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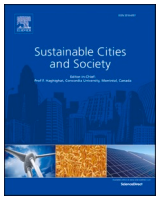

Implementing urban resilience in urban planning: A comprehensive framework for urban resilience evaluation

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ABSTRACT

Urban resilience as a transformative approach has become a central paradigm to define urban policy for making cities resilient. This implementation has multifaceted implications, ranging from the employment of the correct resilience approach for urban systems to the definition of the appropriate assessment framework to address all urban resilience features. This paper addresses the implications concerning the new requirements and open research questions of urban resilience assessment for resilient development for cities. According to this purpose, this paper provides three literature reviews to explore and critically analyse the different approaches of resilience and the several definitions of urban resilience in academic and operative fields, to address the dimensions, multifaceted characteristics, and key factors to being evaluated within an urban resilience enhancement perspective. The result is a comprehensive framework that identifies the five dimensions of urban resilience (economy, society, environment, nature, and governance), the relative urban components, and nine urban resilience capacities that have to be included in the evaluation of urban resilience as a transformative approach. The main novelty and contribution of the proposed research is the obtained framework that can be used as a guideline to define a comprehensive evaluation approach to assess urban resilience in its implementation in urban planning as a transformative approach. The final aim of the proposed research is to support in an operational manner the development of suitable evaluation methods to investigate strategic strategies within the aim of urban resilience enhancement, through a complex and multidimensional perspective.

1. Introduction

Cities are exposed to numerous stresses and shocks, both natural and human-made (Godschalk, 2003; World Economic Forum, 2013). They face new and continuing pressures that impact all dimensions, ranging from job creation to the provision of essential services, as well as green space planning, and management (Büyüközkan, Ilıcak, & Feyzioğlu, 2022; Ribeiro & Pena Jardim Gonçalves, 2019; Sharifi & Yamagata, 2018; UNISDR, 2005). Recognising this scenario, urban resilience is currently applied as a transformative approach in urban planning (Yamagata & Maruyama, 2016) to enhance the resilience of cities to make them able to respond, adapt and transform themselves to face these pressures and natural hazards (Da Silva & Moench, 2014; Gencer, 2017). Therefore, planning for resilient cities is now recognised as a critical objective of the current urban agenda (Johnston, 2016; Vaništa Lazarević, Keković, & Antonić, 2018; Wardekker, 2018). However, multifaceted and multidimensional implications have to be considered and addressed with the implementation of urban resilience as a transformative approach in urban planning (Masnavi, Gharai, & Hajibandeh, 2018; McGill, 2020), ranging from the employment of the correct resilience approach for urban systems to the appropriate urban resilience assessment framework (Holling, 1973; Masnavi et al., 2018; Quinlan, Berbés-Blázquez, Haider, & Peterson, 2016; Sharifi & Yamagata, 2018; UN-Habitat, 2017). This paper explores the implications concerning urban resilience assessment.

Despite the great attention to urban resilience assessment (Feldmeyer et al., 2019; Fu & Wang, 2018; Ilmola, 2016; Quinlan et al., 2016; Sharifi, 2020; Sharifi & Yamagata, 2018), the dimensions, the multi-faceted urban components and urban resilience characteristics to be included in the evaluation are not homogeneously discussed (Büyüközkan et al., 2022; Ebrahimi, Mortaheb, Hassani, & Taghizadeh-yazdi, 2022; Masnavi et al., 2018; Ribeiro & Pena Jardim Gonçalves, 2019). In the literature, different frameworks describe and identify characteristics and dimensions (e.g. society, economy, environment, among others) of urban resilience (Chelleri & Baravikova, 2021; Ribeiro & Pena Jardim Gonçalves, 2019). However, the main

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observed lack in the literature is the absence of a framework that comprehensively lists the multifaceted elements (e.g., social, economic, and environmental aspects, among others) that have to be included for evaluating urban resilience as a transformative approach considering all its features. According to this significant gap, this paper proposes three literature reviews to examine and critically analyse the different resilience approaches, the several urban resilience definitions, and the main characteristics of urban resilience as a transformative approach in urban planning. The result is a comprehensive framework that identifies the dimensions, key factors, urban components, and urban capacities that have to be included for evaluating urban resilience as a transformative approach for urban development, which represents the main novelty and contribution of this research. The final target of the proposed framework is supporting researchers and evaluators to structure the most suitable evaluation approach which includes the listed elements.

1.1. Motivations and objectives

This research is driven by specific research questions and objectives that emerged by a review of both the academic and political literature of urban resilience. The research questions addressed by this paper are the following:

- Question 1: "*What is urban resilience? How can it be described?*"
- Question 2: "*Which are the multifaceted and multidimensional aspects that have to be managed for urban resilience evaluation within its implementation as a transformative approach in urban planning?*"

In addition, four research objectives have been identified as follows:

- Objective 1: Analysing resilience approaches;
- Objective 2: Examining the urban resilience concept as a transformative approach;
- Objective 3: Identifying capacities that urban systems should have to be/become resilient;
- Objective 4: Developing a unique framework which collects urban resilience dimensions, key factors, urban components, and capacities to include in the evaluation.

In this sense, the effort of this research is to provide operative instruments and guidelines to overcome the assessment framework which address only one dimension of urban resilience, such as social resilience (Yang et al., 2022), urban water resilience(Ebrahimi, Mortaheb, Hassani and Taghizadeh-yazdi, 2022), energy resilience (Jamali, Rasti--Barzoki, & Altmann, 2023), among others.

2. Research methodology

This study provides three literature reviews within a critical analysis to explore studies in the field of urban resilience, with specific attention to its implementation as a transformative approach and the implication of its evaluation. Fig. 1 illustrates the methodological approach of the proposed research.

Firstly, the research questions and objectives have been identified. Secondly, three literature reviews have been developed according to the research objectives and questions. Therefore, the results of the different reviews have been analysed and critically examined to achieve the final objective (objective 4), as well as the main research contribution, or rather the development of a unique framework that identifies dimensions, key factors, components, and urban resilience capacities that have to be engaged to evaluate urban resilience as a transformative approach through a comprehensive perspective.

In detail, the first review concerns the concept of resilience to give a general overview of this concept within its different interpretations and thus identify the appropriate resilience approach for urban systems (Chelleri, Waters, Olazabal, & Minucci, 2015; Sharifi, 2016). The second analysis regards both the review and the critical examination of the urban resilience concept to recognise its evolution in different disciplines, as well as its different definitions within similarities and differences. The third review deals with the exploration of the implementation of urban resilience as a transformative approach in urban planning with a specific focus on the consequences of urban resilience evaluation (Masnavi et al., 2018).

This research reviews both publications and policy documents. The papers have been reviewed on the Scopus and Web of Science (WoS) platforms, while the policy documents, such as studies provided by organizations about urban resilience evaluation (Da Silva & Moench, 2015; Gencer, 2017; Melissa & Ebalu, 2012; Molin Valdés, Amaratunga, & Haigh, 2013; UN-Habitat, 2017; UNISDR, 2012b), have been founded by Google. The three sequential literature reviews have been developed according to the reference period from 2012 to 2023, using the same methodological framework: (1) identification with title and keywords, (2) screening with the analysis of title and abstract (3) eligibility by examining the content, findings, and discussions with the support of specific questions, and (4) the inclusion of a limited number of papers. Whereas, for what concerns policies documents, the studies provided by UNISDR and Rockfeller Foundation about urban resilience in planning and evaluation have been collected (Da Silva & Moench, 2014; Molin Valdés et al., 2013; UNISDR, 2012b).

