute. In conclusion, *sustainability regards the preservation of the natural/anthropogenic capital, mitigating changes in biodiversity, heritage artifacts, and intangible cultural traditions and fostering mature self-balanced environments.*

2.5 Governance

The term *governance* is used in political science to describe the multitude of actors and processes that lead to collective binding decisions (Van Asselt and Renn, 2010). It should be considered a multi-level activity done internationally transcending national frontiers. It represents the decision-making among all the actors involved in a collective problem that leads to creating, reinforcing, or reproducing social norms, laws policies, and institutions. In this framework, the state is not the only, single most important actor, but the decisions are implemented in complex networks and processes. In a normative use, the notion of governance refers to a model or framework for organizing and managing society. Therefore, governance has become in the last decades a wider concept, in order to respond to new challenges such as worldwide threats, increased globalization, urgency of stronger international cooperation, quick societal changes, including the increased citizen's engagement, rise of nongovernmental organizations (NGOs), and changing role of the private sector. The culmination of all these factors led to the need for a new legitimate form of governance, taking into account the augmented complexity of policy issues (Finkelstein, 1995; Hermans et al., 2012; Hufty, 2011).

Governance is the umbrella under which Disaster Risk Reduction (DRR) takes place (DRR terminology in UNISDR, 2009). The United Nations Development Programme (UNDP) definition states that "*governance is the exercise of political, economic and administrative authority in the management of a country's affairs at all levels. It comprises mechanisms, processes and institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences. Governance encompasses, but also transcends, government. It encompasses all relevant groups, including the private sector and civil society organizations*" (UNDP, 2010). Principles of reliable ("good") governance, fundamental for an effective DRR, include accountability, efficiency, responsiveness, and broad-participation. Moreover, communication, openness and transparency are central to the governance process and key at all stages.

The catastrophic impact of disasters is not due only to natural causes. Human acts and decisions also trigger disasters. Therefore, Disaster Risk Governance (DRG) refers to the way in which the public authorities, civil servants, media, private sector, and civil society coordinate at national, regional, and community levels to manage and reduce disaster and climate related risks (UNDP, 2013).

The notion of risk governance has been coined only recently. It is an emerging concept that aims to provide an approach for how to deal responsibly with public risks, involving the translation of the substance and core principles of governance to the context of risk-related decision-making. In fact, risk governance pertains to the various ways in which several actors, individuals, and public/private institutions deal with risks surrounded by uncertainty, complexity, and ambiguity. Risk governance comprises and extends the three conventionally identified elements of risk analysis: risk assessment, risk management, and risk communication. It should be taken into account the complex web of actors, rules, conventions, processes, and mechanisms concerning how risk information is collected, analyzed, and communicated, together with the way to make decision by the management, considering the interests and perspectives of various actors and stakeholders (Hermans, Fox and Van Asselt, 2012; IRGC, 2005; Van Asselt and Renn, 2010).

The crucial role of risk governance is also focused on the Hyogo Framework for Action 2005-2015 (UN-ISDR, 2005). In Europe, the White Paper (CEC, 2009) set clear regional policy guidance on reducing climate-related risks as a central issue. The Council of Europe also encouraged the indispensable interaction between decision makers and scientists to enhance Climate Change Adaptation (CCA) and DRR. Such need should be reflected on a consistent identification of the risks and DRR, an analysis of the governance structure, and recommendations for the enhancement of good practices in regional and international organizations (ISDR/Eur-opa/Council of Europe, 2011). However, the European Commission employed risk governance, risk identification, assessment, management, and communication still in a traditional manner rather than as an alternative paradigm. The positivistic and quantitative risk paradigm (Knight, 1921) has been and still is the dominant way of conceptualizing, assessing, and managing risks; it lies on the statement that it is possible to recognize with precision risk from uncertainty, where the first is measurable by using the formula *risk = chance x effect*, while uncertainty is immeasurable and not calculable. Knight's concept of risk focuses on the probability of events and the magnitude of specific consequences. Following this classical risk approach, two phases are distinguished and ideally institutionally separated: risk assessment (identification and evaluation of risk), and risk management (taking measures to control risks deemed unacceptable). Anyway, risk governance involves the recognition that uncertainty and risk cannot be easily distinguished, as assumed in the positivistic risk paradigm. In some cases (for example: car accidents), when risks are simple (i.e. calculable and relatively easy to manage), existing risk assessment tools and risk management approaches suffice. On the contrary, in many other contexts risks cannot be classified as simple. They are not confined to national borders or a single sector, and do not fit the linear, mono-causal model of risk. Such risks are complex (multi-causal) and surrounded by uncertainty and/or ambiguity. Due to complexity, it is impossible to achieve complete deterministic knowledge of cause-effect relationships (Hermans, Fox and Van Asselt, 2012).

For several years, a serious attention missed about risk governance's meaning and use. This situation changed after the foundation of the International Risk Governance Council (IRGC) in 2003, a private, independent, not-for-profit organism. The IRGC Risk Governance Framework describes the fundamental principles and concepts for managing risks marked by complexity, uncertainty, and ambiguity (IRGC, 2018).

The idea of risk governance can be explained with a set of principles: (a) communication and inclusion; (b) integration; (c) reflection.