Fig. 2 illustrates the PRISMA diagram of the three developed literature reviews, also specifying the eligibility questions used.

3. The concept of resilience

The purpose of this review is to provide a general overview about approaches and definitions of the concept of resilience across multiple disciplines. Therefore, it is necessary to declare that the interest of this section is reporting some of the most important definitions in different disciplines, and not examining an in-depth analysis of resilience concept implementation across several disciplines. The concept of resilience, which originated in the fields of ecology and natural science (Folke et al., 2010; Walker & Cooper, 2011) is actually applied and analysed in different fields and disciplines with different approaches (Sharifi & Yamagata, 2018). Its engagement in several disciplines is due to its ability to face environmental, socioeconomic, and political uncertainty (Kolers, 2016; Meerow & Newell, 2015; Meerow, Newell, & Stults, 2016). Resilience concept has been investigated in psychology (Bonanno, 2004; Coutu, 2002; Luthans, Vogelgesang, & Lester, 2006), ecology (Holling, 1973), engineering (Fiksel, 2004; Hollnagel, Woods, & Leveson, 2006), socio-ecological systems (Carpenter, Walker, Anderies, & Abel, 2001; Folke et al., 2002; Walker, Hollin, Carpenter, & Kinzig, 2004), climate change and adaptation (Nelson, Adger, & Brown, 2007; Tanner, Mitchell, Polack, & Guenther, 2009; Tyler & Moench, 2012), urban planning (Ahern, 2011; Wilkinson, 2012) and disaster risk management (Coaffee, 2008; Cutter et al., 2008; Gaillard, 2010).

Its implementation in several disciplines has significant methodological and practical implications.

Firstly, the concept of resilience has not a unique definition (Meerow et al., 2016). Each discipline explains and describes the concept of resilience with a different meaning, according to their needs and priorities (Sharifi & Yamagata, 2018). Different scholars have compiled representative definitions of resilience from different research fields. Table 1 summarizes the most significative definitions, elaborated by the works proposed by Meerow and colleagues and Bhrama and colleagues. (Bhamra, Dani, & Burnard, 2011; Meerow et al., 2016).

Therefore, by the performed review (Table 1) it is possible to state that (1) engineering and (2) ecology are the main fields of resilience implementation (Sharifi & Yamagata, 2018). Furthermore, it has been also possible to address the existence of two different approaches to conceptualising the concept of resilience, the static and the dynamic approach.

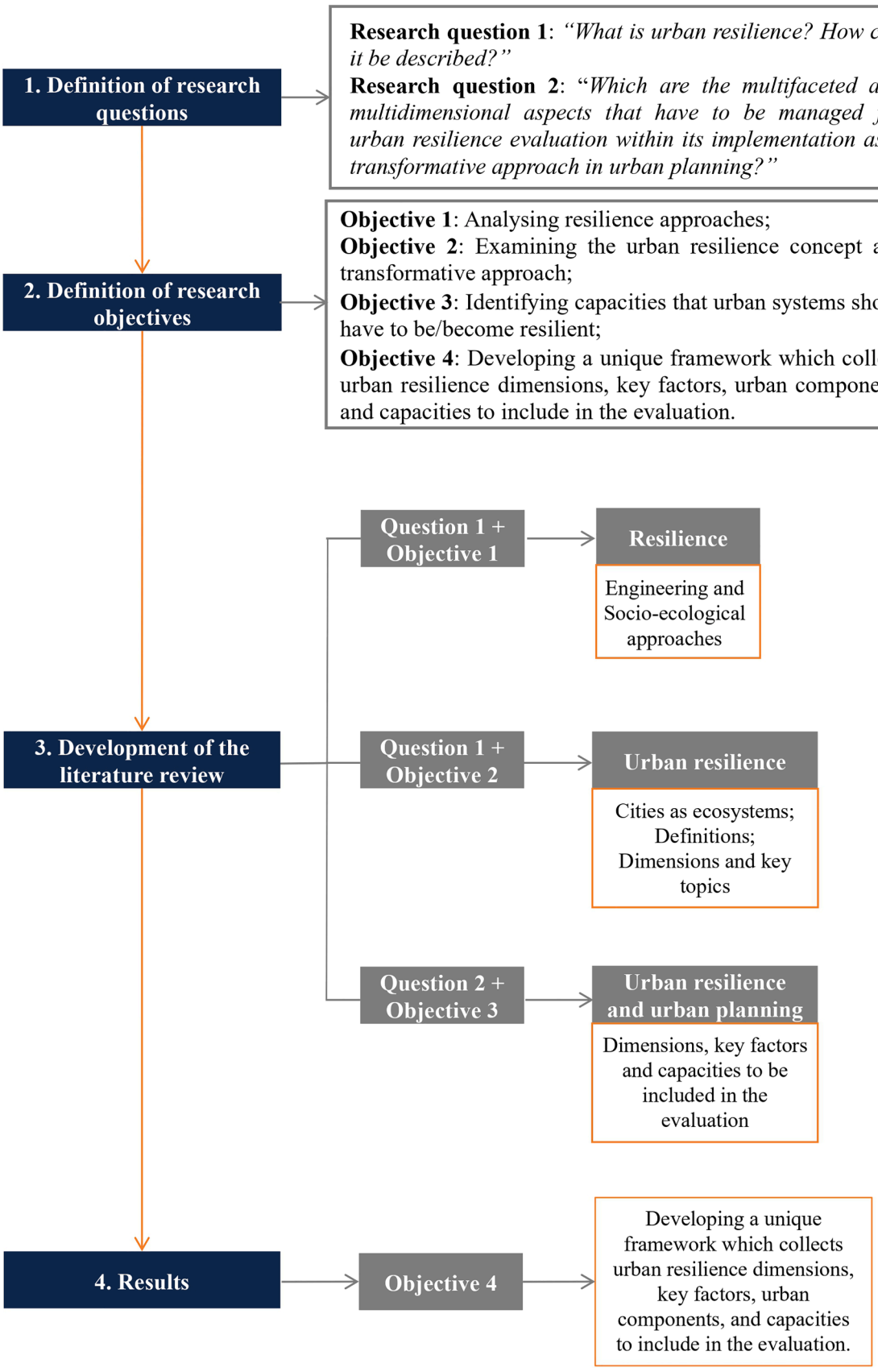


Fig. 1. Methodology flowchart.

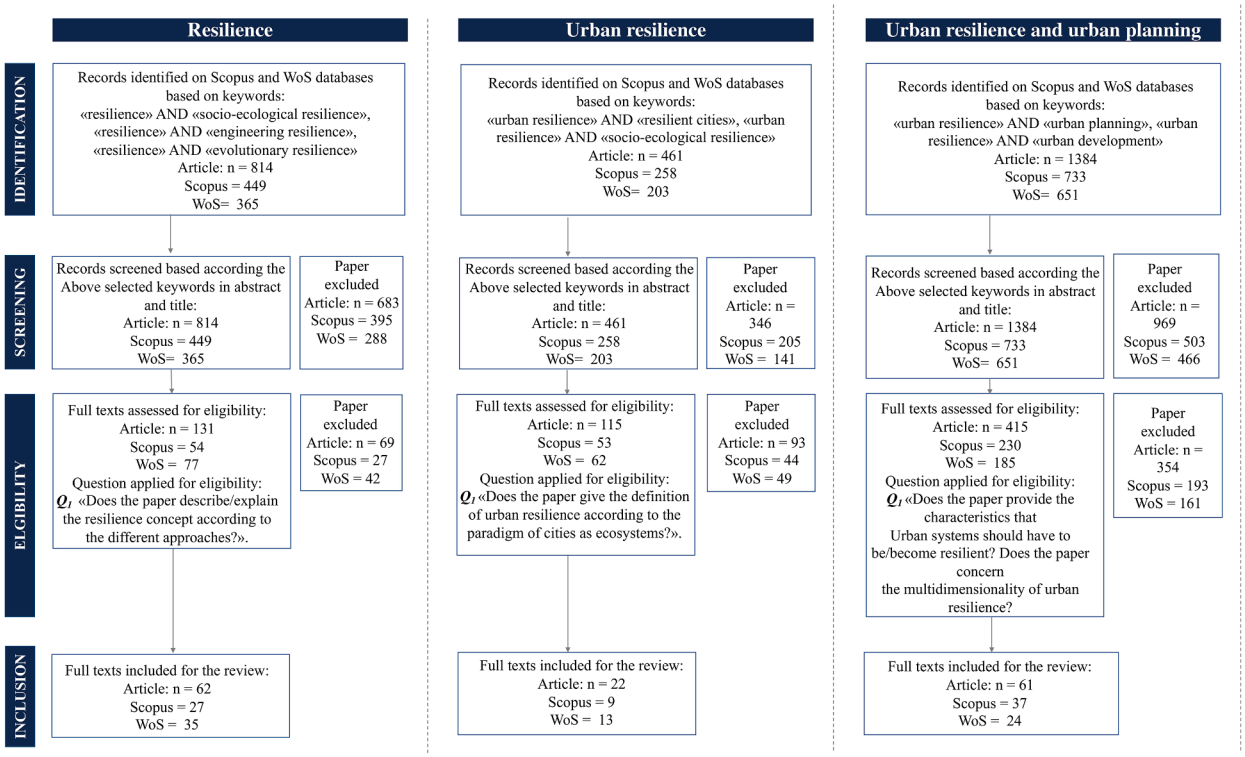


Fig. 2. Literature reviews PRISMA diagram.

Table 1
Representative resilience definition according to different research fields (elaboration from Bhamra et al., 2011; Meerow et al., 2016).

Author	Field	Definition of Resilience	Static or dynamic conceptualisation
(Holling, 1973)	Ecology	"*The ability of these systems to absorb changes of states variables, driving variables, and parameters, and still persist*" (p. 17)	Dynamic
(Pimm, 1984)	Ecology	"*How fast the variables return towards their equilibrium following a perturbation*" (p. 322)	Static
(Carpenter et al., 2001)	Social-ecological systems	"*The magnitude of disturbance that can be tolerated before a socio-ecological system (SES) moves to a different region of state space controlled by a different set of processes*" (p. 765)	Dynamic
(Adger, 2000)	Geography	"*The ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change*" (p. 347)	Dynamic
(Rose, 2007)	Economics	"*The speed at which an entity or system recovers from a severe shock to achieve a desired state.*" (p. 384)	Dynamic
(Fiksel, 2004)	Systems engineering	"*The capacity of a system to tolerate disturbances while retaining its structure and function*" (p. 16)	Dynamic
(Zhu & Ruth, 2013)	Industrial ecology	"*The ability [for industrial ecosystems] to maintain their defining feature of eco-efficient material and energy flows under disruptions*" (p. 74)	Dynamic
(Zeng, Xiao, & Li, 2013)	Networks	"*The critical threshold at which a phase transition occurs from normal state to collapse*" (p. 12)	Static
(Ouyang & Dueñas-Osorio, 2014)	Engineering	"*The joint ability of a system to resist (prevent and withstand) any possible hazards, absorb the initial damage, and recover to normal operation*" (p. 53)	Static
(Godschalk, 2003)	Engineering	"*A resilient city is a sustainable network of physical systems and human communities*" (p.2)	Static

3.1. The static approach: the engineering resilience

The static perspective or the "bounce back" approach of resilience is referred to the discipline of engineering. Engineering resilience can be defined as the measure of the speed through which the system can return to its previous equilibrium, or rather "*the faster the system bounces back, the more resilient it is*"[1] (Davoudi, Brooks, & Mehmood, 2013; Holling, 1996). Thus, the system's resilience can be measured by considering its resistance to disturbance and speed of return to the equilibrium (Holling, 1996). According to this assumption, engineering resilience considers the original state as the optimal condition of the system, not assuming the possibility of a system to transform and improve on initial conditions (Meerow et al., 2016).

[1] Holling 1996, p. 31

3.2. The dynamic approach: the socio-ecological resilience

This perspective is referred to a dynamic and evolutionary approach of resilience (Davoudi et al., 2013; Desouza & Flanery, 2013). The theory of the socio-ecological resilience was developed by Holling (Holling, 1973). This approach is based on the hypothesis that systems are complex networks, and their evolution is grounded on non-linear progressions with multiple equilibria (Batty, 2012, 2013), sustaining the idea that complex systems can change over time, with or without an external disturbance (Davoudi et al., 2012; Gunderson, Allen, & Holling, 2010; Meerow & Newell, 2015; Scheffer, 2009). Therefore, socio-ecological resilience addresses the ability of the system to transform itself, then return to a previous equilibrium. Moreover, socio-ecological resilience examines, systems within their interconnected socio-spatial subsystems, that operate at different scales and timeframes (Davoudi et al., 2012; Du Plessis & Hes, 2014).

Social-ecological systems are thus described as complex, adaptive, and multi-scaled systems that involve both the human (social and cultural) and biophysical (ecological) subsystems that are characterized by a mutual interaction (Davoudi et al., 2013; Walker, Salt, & Reid, 2006). These systems are thus distinguished by dynamic behavior, feedbacks, interdependencies, and cross-scale interactions (Folke, 2006). Therefore, socio-ecological resilience depends upon the balance and the relationship between environmental governance and ecosystem dynamics.