In times of new global challenges, proper communication is crucial to make citizens groups more resilient. Risk communication, in fact, is not just a matter of simple real-time exchange of information, advice and opinions between experts or officials and people who face a threat (hazard). Rather, it is a complex relation between those who know (experts), those in charge (authorities), and those affected. Here, trust plays a crucial role. Citizens' trust toward the preparedness of institutions to manage crisis (being these natural disasters, health emergencies or terrorism) is the most important variables in effective communication management (Longstaff P. H., Yang S-U. 2008). Particularly challenging is the communication management of hazards which present more "non-technical" (ethical, moral, economic) rather than "technical" issues (Sandman 1989). Paradigmatic are the cases of technology transfer when new products of innovations enter in the citizens' everyday lives, such as, for instance, the locations of incinerators which has led to the NIMBY movements (Hermansson, 2007), the oppositions to the releases in the environment/on the market of genetically modified products (Martinelli et al., 2013) and the nowadays hesitancy/opposition to the vaccination to prevent the SARS-CoV-2 spread (Dror et al., 2020).

Risk communication has been initially (and still is) intended in terms of "deficit models", i.e. the assumption that educating (or providing notions) and persuading the public, often considered incapable of understanding and interpreting science, could result in citizens' trust (Simis et al., 2016). Such approach, however, has been questioned by empirical research because there are often various, conflicting risk perspectives to be questioned, about whose knowledge and information should be shared, including all various actors in the decision-making process, increasing the level of trust (Svalastog et al., 2014). Inclusion means that different stakeholders should play a key role in pre-assessing the risk, with the right to participate in the evaluation of the risks affecting themselves. Inclusion does not necessarily lead to more widely accepted decisions or reduce the societal conflict. Indeed, participation procedures themselves sometimes become a crucial source of conflict, which should be accepted and addressed. Integration refers to the need to collect and synthesize all relevant knowledge and experience from various disciplines and various sources, especially when complex, and/or ambiguous risks are concerned. Multidimensional risk(s)-benefit(s) evaluations are required with a holistic approach, avoiding a counterproductive separation between risk assessment and risk management. Reflection means that a critical outlook should be always maintained among actors and institutions involved; risk governance cannot be considered a simple routine activity among technocratic entities, differing from the traditional, positivistic approach due to the difficult issues of uncertainty, complexity, and ambiguity (Hermans, Fox and Van Asselt, 2012).

In conclusion, *governance pertains to a shared risks assessment and management among all the actors involved, taking into account factors as uncertainty, complexity, and ambiguity, towards a new equilibrium before/throughout/after traumas/disasters.*

2.6 Anamnesis

In disaster risk, local authorities address mitigation and prevention, in increasing preparedness of the community. Knowledge and memory of past events are key in preparing efficient prevention strategies and strengthening the community's resilience.

Cultural memory studies arose at the beginning of the twentieth century, with the Maurice Halbwachs' works on *mémoire collective* (Halbwachs, 1950; Marcel and Mucchielli, 2010). The complex issue of cultural memory is remarkably interdisciplinary. It is argued that remembering disasters may help building risk awareness and therefore avoiding new disasters or, at least, anticipating and mitigating risks. Le Blanc (2012) affirms that this disaster memory can be territorialized through physical material traces of catastrophes, including urban ruins and memorials, intended to reach a large audience. However, the process of giving materiality to memory and more generally recalling disasters, is very complex, subtle, and political; whereas the conventional risk management practices led to debatable choices in terms of disaster memory, the resilience approach might consist in a renewed method, more appropriate to the complexity and the subtlety of collective memory (Halbwachs, 1950).

Figure 2a. The Chiesa Madre of Santa Margherita Belice, completely destroyed by the 1968 Belice earthquake, now hosts the Earthquake Memory Museum (Museo della Memoria, 2021).

Figure 2b. The restored ruins of the Madonna delle Grazie Church (plant: left; portal, right), completely destroyed by the 1976 Friuli earthquake (Cragnolini, 2012).

Le Blanc (2012) discusses how the paradigm of disaster resilience can reorient urban planning policies with the aim to mitigate various types of risks, thanks to a mindful action on heritage and conservation practices. Resilience is defined as the "*capacity of a social system to proactively adapt to and recover from disturbances that are perceived within the system* *to fall outside the range of normal and expected disturbances*" (Comfort et al., 2010). Resilience relies strongly on the perception of risk (Slovic et al., 1985) and the memory of catastrophes. Halbwachs (1950) argues that states, regions, and municipalities have been giving territorial materiality to collective memory for centuries. This tendency considerably increased in the second half of the 20th century (Choay, 1992; Jeudy, 2001), in particular with regards to the memory of disasters: as when important traces of catastrophes, such as urban ruins, have been preserved; as these were expected to maintain some awareness and therefore foster urban resilience. *Berlin's Gedächtniskirche* is considered as an example of this approach (Robin, 2001). Le Blanc (2010) refers to preserved urban ruins as efficient tools of territorial resilience, with these massive monuments resulting effective discontinuity marks in an urban landscape, generating powerful emotions. Cases in point are the preserved ruins of two churches: the previous *Chiesa Madre*, now *Earthquake Memory Museum*, at Santa Margherita Belice, Sicily, (Italy), destroyed by the 1968 seismic event (Figure 2a); *Madonna delle Grazie* (Figure 2b), intended to maintain the memory of the 1976 earthquake in Gemona, Friuli (Italy).

Yet, Le Blanc argues that, in spite of preserved traces of catastrophes and various warnings and heritage policies, there are numerous examples of risk mismanagement and urban tragedies (Le Blanc, 2012).