4. The concept of urban resilience

Urban resilience is a concept analysed in several disciplines. The literature on urban resilience concept is significantly extended and it is explored both in academic research and policy statements (Fu & Wang, 2018; Ribeiro & Pena Jardim Gonçalves, 2019; Yamagata & Maruyama, 2016), as well as in papers that propose both conceptual and empirical approaches (Büyüközkan et al., 2022). In detail, this section is the core of this research. The aim is analysing the evolution of the concept of urban resilience in several disciplines and collecting the most important definition provided by the literature (Table 2). This review and critical analysis of several disciplines has the task to recognise the features of urban resilience in order to be able to engage them through both planning and evaluation perspectives. For what concerns the evolution of the concept of urban resilience among different disciplines, it has been recognised an evident improvement of urban resilience investigation in the field of urban studies during the last decade (Amirzadeh, Sobhaninia, & Sharifi, 2022). At the beginning, the concept of urban resilience was mainly related to climate change (Leichenko, 2011; Wardekker, 2018) and disaster risk management perspective (Burby, Deyle, Godschalk, & Olshansky, 2000; Campanella, 2006; Chelleri et al., 2015; Godschalk, 2003). Nowadays, the application of the concept of urban resilience is much more extended (Chelleri et al., 2012). Urban resilience is actually employed as a transformative approach to enhance and improve the resilience of cities (Amirzadeh et al., 2022; Sharma, Sharma, Kumar, & Kumar, 2023; Yamagata & Maruyama, 2016), implying that the concept of urban resilience embraces the socio-ecological perspective of resilience which assumes the change and improvement of complex systems over time (Holling, 1973).

4.1. Urban resilience definitions and dimensions

As the general concept of resilience, urban resilience has several definitions with different meanings according to the study disciplines (Meerow et al., 2016; Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008; Sharifi & Yamagata, 2016). Table 2 shows the main definitions of urban resilience available both in academic and political fields.

Despite the consideration of the urban resilience concept as an umbrella term that embraces different fields (Chelleri et al., 2015; Sharifi & Yamagata, 2018; Sharma et al., 2023; UN-Habitat, 2017), it is possible to recognise some common research areas among the examined definitions (Table 2). It can be addressed that (1) climate change, (2) urban planning, (3) urban communities, (4) energy, and (5) disaster risk are the main considered research areas and implementing fields (Fu & Wang, 2018; Ribeiro & Pena Jardim Gonçalves, 2019).

Moreover, the common element that emerges from the performed analysis is the fact that these definitions describe urban resilience as the generic multidimensional capacity of urban systems to deal with impacts and disturbances and to incorporate changes, as opposed to resistance or recovery (Meerow & Stults, 2016), addressing the dynamic behavior of urban resilience process both in spatial and temporal scale (Chelleri et al., 2015; Sharifi & Yamagata, 2018). Therefore, urban resilience is widely accepted as the ability of urban systems not only to maintain essential functions but also to improve its original conditions. Moreover, all definitions consider urban resilience as a multidimensional, complex

Table 2
Some peculiar definitions of urban resilience.

Authors and Year	Author field[2]	Definition	Field
(Meerow et al., 2016)	Urban geography, urban planning	"*Urban resilience refers to the ability of an urban system and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity*" (p. 39)	Academic
(UN-Habitat, 2017)	UN-Habitat[3]	"*Urban resilience is the measurable ability of any urban system, with its inhabitants, to maintain continuity through all shocks and stresses, while positively adapting and transforming toward sustainability*" (p. 5)	Politic
(Mackay, 2019)	Urban planning	"*Urban resilience is the capacity of urban systems, communities, individuals, organizations and businesses to recover maintain their function and thrive in the aftermath of a shock or a stress, regardless its impact, frequency or magnitude*" (p. 6)	Politic
(Desouza & Flanery, 2013)	Urban planning	"*Urban resilience is the ability to absorb, adapt and respond to changes in urban systems*" (p. 89)	Academic
(Hamilton, 2009)	Urban planning	"*Urban resilience is the ability to recover and continue to provide their main functions of living, commerce, industry, government and social gathering in the face of calamities and other hazards*" (p. 109)	Academic
(Lu & Stead, 2013)	Urban and spatial planning	"*Urban resilience is the ability of a city to absorb disturbance while maintaining its functions and structures*" (p.200)	Academic
(Thornbush, Golubchikov, & Bouzarovski, 2013)	Geography	"*Urban resilience is a general quality of the city's social, economic, and natural systems to be sufficiently future-proof*" (p. 2)	Academic
(Leichenko, 2011)	Geography	"*Urban resilience is the ability to withstand a wide array of shocks and stresses*" (p. 164)	Academic
(Romero-Lankao & Gnatz, 2013)	Environmental Engineering	"*Urban resilience is a capacity of urban populations and systems to endure a wide array of hazards and stresses*" (p. 358)	Academic
(Figueiredo et al., 2018)	OECD[4]	"*Resilient cities are cities that can absorb, recover and prepare for future shocks (economic, environmental, social, and*	Politic

(*continued on next page*)

Table 2 (*continued*)

Authors and Year	Author field[2]	Definition	Field
		institutional). Resilient cities promote sustainable development, well-being, and inclusive growth"	
(Walker et al., 2010)	Ecology and environmental science	"*A resilient city is one that has developed capacities to help absorb future shocks and stresses to its social, economic and technical systems and infrastructures so as to still be able to maintain essentiality the same functions, structures, systems, and identity*"	Academic
(Da Silva & Moench, 2014)	ARUP[5]	"*A resilient city is prepared to absorb and recover from any shocks or stress while maintaining its essential functions, structures, and identity as well as adapting and thriving in the face of continual change. Building resilience requires identifying and assessing hazard risks, reducing vulnerability and exposure, and lastly, increasing resistance, adaptive capacity, and emergency preparedness!*"	Politic
(Godschalk, 2003)	Urban planning	"*A resilient city is a sustainable network of physical systems and human communities*" (p.2)	Academic
(Campanella, 2006)	Urban planning and built environment	"*Urban resilience is the ability of a city to recover from the destruction*" (p.142)	Academic
(Coaffee, 2008)	Urban geography	"*Urban resilience refers both to design changes (structural, architectural, spatial planning) and to management and governance measures that aim to prevent or mitigate the physical and social vulnerability of urban areas, to protect life, property, and the economic activity of the city*" (p.174)	Academic
(Liao, 2012)	Urban planning	"*Urban resilience to flooding is a city's ability to tolerate flooding and reorganize if physical damage and socioeconomic disturbances occur to prevent death and injury and maintain current socioeconomic*" (p. 5)	Academic
(Chelleri et al., 2012)	Urban geography	"*Although urban resilience usually refers only to the ability to maintain functions and structures, it must be framed in the visions of resilience (system persistence), transition (incremental system change), and transformation (system reconfiguration)*" (p. 287)	Academic
(Wu & Wu, 2013)	Ecology	"*Urban resilience is the ability of a city to persist without qualitative changes in its structure and function, despite the disturbances*"	Academic
(Wagner & Breil, 2013)	Ecology	"*A more comprehensive definition of a resilient city emphasizes a community's overall ability and ability to withstand stress, survive, adapt and recover from a crisis or disaster, and move forward quickly*" (p. 114)	Academic
(Mehmood, 2016)	Planning and sustainability	"*Urban resilience can be defined in evolutionary terms as a proactive vision for planning, policy formulation, and strategic direction in which communities play a vital role in resilient place modeling through their active learning ability, robustness, capacity for innovation and adaptability*"	Academic

[2] regarding the academic field, the area of affiliation of most of the authors is indicated, compared with the keywords of the paper and the objectives and themes of the journal. On the other hand, for what concerns politic field, the description of the authors is reported to better clarify their objectives and missions.