When resilience is exploited as a guiding concept, the results of these failed risk mitigation policies and irrelevant disaster memory processes might change. Resilience effectively deals with the complexity of temporal and spatial scales, and with partly emotional and qualitative processes. This approach fits the issues of urban memory management (Le Blanc, 2012). Resilience might help emphasize the complexity and the subtlety of remembrance messages, leading to alternative methodologies better adapted to the diversity of risks, places and actors. However, beside an assigned territorial materiality, memory is often symbolically and politically framed and interpreted. Vale and Campanella (2005) outlines this political aspect of remembrance and resilience; Le Blanc (2012) considers that resilience and the territorialization of memory are not ideologically neutral, but urban risk mitigation may be; he notes that memory (being materialized or immaterial, territorial or oral, creating multiple and complex links between people and their territory) might be the best way to overcome the disaster and re-establish the complexity of place. A real resilience is achieved when the complexity of urban space (a dynamic way to live together, the actual sharing of the city's material and immaterial assets) is recovered.

Disaster management authorities and city managers need to adopt renovation and reconstruction policies that improve local resilience through the revival of collective memories. Aslani and Hosseini (2019) presented a new method to evaluate the impacts of identity and collective memory (CM) on social resilience, applying this approach to Bam (Iran), in the aftermath of the 2003 earthquake; during the reconstruction, the authors argue that little was done to preserve both the identity and CM; they relied on grounded theory to assess the social resilience, referring to key concepts and core categories on a local level. They concluded that identity and CMs diminished gradually, as the intangible needs of local residents were neglected during the Bam reconstruction (Aslani and Hosseini; 2019).

Through history, Constantinople maintained greater diversity of insurance strategies than many other historical and contemporary urban centers, due to its heavy investment in military infrastructure and systems for supplying, storing, and producing food and water (Barthel et al., 2011). Citizens could receive seaborne goods from major granaries and at least four harbors. When trade networks broke down during sieges of the city, citizens relied on food cultivation within the defensive walls and fishing in the Golden Horn. Cycles of sieges, every fifty years on average, generated a diversity of social-ecological memories. This allowed knowledge, experience, and practice of how to manage a local ecosystem, to be stored and transmitted in a community. Therefore, such memories persisted in multiple groups of society. This aspect was considered in part as a response to the collapse of long-distance, seaborne grain transport from Egypt and food production; transports were decentralized into smaller subsistence communities, selling surplus to the markets, with Constantinople becoming more self-reliant on regional ecosystems. (Barthel et al., 2011).

Borg et al. (2016) review the effects of the 1908 Messina earthquake on the local community and the Maltese experience of this seismic event, relying on the communication published in Malta immediately after the catastrophe. The authors analyze the experience based on first-hand sufficiently detailed accounts of the disaster. The reports influenced the community's CM, providing information on the building deficiencies and damage, limitations of communication infrastructure during that period, limits to timely emergency response to support the population and emergency action at the beginning of the 20th century.

Lamond et al. (2014) discuss the complexity of recurring changes in the natural environment and their impact on the dynamic urban built environment setting, in specific the primary physical impact by means of water ingress to normally dry areas or evacuation from the push of high velocity flood water. The research speaks about a constant change in the level of exposure and vulnerability of the surrounding built environment, as a result of the memory stored within the system, partly due to repeated impacts of flood events. The enhancement of the resilience against such irregular changes should consider the interactions and feedbacks within the built environment, on a scenario specific basis, reflecting the antecedent memory inside the system. However, it still remains a crucial challenge to direct the attributes of physical memory within the built environment, maintaining the system functionality improving its specific resilience. Again, Lamond et al. (2014) propose a framework to identify the system potential vulnerability by developing resilience with special reference to flood induced physical memory.

It is argued that all steps of a restoration process are critical in the understanding of the structural behavior of cultural heritage buildings. Key themes such as anamnesis, diagnosis and analysis are critical in approaching the analysis of historical constructions, through material characterization, structural modelling, monitoring, rehabilitation and repair (SAHC2016).

Wilson (2015) says that the resilience concept is rapidly emerging as a research topic, gaining importance especially the "social resilience". However, Wilson notes that, due to the relative novelty of the research field, discussions about processes of social resilience are not yet fully developed, in particular with regard to how the inbuilt memory of a local community helps shape resilience pathways (social memory). The focus of the discussion is on the interlinkages between social memory and community resilience, analyzing the importance of rites, traditions and social learning processes in shaping community resilience and vulnerability.

Nemeth et al. (2017) also note that the memories of a devastating event, together with the lingering willingness to help others, are powerful forces that coalesce to change collective behavior, and therefore create CM.

In conclusion, we can update the definition of *anamnesis*, always as an autonomous attribute of resilience (see Table 1), as *the safe-guarding and transmitting collective disaster memory (material or immaterial, territorial or oral) and cultural identity intact to posterity as a drop anchor for social wellbeing and democracy.*

4. Conclusions

This chapter has been conceived to discuss the suitability of the tool developed in Indirli (2019) to evaluate the resilience based on the six attributes described in Table 1. Thanks to the discussion developed by the authors of the present study, the validity of the initial cornerstones, *in primis* the relationship between the resilience's main concept and its attributes, has been confirmed and enhanced, modifying and fulfilling the initial definitions (final results in Table 3, differences in bold). Hence, this original and captivating methodology, conceived to provide an effective framework to study, without rigidity, complex questions as the combination of natural and anthropogenic hazards, with particular reference to global warming, can be considered an effective framework to assess resilience, to be adopted in times of new global challenges.

Of course, it is easier to apply this analysis case by case. In fact, this approach has been already adopted, in parallel with this theoretical discussion, to basically evaluate the overall resilience of the Italian community during the first period of the COVID-19 pandemic (Indirli et al., 2021). Such a tragic event, which has certainly been a very hard test for our whole Planet, is one of the examples of the tragic events that the humanity is expected to face in the future. Analysis tools to prevent/properly govern the future crisis are urgent. With our study we wish to have given a useful hint toward the adoption of resilient governance in times of new global challenges and to evaluate if we are *homeostatic* or *autopoietic*.

Table 3: reviewed nuclei for a pluralistic but holistic view of resilience (in bold the integrated definitions).

attributes	description	target
safety	*Protection of life, heritage, and assets from natural/human-made disasters across climate/social changes* ***in the framework of multi-hazard scenarios, reducing failure probabilities, consequences from failures, and time to recovery.***	*multi-hazard combinations and maps*
robustness	*Adequacy of structural/infrastructural systems to withstand actions,* ***under exceptional or normal conditions****, related to their function/exposure,* ***mitigating the susceptibility towards disproportionate or progressive collapse and surviving without failure over a time period.***	*multilevel networks*
adaptive capacity	*Ability* ***of systems, institutions, humans and other organisms to modify themselves in order to recovery (short term) with acceptable consequences after catastrophic events and*** *respond successfully* ***to new global changes (long term).***	*social-ecological models*
sustainability	***Preservation of*** *the natural/anthropogenic capital,* ***mitigating changes in biodiversity, heritage artifacts, and intangible cultural traditions*** *and fostering mature self-balanced environments.*	*sustainability models*
governance	*Consensual and shared* ***risks assessment and*** *management of conflicts towards* ***among all the actors involved, taking into account factors as uncertainty, complexity, and ambiguity,*** *towards a new equilibrium before/throughout/after traumas/disasters.*	*risk management*
anamnesis	*Safe-guarding and transmitting collective* ***disaster*** *memory* ***(material or immaterial, territorial or oral)*** *and cultural identity intact to posterity as a drop anchor for* ***social wellbeing and*** *democracy.*	*preservation of tangible/intangible heritage*

Bibliography

Adger W.N., Brooks N., Bentham G., Agnew M., and Eriksen S., 2004. New indicators of vulnerability and adaptive capacity, *Tyndall Centre for Climate Change Research, Technical Report 7*, January 2004.

Adger N. and Vincent K., 2005. Uncertainty in adaptive capacity, *C. R. Geoscience*, 337: 399-410.

Armitage D., 2005. Adaptive Capacity and Community-Based Natural Resource Management, *Environmental Management* 35 (6): 703-715.

ASCE, 2002. Minimum Design Loads for Buildings and Other Structures. *American Society of ASCE*, Washington D.C.

Aslani F. and Hosseini K.A., 2019. Evaluation of the Impacts of Identity and Collective Memory on Social Resilience at Neighborhood Level using Grounded Theory, SAGE Journals. https://doi.org/10.1177/1206331219886256.

Barthel S., Sörlin S., and Ljungkvist J., 2011. Innovative memory and resilient cities: echoes from Ancient Constantinople, The Urban Mind, cultural and environmental dynamics, in *Studies in Global Archaeology* 15, Sinclair P., Herschend F., Isendahl C., and Nordquist G. (Eds) Uppsala University Press, Uppsala, Sweden.

Beer M., Liebscher M., 2008. Designing robust structures – A non linear simulation based approach *Computers and Structures* 86: 1102-1122.

Blockey D., Agarwal J., Pinto T., Woodman N. J., 2002. Structural vulnerability, reliability and risk, *Progress Structural Engineering Materials* 4: 203-212.

Bobrowsky P.T., 2013. *Encyclopedia of Natural Hazards*, Peter T. Bobrowsky (Ed.), Part of the Encyclopedia of Earth Sciences Series book series (EESS), Springer, Dordrecht, 2013.

Borg R.P., 2019. Introduction: Sustainability & Resilience in the Built Environment, *Proceedings of SBE 19 Malta International Conference*, 21-22 November 2019, Malta, ISBN 978-99957-1-612-7, ISBN 978-99957-1-613-4 (ebook).

Borg R.P., D'Amico S., Galea P., 2016. The Messina Earthquake, 1908: The Maltese Experience; in *Earthquakes and their Impact on Society*, D'Amico S. (Ed.), Publisher Springer Natural Hazards, Springer International Publishing, Switzerland. DOI 10.1007/978-3-319-21753-6_22).

Bruneau M., Chang S.E., Eguchi R.T., Lee G.C., O'Rourke T.D., Reinhorn A.M., Shinozuka M., Tierney K., Wallace W.A., and Von Winterfeldt D., 2003. A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities, *Earthquake Spectra* 19: 733-752.

Carpenter S., Walker B., Anderies J. and Abel N., 2001. From metaphor to measurement: Resilience of what to what? *Ecosystems* 4: 765-781.

CEC, 2009. Commission of the European Communities. *White Paper: Adapting to Climate Change: Towards a European Framework for Action*, COM (2009) 147 final, Brussels, Belgium. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52009DC0147&from=EN.