[3] "It is mandated by the UN General Assembly to promote socially and environmentally sustainable towns and cities. UN-Habitat is the focal point for all urbanization and human settlement matters within the UN system." (https://unhabitat.org/about-us)

[4] "Organization for Economic Co-operation and Development (OECD) is an international organization that works to build better policies for better lives. Our goal is to shape policies that foster prosperity, equality, opportunity and well-being for all." (https://www.oecd.org/about/)

[5] "Dedicated to sustainable development, the firm is a collective of 18,000 designers, advisors, and experts. Arup's primary goal is to develop a truly sustainable built environment." (https://www.arup.com/our-firm)

and transformative approach (Desouza & Flanery, 2013; Meerow & Stults, 2016; Ribeiro & Pena Jardim Gonçalves, 2019; Sharifi & Yamagata, 2017), that engages social, economic, institutional, infrastructural, ecological and community elements (Bruneau et al., 2003; Cutter, Burton, & Emrich, 2010). In conclusion, urban resilience can be defined as "*the ability of an urban system and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales to maintain or rapidly return to desired functions in the face of a disturbance, to adapt, to change and to quickly transform systems that limit current or future adaptive capacity*"[2]. Therefore, from this analysis, it is possible to underline the necessity and urgency of investigating the multidimensionality of urban resilience as a transformative approach in urban planning. Therefore, it is fundamental to identify which are the factors involved in the process of resilience as a transformative approach to recall them in the evaluation (Ribeiro & Pena Jardim Gonçalves, 2019).

In this context, different scholars have investigated the different dimensions of urban resilience (Amirzadeh et al., 2022). As an example, Ostadtaghizadeh and colleagues identified ten different models that try to measure resilience within these five dimensions: (1) physical, (2) natural, (3) economic, (4) institutional and (5) social (Ostadtaghizadeh, Ardalan, Paton, Jabbari, & Khankeh, 2015). In detail, "physical" resilience includes resilience in infrastructures, "natural" resilience consists

[2] Meerow et al., 2016, p. 39.

of ecological and environmental resilience, "economic" resilience comprises the development of societies and economies, "institutional" resilience includes the governance and mitigation policies, and "social" resilience includes communities and people in general. Fig. 3 summarizes urban resilience dimensions with their specific topics.

5. Urban resilience and urban planning

As previously mentioned, urban resilience is currently used to define urban policy with the statement of "urban resilience as transformative approach" (Masnavi et al., 2018; Yamagata & Maruyama, 2016). In detail, the urban resilience as transformative approach deals with transformation, or rather the definition of a new entity of the city, to emerge better and stronger after the shock (Yamagata & Maruyama, 2016). Therefore, it is applied as an urban planning pillar to improve the initial condition and make cities able to adapt, evolve and transform facing several disturbances (Desouza & Flanery, 2013; Ilmola, 2016; Lu & Stead, 2013; Sharifi & Yamagata, 2017, 2018). In this context, it can be addressed that the main challenge of the current urban agenda is grounded on the relationship between "urban resilience and urban planning" (Ahern, 2011; Davoudi et al., 2013; Meerow & Newell, 2015; Shivaprasad Sharma, Roy, Chakravarthi, & Srinivasa Rao, 2018; UNISDR, 2012a; Wilkinson, 2012). Thus, a general survey about the implication of this challenge is required to identify which elements have to be considered for urban resilience evaluation when applied in urban planning. However, the implementation in urban planning of urban resilience as a transformative approach has several implications, that have to be carefully addressed (Pizzo, 2015; Sharifi & Yamagata, 2017; UN-Habitat, 2017). First of all, one implication is the necessity to use in this context the conceptualisation of cities as ecosystems, among others (Brown et al., 2018; Douglas, 1981; Odum, 1968). This is since urban resilience as transformative approach is aligned with the socio-ecological approach of resilience that engages complex and dynamic systems. Therefore, to apply urban resilience as transformative approach implies the necessity of manage cities as dynamic, complex, and adaptive systems that can extend across multiple spatial and temporal scales (Batty, 2012; Davoudi et al., 2013; Godschalk, 2003). In fact, this perspective allows admitting that cities are complex systems that can change and evolve both in temporal and spatial scales. Thus, it is possible to focus on adapting and adjusting in face to uncertainties and disruptions. Therefore, it can be addressed that the resilience of urban systems is affected by the socio-ecological approach of resilience (Sharifi & Yamagata, 2018). Accordingly, one of the main implications of the introduction of urban resilience concept in urban planning is to analyse and manage cities as socio-ecological systems (Masnavi et al., 2018). It is thus fundamental to be able to examine and manage cities within their multidimensionality and mutual interdependencies and dynamic behavior over time (Ilmola, 2016). Therefore, it can be addressed that the main consequence of urban resilience implementation in urban planning within the transformation perspective is the necessity of urban resilience measurement able to measure these peculiarities (Desouza & Flanery, 2013; Sharifi, 2016). In fact, urban resilience assessment is essential in supporting planners to understand the status of resilience of urban systems, and identify needs for improving resilience capacities, in order to define the preferable strategy to enhance urban resilience (Sharifi & Yamagata, 2018).

5.1. Urban resilience capacities

Considering the challenge of implementing urban resilience concept in urban planning, as well as its implication of managing and evaluating cities as ecosystems, it is essential to identify which are the main characteristics that can make cities resilient, or rather which capacities urban systems should have to enhance or maintain resilience. Different scholars analysed which are the capacities that make systems resilient, according to the different disciplines of analysis (e.g., sustainability, ecology, economy, climate change, engineering) (Galderisi, 2014). This paper lists the characteristics recognised collecting both academic papers and policy documents (Chelleri & Baravikova, 2021; Cutter et al., 2010; Da Silva & Moench, 2014; Figueiredo, Honiden, & Schumann, 2018; Ribeiro & Pena Jardim Gonçalves, 2019; Sharifi & Yamagata, 2016). Table 3 generally schedules the recognised characteristics in the literature with their brief description, addressing also to which urban dimensions they are referred to.

Table 3 represents a general list of capacities related to urban resilience. However, the main objective of this research is to develop a unique framework which collects urban resilience dimensions, key factors, urban components, and capacities (objective 4) to include in the evaluation of urban resilience as a transformative approach. Therefore, a critical analysis has been made to identify only those capacities to include in the assessment of urban resilience as a transformative approach. Different methodological criteria have been applied to perform this selection, as represented by Fig. 4.