Choay F., 1996. *L'allégorie du patrimoine*, Seuil, Paris, France.

Colocci A., 2020. Modelling disaster risk reduction: decoding social-ecological interactions to foster transformative adaptation, *PhD thesis*, 2020.

Comfort L., Boin A., Demchak C.C., 2010. *Designing Resilience. Preparing for Extreme Events*, Comfort, Boin, and Demchak (Eds), University of Pittsburgh Press, Pittsburg, Pennsylvania, USA.

COST Action C26, 2010a. *Proceedings of COST Action C26 Final International Conference* on *Urban habitat construction under catastrophic events*, Naples, 16-18 September 2010, M. Byfield, G. De Matteis, D. Dubina, B. Faggiano, M. Indirli, A. Mandara, F.M. Mazzolani (chair), E. Mistakidis, J.P. Muzeau, F. Wald (eds).

COST Action C26, 2010b. *Final Report of COST Action C26 Final International Conference* on *Urban habitat construction under catastrophic events*, Naples, 16-18 September 2010, M. Byfield, G. De Matteis, D. Dubina, B. Faggiano, M. Indirli, A. Mandara, F.M. Mazzolani (chair), E. Mistakidis, J.P. Muzeau, F. Wald (eds).

Cragnolini S., 2012. *Pictures of the restored ruins of Santa Maria delle Grazie*, Gemona, Italy. In glemone.it. https://www.glemone.it/archivio/monumenti_storici/madonna_grazie.htm.

De Gregorio D., Faggiano B., Formisano A., Mazzolani F.M., 2010. Air fall deposits due to explosive eruptions: action model and robustness assessment of the Vesuvian roofs, *Proceedings of COST Action C26 Final International Conference* on *Urban habitat construction under catastrophic events*, Naples, 16-18 September 2010, M. Byfield, G. De Matteis, D. Dubina, B. Faggiano, M. Indirli, A. Mandara, F.M. Mazzolani (chair), E. Mistakidis, J.P. Muzeau, F. Wald (eds).

Donghyun K. and Seul-Ki S., 2018. Measuring changes in urban functional capacity for climate resilience: Perspectives from Korea, *Futures* 102: 89-103.

Dror A.A., Eisenbach N., Taiber S., Morozov N.G., Mizrachi M., Zigron A., and Sela E., 2020. Vaccine hesitancy: the next challenge in the fight against COVID-19. *European Journal of epidemiology* 35(8).

Elmqvist T., 2017. Sustainability and Resilience differ, *Nature* 546, 15 June 2017 (Correspondence, T. Elmqvist, Stockholm Resilience Centre, Stockholm University, Stockholm, Sweden).

EN 1991-1-7, 2006. Actions on structures – Part 1–7: General actions – accidental actions. *European Committee for Standardization,* Bruxelles, Belgium, January 2006.

Faggiano B., Nigro E., De Gregorio D., Zuccaro G., and Cacace F., 2010. Volcanic actions and their consequences on structures, *Proceedings of COST Action C26 Final International Conference* on *Urban habitat construction under* *catastrophic events*, Naples, 16-18 September 2010, M. Byfield, G. De Matteis, D. Dubina, B. Faggiano, M. Indirli, A. Mandara, F.M. Mazzolani (chair), E. Mistakidis, J.P. Muzeau, F. Wald (eds).

Fazey I., Fazey J., Fischer J., Sherren K., Warren J., Noss R. and Dovers S., 2007. Adaptive capacity and learning to learn as leverage for social-ecological resilience, *Frontiers in Ecology and the Environment* 5 (7): 375-380.

Feofilovs M., Romagnoli F., 2021. Dynamic assessment of urban resilience to natural hazards, *International Journal of Disaster Risk Reduction* 62: 102328.

Feofilovs M., Romagnoli F., Campos J.I., Gotangco C.K., Josol J.C., Jardeleza J.M.P., Litam J.E., Abenojar K., 2020. Assessing Resilience against Floods with a System Dynamics Approach: A Comparative Study of Two Models, *International Journal of Disaster Resilience in the Built Environment* 11(5): 615-629.

Finkelstein L.S., 1995. What Is Global Governance? *Global Governance* 1(3): 367-372.

Formisano A., Mazzolani F.M., and Marzo A., 2009. Robustness based design of new and existing steel structures, *Proc. Behaviour of Steel Structures in Seismic Areas, STESSA 2009*, August 12, 2009, Philadelphia, USA.

Formisano A., Landolfo R., Mazzolani F.M., 2015. Robustness assessment approaches for steel framed structures under catastrophic events *Computers and Structures* 147: 216-228.

Formisano A., 2019. Robustness and progressive collapse of new and existing city structures, in *Resilience and Sustainability of Cities in Hazardous Environments*, GVES, Napoli - New York, 2019, ISBN 978-88-903183-1-3.

Gallopin G., 2006. Linkages between vulnerability, resilience, and adaptive capacity, *Global Environmental Change* 16: 293-303.

Garmestani A. S., Allen C. R., and Gunderson L., 2009. Panarchy: Discontinuities Reveal Similarities in the Dynamic System, *Ecology and Society* 14(1): 15.

Halbwachs M., 1950. *La mémoire collective*, Les Presses universitaires de France, PUF, Paris, France, 1967, XII edition.

Hassler U., Kohler N., 2014. Resilience in the built environment, *Building Research & Information* 42(2): 119-129.

Hermans M.A., Fox T., Van Asselt M.B.A., 2012. Risk Governance, In: Roeser S., Hillerbrand R., Sandin P., Peterson M. (Eds.), *Handbook of Risk Theory, Epistemology, Decision Theory, Ethics, and Social Implications of Risk*, Springer Science + Business Media.

Hermansson H., 2007. The ethics of NIMBY conflicts. *Ethical Theory and Moral Practice* 10(1): 23-34. https://doi.org/10.1007/s10677-006-9038-2.

Holling, C.S., 1973. Resilience and stability of ecological systems, *Annu. Rev. Ecol. Systemat.* 4 (1): 1-2.

Hufty M., 2011. Investigating Policy Processes: The Governance Analytical Framework (GAF). In: Research for Sustainable Development: Foundations, Experiences, and Perspectives, Wiesmann U., Hurni H. et al. (eds.), Bern: *Geographica Bernensia*: 403-24.

Indirli M., Di Maio V., Martinelli L., 2021. *An analysis of Italian resilience during COVID-19 pandemic: first phase from January to June 2020.* Book: Geographies of Anthropocene, Monograph volume. https://www.ilsileno.it/edizioni/ebooks/.

Indirli M., 2019. *An historical flight and some open questions towards a pluralistic but holistic view of resilience*. Book: Geographies of Anthropocene, Special Issue: *Earthquake risk perception, communication and mitigation strategies across Europe*, Vol. 2, No. 2, Publisher: Il Sileno Edizioni, pp.195.

Indirli, M., 2007. Overview on risk assessment approaches for natural hazards, *Proc. Workshop of EU Project COST Action C26 Urban Habitat under Catastrophic Events*, Prague, Czech Rep., 30-31 March 2007.

IPCC, 2014. Intergovernmental Panel on Climate Change. *Fifth Assessment Report-Synthesis Report (AR5-SYR): Climate Change 2014, Annexes, Glossary.*

IPCC, 2001. Intergovernmental Panel on Climate Change. *Climate Change 2001: Impacts, Adaptation and Vulnerability. Summary for Policy Makers*, World Meteorological Organization, Geneva.

IRGC, 2018. International Risk Governance Council. *IRGC guidelines for the governance of systemic risks in systems and organizations in the context of transitions*. Lausanne: International Risk Governance Center (IRGC). https://irgc.org/risk-governance/systemic-risks/guidelines-governance-systemic-risks-context-transitions/.

IRGC, 2005. *Risk governance. Towards an integrative approach*. Geneva: IRGC. https://www.irgc.org/risk-governance/irgc-risk-governance-framework/.

ISDR/Eur-opa/Council of Europe, 2011. ISDR/United Nations International Strategy for Disaster Reduction, Eur-opa Major Hazards Agreement, Council of Europe. Climate Change Adaptation and Disaster Risk Reduction in Europe, a Review of Risk Governance, June 2011. https://www.preventionweb.net/files/submissions/20591_governanceccriskeurope.pdf.

Jabareen Y., 2013. Planning the resilient city: Concept and strategies for coping with climate change and environmental risk, *Cities* 31: 220-229.

Jakku E. and Lynam T., 2010. What is adaptive capacity? *CSIRO (the Commonwealth Scientific and Industrial Research Organization) Report*, Climate Adaptation National Research Flagships, February 2010.

Jeudy H.-P., 2001. *La machinerie patrimoniale*, Sens & Tonka, Paris, France.

Keith, M., O'Clery N., Parnell S., Revi A., 2020. The future of the future city? The new urban sciences and a PEAK Urban interdisciplinary disposition. *Cities* 105: 102820.

Lamond J.E. and Bhattacharya-Mis N., 2014. Towards an integrated framework for building resilience using flood memory in built environment. *Proc. Conference Urban Sustainability and Resilience (USAR)*, November 2014 London, UK.