More in detail, the used criteria correspond to C_1 "relationship and clear connection with urban resilience dimensions and urban components", C_2 "coherence with the pillars of the paradigm of resilience as a transformative approach", C_3 "coherence and relationships with the different urban resilience campaigns objectives and the targets of the Sustainable Development Goals (SDGs)". Therefore, it was possible to identify the nine urban resilience capacities to be considered for urban resilience as a transformative approach evaluation. The selected capacities are here listed and described in-depth:

- Robustness. In the literature (Meerow & Stults, 2016), great importance is given to this capacity. The robustness can be defined as the ability urban systems to resist to external stresses and disturbances. Therefore, this characteristic is strictly related to "strength" (Lu & Stead, 2013). Therefore, the robustness deals mainly with the infrastructure dimension of urban resilience, concerning well-conceived, well-constructed, and well-managed physical assets. Thus, they can withstand the impacts of hazard events without significant damages or loss function losses;
- Redundancy. The redundancy can be defined as the presence of several components with the same or similar functions, guaranteeing

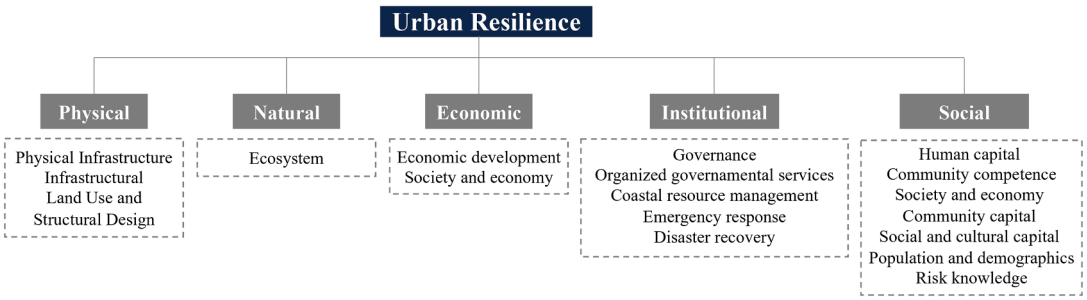


Fig. 3. Urban resilience dimensions and referred topics (elaborated from Ribeiro et al., 2019).

Table 3
List of characteristics of resilient urban systems.

Characteristic	Definition[7]	Sources
Robustness	*"Ensuring municipal-wide infrastructure and organizations can withstand external shocks and quickly return to the previous operational state"*	(Godschalk, 2003; Rose, 2007)
Redundancy	"*Having back-up systems, infrastructure, institutions, and agents*"	(Ahern, 2011; Brown, Dayal, & Rumbaitis Del Rio, 2012; Campanella, 2006; Desouza & Flanery, 2013; Godschalk, 2003; Wilkinson, 2012)
Diversity	"*Ensuring a diverse economy, infrastructure, and resource base (e.g., not relying on single mode of operation, solution, or agent / institution)"*	(Ahern, 2011; Desouza & Flanery, 2013; Godschalk, 2003; Liao, 2012; Lu & Stead, 2013; Tyler & Moench, 2012; Wilkinson, 2012)
Integration	"*Making sure that plans and actions are integrated across multiple departments and external organizations*"	(Coaffee, 2008; Tyler & Moench, 2012)
Inclusivity	"*Ensuring that all residents have access to municipal infrastructure and services, including providing an opportunity for all people to participate in decision-making processes*"	(Ayda Eraydin, 2012; Tanner et al., 2009; Tyler & Moench, 2012)
Equity	"*Ensuring that the benefits and impacts associated with actions are felt equitability throughout the municipality*"	(Bahadur, 2010; Godschalk, 2003)
Iterative process	"*Creating a process whereby feedback and lessons learned are continually used to inform future actions*"	(Brown et al., 2012; Tyler & Moench, 2012)
Decentralization	"*Decentralizing services, resources, and governance (e.g., solar or wind energy; stronger local governance)"*	(Ahern, 2011; Chelleri et al., 2012; Tanner et al., 2009)
Feedback	"*Building mechanisms so that information is rapidly fed back to decision-makers or system operators*"	(Ahern, 2011; Wilkinson, 2012)
Environmental	"*Protecting natural systems and assets*"	(Brown et al., 2012; Godschalk, 2003)
Transparency	"*Ensuring that all municipal processes and operations are open and transparent*"	(Tanner et al., 2009; Tyler & Moench, 2012)
Flexibility	"*Making municipal operations and plans flexible and open to change when needed*"	(Ahern, 2011; Bahadur, 2010; Tanner et al., 2009)
Forward – Thinking	"*Integrating information about future conditions (i.e., population, economy, weather) into community planning and decision-making*"	(Tyler & Moench, 2012; Wardekker et al., 2010)
Adaptive Capacity	"*Ensuring that all residents have the capacity to adapt to climate change*"	(Ayda Eraydin, 2012; Wardekker et al., 2010)
Predictable	"*Ensuring that systems are designed to fail predictable, safe ways*"	(Ahern, 2011; Tyler & Moench, 2012)
Efficiency	"*Enhancing the efficiency of government and external operations*"	(Ahern, 2011; Godschalk, 2003)
Resourceful	"*Existence of resources that can be rapidly displaced to respond to disruptions and their effects*"	(Allan & Bryant, 2011; Kim & Lim, 2016; McLellan et al., 2012; Spaans & Waterhout, 2017; Wardekker et al., 2010)
Reflective	"*The system can examine and systematically learn from past experiences, to inform future decision making that will enable adaptation and change*"	(Leichenko, 2011)
Connectivity	"*Connected system components for support and mutual interaction*"	(Godschalk, 2003)
Independence	*"Ability to operate for a continuous post-disaster period without relying on external physical intervention"*	(McLellan et al., 2012)
Innovation	*"Ability to quickly find different ways to achieve goals or meet their needs during a sock, or when a system is under stress. Innovation is critical to developing a city's ability to restore the functionality of critical systems under severely limited conditions"*	(Allan & Bryant, 2011; Spaans & Waterhout, 2017; Wardekker et al., 2010)

[7] The definitions reported in this table have been founded in Meerow et al., 2016; Ribeiro & Pena Jardim Gonçalves, 2019; Chelleri & Barabaravikova, 2021; Figueiredo et al., 2018.

thus the functioning of the overall system when one of its components fail (Allan & Bryant, 2011; Godschalk, 2003; Kim & Lim, 2016; McLellan, Zhang, Farzaneh, Utama, & Ishihara, 2012; Spaans and Waterhout, 2017; Wardekker, 2018). It is also related with the diversity capacity, in order to ensure the existence of backup systems (Allan & Bryant, 2011; Godschalk, 2003; Kim & Lim, 2016; McLellan et al., 2012; Spaans and Waterhout, 2017; Wardekker, de Jong, Knoop, & van der Sluijs, 2010). The redundancy concerns both the infrastructure (e.g., infrastructure networks, resource reserves, electricity infrastructure) and the social dimension.