Leach M., Stirling A., Scoones I., 2010. *Dynamic Sustainabilities: Technology, Environment, Social Justice,* Leach M., Scoones I., Stirling A. (Eds), Routledge.
Le Blanc A., 2010. The Conservation of Traumatic Urban Ruins: An Ambiguous Marker of Urban History, *L'Espace géographique* 39(3): 253-266.
Le Blanc A., 2012. Remembering Disasters: the Resilience Approach, *hal.archives-ouvertes.fr:* 00719057. https://hal.archives-ouvertes.fr/hal-00719057.
Lew A.A., Ng P.T., Ni C.C., Wu T.C., 2016. Community sustainability and resilience: similarities, differences and indicators, *Tourism Geogr.* 18 (1): 18-27.
Lizarralde G., Chmutina K., Bosher L., and Dainty A. (2015). Sustainability and resilience in the built environment: The challenges of establishing a turquoise agenda in the UK. *Sustainable Cities and Society*, 15, 96–104.
Longstaff P.H. and Yang S-U., 2008. Communication management and trust: their role in building resilience to "surprises" such as natural disasters, pandemic flu, and Terrorism. *Ecology and Society* 13(1): 3 [online]. http://www.ecologyandsociety.org/vol13/iss1/art3/.
Lorenz D.F. and Dittmer C., 2016. Resilience in catastrophes, disasters and emergencies, socio-scientific perspectives; in: *New Perspectives on Resilience in Socio-Economic Spheres*, Maurer A. (Ed.), SpringerVS, 2016.
Martinelli L., Karbarz M., Siipi H., 2013. Science, safety and trust: the case of transgenic food. *Croat. Med. J.* 54: 91-96: 10.3325/cmj.2013.54.91.
http://www.cmj.hr/2013/54/1/23444254.htm.
Mazzolani F.M., Indirli M., Faggiano B., Formisano A., De Gregorio D., Zuccaro G., 2009. Catastrophic effects of a Vesuvian eruption on the built environment, *Proc. PROTECT2009 – II International Workshop, Performance, Protection & Strengthening of Structures under Extreme Loading*, Hayama, Japan, August 19-21, 2009.
Mallick, S.K. Prediction-Adaptation-Resilience (PAR) approach-A new pathway towards future resilience and sustainable development of urban landscape. Geography and Sustainability 2: 127-133.
Marcel J.-C. and Mucchielli L., 2010. Maurice Halbwachs's mémoire collective, in *Cultural Memory Studies. An International and Interdisciplinary Handbook*, Published by De Gruyter 2010, Erll A., Nünning A. (Eds).
Matthews E.C., Sattler M., Friedland C.J., 2014. A critical analysis of hazard resilience measures within sustainability assessment frameworks, *Environ. Impact Assess. Rev.* 49: 59-69.
McAslan, A., 2010. The Concept of Resilience, Understanding its Origins, Meaning, and Utility, *Torrens Resilience Institute*.
Mendis S., Mills S., and Yantz J., 2003. Building community capacity to adapt to climate change in resource-based communities. *Report from the University of Saskatchewan and University of Manitoba*, prepared for the Prince Albert Model Forest, Prince Albert, Canada.
Ministerial Decree of Public Works (M. D.), 2008. New Technical Codes for Constructions (in Italian). *Official Gazette of the Italian Republic published on 2008 January 14th*, Rome.
Ministerial Decree of Public Works (M. D.), 2018. Updating of Technical Codes for Constructions (in Italian). *Official Gazette of the Italian Republic published on 2018 January 17th*, Rome.
Museo della Memoria, 2021. *The Memory Museum at Santa Margherita Belice, Sicily (Italy).* http://retemusealebelicina.it/museo-della-memoria/.
Nelson D., Adger W. and Brown K., 2007. Adaptation to Environmental Change: Contributions of a Resilience Framework. *Annual Review of Environment and Resources* 32: 395-419.
Nemeth D.G., Olivier T.W., 2017. *Innovative Approaches to Individual and Community Resilience, from theory to practice*, Academic Press, eBook ISBN: 9780128039137.
Panza G.F., Kossobokov V., Laor E., DeVivo B. (Eds.), 2021. *Earthquakes and Sustainable Infrastructure*, Elsevier (1st Edition, 672 pp).
Preston B. and Stafford-Smith M., 2009. Framing vulnerability and adaptive capacity assessment. *CSIRO (the Commonwealth Scientific and Industrial Research Organization) Working Paper No. 2*, Climate Adaptation National Research Flagships, 2009.
Robin, R.,2001. *Berlin chantiers. Essai sur les passés fragiles*, Paris, Stock.
Rochas C., Kuzņecova T., Romagnoli F., 2014. The Concept of the System Resilience within the Infrastructure Dimension: Application to a Latvian Case. *Journal of Cleaner Production* 88: 358-368.
Roostaie, S., Nawari, N., Kibert, C.J., 2019. Sustainability and resilience: A review of definitions, relationships, and their integration into a combined building assessment framework. *Building and Environment* 154: 132-144.
Roostaie S., Nawari N., 2021. The DEMATEL approach for integrating resilience indicators into building sustainability assessment frameworks, *Building and Environment*: 108113.
Rossetto T., Kappos A.J., Kouris L.A., Indirli M., Borg R.P., Lloyd T.O., and Sword-Daniels, 2010. Comparison of damage assessment methodologies for different natural hazards, *Proceedings of COST Action C26 Final International Conference* on *Urban habitat construction under catastrophic events*, Naples, 16-18 September 2010, M. Byfield, G. De Matteis, D. Dubina, B. Faggiano, M. Indirli, A. Mandara, F.M. Mazzolani (chair), E. Mistakidis, J.P. Muzeau, F. Wald (eds).
Rugarli P., Amadio C., Peresan A., Fasan M., Vaccari F., Magrin A., Romanelli F. And Panza G.F., 2019. Neo-Deterministic Scenario-Earthquake Accelerograms and Spectra: a NDSHA approach to seismic analysis, Chpt. 6 in

"*Engineering Dynamics and Vibrations: Recent Developments*", Jia, J. and Paik, J.K., Eds., pp. 187- 241, CRC Press Boca Raton, Florida, USA. ISBN 978-1-4987-1926-1 DOI: 10.1201/9781315119908-6.

Rus K., Kilar V., Koren D., 2018. Resilience assessment of complex urban systems to natural disasters : A new literature review," *Int. J. Disaster Risk Reduct*. 31(1): 311-330.

SAHC 2016. Structural Analysis of Historical Constructions. Anamnesis, diagnosis, therapy, controls, *Proc. of SAHC2016*, the 10th International Conference on Structural Analysis of Historical Constructions, Van Balen K. and Verstrynge E. (Eds), Leuven, Belgium, 13-15 September 2016.