- Diversity. The diversity capacity deals with the existence of different modes to reach the same requirement. It concerns also the presence of different functional components, that protect the system against stresses and possible hazards (Ribeiro & Pena Jardim Gonçalves, 2019). For these reasons, diversity is often cited in the literature as one of the fundamental characteristics to enhance or maintain resilience. In fact, with a high level of diversity the system can have a better ability to adapt in face to a wide range of different circumstances (Allan & Bryant, 2011; Godschalk, 2003; Walker et al., 2006). In detail, this characteristic is mainly related to the infrastructure dimension of urban resilience (Tyler & Moench, 2012);
- Integration. This characteristic mainly concerns the decision-making process. In fact, it is mainly related to the governance dimension of urban resilience (Tyler & Moench, 2012). It aims at promoting the consistency, to support coherent decision-making processes with a common objective (Ribeiro & Pena Jardim Gonçalves, 2019). The principle that stands at the basis of integration is the sharing of the information among different sub-systems, permitting thus their collectively functioning and quickly response across city (Godschalk, 2003; Spaans and Waterhout, 2017). Thus, this characteristic directly influences the ability to respond rapidly through shorter feedback loops throughout the city and it is connected to different city's dimensions, or rather: society, economy, environment, infrastructure, and governance;
- Inclusivity. It mainly deals with the engagement of communities, including the most vulnerable groups in the decision-making process, emphasising the necessity of a broad consultation. However, the inclusivity also ensures other urban aspects, related both to the social and the economic dimensions of urban resilience, representing thus a fundamental characteristic to enhance the city's resilience in a multidimensional perspective, as underlined by different scholars (Godschalk, 2003; Spaans and Waterhout, 2017);
- Transparency. It can be described as "ensuring that all municipal processes and operations are open and transparent". Therefore, it is

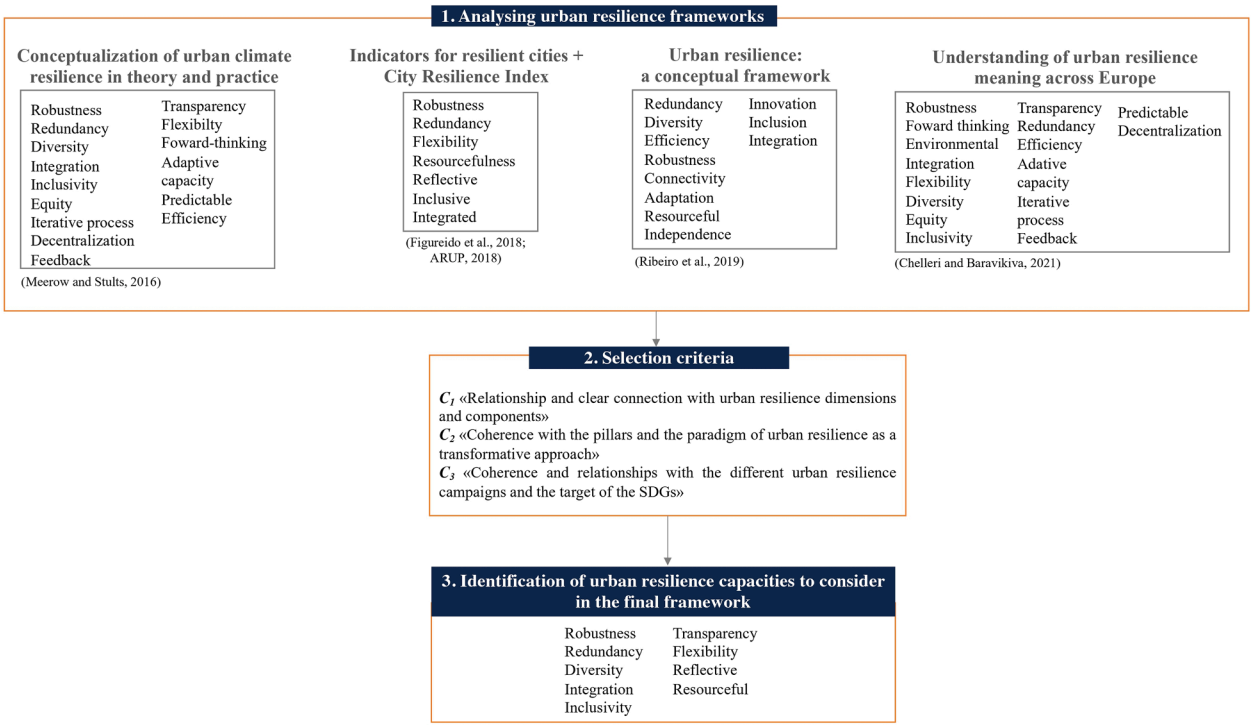


Fig. 4. Methodological flowchart to select the list of urban resilience capacities to consider for urban resilience evaluation as a transformative approach.

mainly related to the governance dimension and the decision-making processes, to make them as much more coherent and transparent as possible. For this reason, this characteristic can be also considered as complementary to the inclusivity (Tyler and Moench, 2012);

- Flexibility. This characteristic concerns the capacity of urban systems to perform essential tasks under a wide range of conditions. Moreover, it underlines the ability of systems to modify or introduce a new way to reach the necessity, or rather the capacity to adapt according to the changing of the initial conditions. In fact, the flexibility addresses the ability of the system to transform, evolve and adapt in response to changes. This principle can support and imply the modularity both in infrastructure approach and ecosystem management (Leichenko, 2011), thus it is mainly related to society, economy, environment, infrastructure and governance dimensions;
- Reflective. It deals with the capacity of urban systems of the inherent and the ever-increasing uncertainty and change in today's world. In this sense, reflective systems have mechanisms that permit them to continuously evolve and to modify standards or norms, according to the emerging evidence, rather than seeking permanent solutions based on the status quo. This capacity is also related to the capacity of both people and institutions to examine and systematically learn from past experiences and leverage this learning to inform future decision-making (Leichenko, 2011). Therefore, this capacity is mainly related to the governance dimension;
- Resourceful. It is mainly related to the presence of different sources that can be applied to respond to different effects produced by different stresses. In this sense, it mainly deals with the capacity of people and institutions to rapidly find a way to achieve their needs during a shock or when under stress. It also deals with the investment in systems to anticipate possible future conditions, setting priorities, and the coordination of human, financial and physical resources (Allan & Bryant, 2011; Kim & Lim, 2016; McLellan et al., 2012; Spaans and Waterhout, 2017; Wardekker et al., 2010). Therefore, it is related to society, economy, environment, and governance.

6. Findings and discussion

This section discusses and critically analyses the results obtained by the three literature reviews, according to the main objectives of the present work (Section 1):

6.1. Objective 1: analysing resilience approaches

The first objective of this paper is to analyse resilience approaches. The performed literature review supports the general recognition of two approaches, or rather the static and the dynamic, highlighting the relationship between resilience definitions with the different approaches (Table 1). This general survey permits addressing the marked conceptual difference between the two approaches. The static approach defines systems as resilient when capable of returning to the previous equilibrium state (Holling, 1996). On the contrary, the evolutionary approach accounts systems as resilient when capable of reacting, evolving and transforming (Davoudi et al., 2012, 2013). In this context, it is necessary to declare that the recognition of these two approaches is not one of the main findings of the proposed research, as it is largely discussed in the literature (Cutter et al., 2008; Davoudi et al., 2013; Holling, 1996). However, this review permits to recognise the high presence of urban studies, and the urban planning field concerning the dynamic approach of resilience, as well as identifying the conceptual basis of urban resilience as a transformative approach (Yamagata & Maruyama, 2016).

However, according to the focus of the paper is important to recall the significative relevance recognised of urban studies, and urban planning topic during the screening phase within the combination of the keywords "resilience" AND "socio-ecological resilience".

6.2. Objective 2: examining the urban resilience concept as a transformative approach

The developed review examines the evolution of urban resilience implementation across several disciplines and research fields, providing as a result a list of the most significative definitions concerning both research papers and political discourse (Table 2). Despite the

consideration of the urban resilience concept, the analysis of the considered definitions permits to identify some common elements, such as the description of urban resilience as complex, multidimensional and dynamic process (Meerow & Newell, 2015; Meerow et al., 2016). As well, it has been possible to state the main dimensions of urban resilience to be included in the evaluation, namely (1) physical, (2) natural, (3) economic, (4) institutional, and (5) social within the main key factors (Ribeiro & Pena Jardim Gonçalves, 2019).