Sandman P.M., 1989. Hazard versus Outrage in the Public Perception of Risk. In: *Effective Risk Communication. Contemporary Issues in Risk Analysis, vol. 4*., Covello V.T., McCallum D.B., Pavlova M.T. (Eds), Springer, Boston, MA. https://doi.org/10.1007/978-1-4613-1569-8_6.

Simis M.J., Madden H., Cacciatore M.A., and Yeo S. K., 2016. The lure of rationality: Why does the deficit model persist in science communication? *Public understanding of science* 25(4), 400-414.

Slovic P., Fischhoff B., Lichtentein S., 1985. Characterizing perceived risk, pp. 91-125, in *Perilous Progress: Managing the Hazards of Technology*, Kates R.W., Hohenemser C., Kasperson J.X. (Eds), Westview, Boulder.

Svalastog A.L., Allgaier J., Martinelli L., Gajovic S., 2014. Distortion, confusion, and impasses: could a public dialogue within Knowledge Landscapes contribute to better communication and understanding of innovative knowledge? *Croat. Med. J.* 55:54-60.
http://www.cmj.hr/2014/55/1/24577828.htm

Thompson M. and Beck M., 2014. Coping with change: Urban resilience, sustainability, adaptability and path dependence. *Future of cities: working paper.* Foresight, Government Office for Science, London, UK.

United Nations, 1987. *Report of the World Commission on Environment and Development Our Common Future*. In UN. https://doi.org/10.9774/gleaf.978-1-907643-44-6_12.

United Nations, 2015. *United Nations General Assembly, New York*. Transforming our world: The 2030 Agenda for Sustainable Development A/RES/70/1.

UNDP, 2013. United Nations Development Programme, Empowered lives, resilient nations. *Issue brief: Disaster Risk Governance, Crisis Prevention and Recovery*, January 2013.
https://www1.undp.org/content/dam/undp/library/crisis%20prevention/disaster/issue_brief_disaster_risk_reduction_governance_11012013.pdf.

UNDP, 2010. United Nations Development Programme, Bureau for Crisis Prevention and Recovery. *Disaster Risk Reduction, Governance and Mainstreaming*, October 2010.
https://www.preventionweb.net/files/17429_4disasterriskreductiongovernance1.pdf.

UN-ISDR, 2005. United Nations-International Strategy for Disaster Reduction. *Building the Resilience of Nations and Communities to Disasters World Conference on Disaster Reduction*, 18-22 January 2005, Kobe, Hyogo, Japan; Geneva: United Nations International Strategy for Disaster Reduction; 2005.
https://www.undrr.org/publication/hyogo-framework-action-2005-2015-building-resilience-nations-and-communities-disasters.

UNISDR, 2009. United Nations Office for Disaster Risk Reduction. *Terminology on Disaster Risk Reduction (DRR)*, published by the United Nations International Strategy for Disaster Reduction, UNISDR, Geneva, Switzerland, 2009.
https://www.undrr.org/publication/2009-unisdr-terminology-disaster-risk-reduction.

Vamvatsikos D., Kouris L.A., Panagopoulos G., Kappos A.J., Rossetto T., Lloyd T.O., and Stathopoulos T, 2010. Structural Vulnerability Assessment under Natural Hazards: A review, *Proceedings of COST Action C26 Final International Conference* on *Urban habitat construction under catastrophic events*, Naples, 16-18 September 2010, M. Byfield, G. De Matteis, D. Dubina, B. Faggiano, M. Indirli, A. Mandara, F.M. Mazzolani (chair), E. Mistakidis, J.P. Muzeau, F. Wald (eds).

Visvizi A., Perez del Hoyo R., 2021. Chapter 1 - Sustainable development goals (SDGs) in the smart city: A tool or an approach? (An introduction), in: *Smart Cities and the un SDGs*, Visvizi A. and Pérez del Hoyo R. (Eds), Elsevier.

Walker B., Holling C.S., Carpenter S. and Kinzig A., 2004. Resilience, Adaptability and Transformability in Social-ecological Systems, *Ecology and Society* 9 (2): 5.

Wall E. and Marzall K., 2006. Adaptive capacity for climate change in Canadian rural communities, *Local Environment* 11 (4): 373-397.

Wilson G.A., 2015. Community Resilience and Social Memory, *Environmental Values* 24(2): 27-257.

Yohe and Tol, 2002. Indicators for social and economic coping capacity-moving toward a working definition of adaptive capacity, *Global Environmental Change* 12: 25-40.

Van Asselt M.B.A. and Renn O., 2010. Risk governance. *Journal of Risk Research* 14(4): 431-449.

Vale J.V., Campanella T.J., 2005. *The Resilient City. How modern cities recover from disaster*, Vale and Campanella (Eds), Oxford University Press, New York, USA.

Zanotti L., Ma Z., Johnson J.L., Johnson D.R., Yu D.J., Burnham M., Carothers C., 2020. Sustainability, resilience, adaptation, and transformation: Tensions and plural approaches, *Ecol. Soc.* 25 (3): 4.

Zuccaro G., Cacace F., and Nardone S., 2010. Human and structural damage consequent to a Sub-Plinian like eruption at Mount Vesuvius, *Proceedings of COST Action C26 Final International Conference* on *Urban habitat construction under catastrophic events*, Naples, 16-18 September 2010, M. Byfield, G. De Matteis, D. Dubina, B. Faggiano, M. Indirli, A. Mandara, F.M. Mazzolani (chair), E. Mistakidis, J.P. Muzeau, F. Wald (eds).