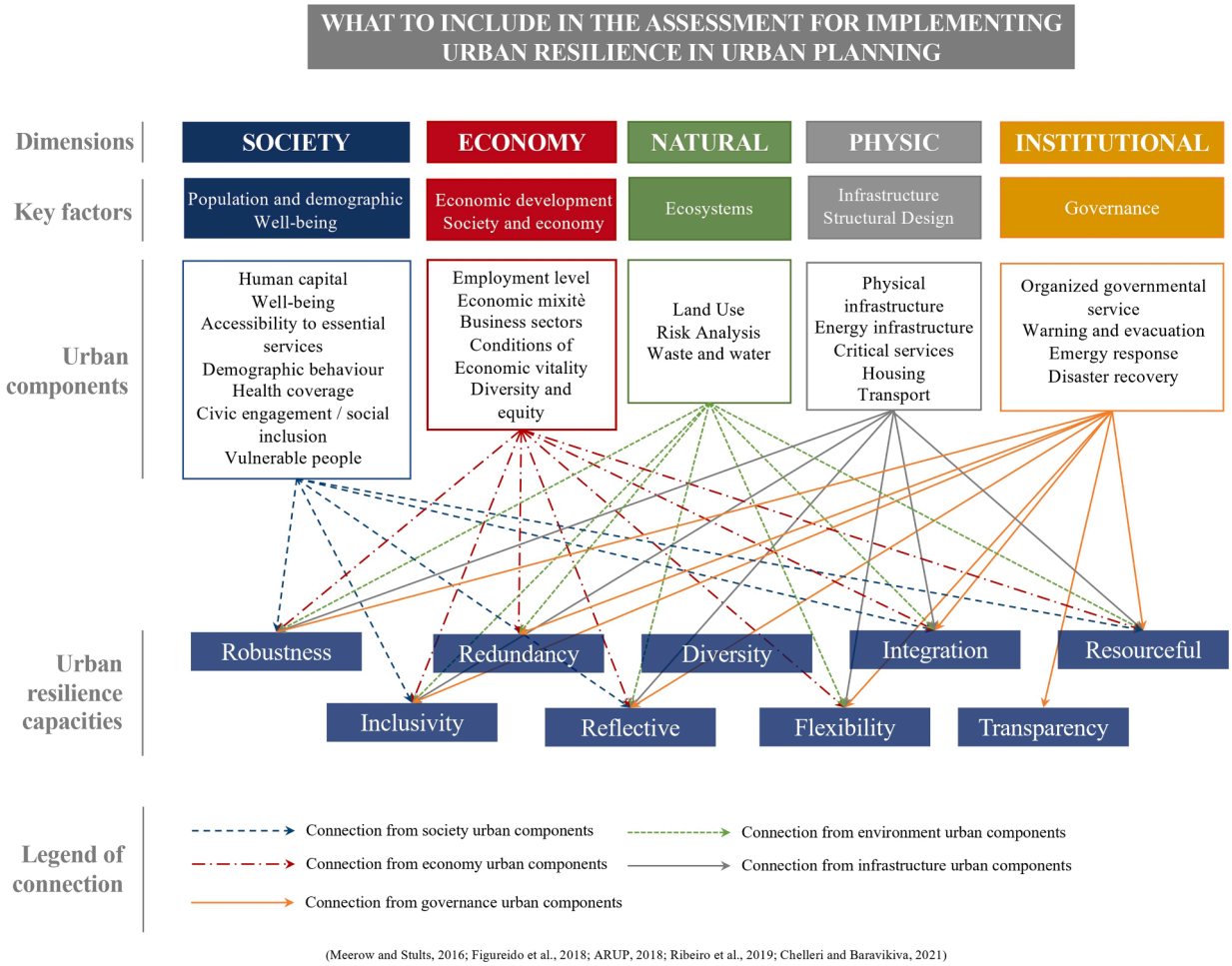
Moreover, assuming the fact that the concept of urban resilience has its conceptual basis on the socio-ecological approach of resilience, it can be stated that the implementation of urban resilience as a transformative approach in urban planning implies the conceptualisation of cities as ecosystems among others (Brown et al., 2018; Douglas, 1981; Odum, 2007). Therefore, operative implications concern the evaluation of urban resilience as a transformative approach in urban planning, according to the necessity to manage complexity and multidimensionality to support the definition of appropriate urban strategies within resilience enhancement perspective. It is thus necessary to identify which are the dimensions, elements, key factors, and capacities to engage in a comprehensive evaluation framework.

6.3. *Objective 3: identifying the capacities that urban systems should have to be/become resilient*

The identification of these nine urban resilience capacities to engage in the comprehensive evaluation framework is an important finding of the proposed research. In fact, including them in the evaluation framework it is possible to recognise in an operative way their contribution to enhancing resilience for cities, according also to their ability to make the application of the urban resilience concept operational for local stakeholders, translating it into concrete action (Da Silva & Moench, 2014). As well, the identification of cities' performance concerning these capacities permits to identify which are the main criticalities of the city, supporting the prioritisation of different interventions according to short, medium, and long-term temporal scales (Caprioli, Bottero, & De Angelis, 2023; Datola, Bottero, & de Angelis, 2021; Napoli et al., 2020; Oppio, Dell'Ovo, Torrieri, Miebs, & Kadziński, 2020).

6.4. *Objective 4: developing a comprehensive framework which collects urban resilience dimensions, key factors, urban components, and capacities to include in the evaluation*

This objective is the core of the present research, or rather the construction of a comprehensive framework that collects all the elements that have to be considered to manage and evaluate urban resilience as a transformative approach through the appropriate perspective, also respecting the implications of its implementation in urban planning (Davoudi et al., 2012; Masnavi et al., 2018). This framework is the result of the performed literature reviews within the relative critical analysis (Sections 3–5). Fig. 5 represents the proposed framework that collects all the aspects that have to be considered and investigated in evaluating urban resilience as a transformative approach, or rather: (1) dimensions, (2) key factors, (3) urban components, and (4) urban resilience



(Meerow and Stults, 2016; Figureido et al., 2018; ARUP, 2018; Ribeiro et al., 2019; Chelleri and Baravikiva, 2021)

Fig. 5. Framework that collects dimensions, key factors, urban components and urban resilience capacities to consider for urban resilience evaluation as a transformative approach.

capacities.

The framework firstly identifies the five dimensions concerning urban resilience as a transformative approach, or rather (1) society, (2) economy, (3) natural environment, (4) physical environment, and (5) governance. Secondly, it provides which key factors are related to the specific dimension. Thirdly, it recognises the urban components which address and permit to investigate urban resilience dimensions'. Finally, the nine selected urban resilience capacities are integrated, and the designed rows represent the linkages which occur between urban components and the touched capacity, which are identified by the examination of capacities definitions (Table 3). Therefore, it is possible to address the fact that urban components permit enhancing and achieving different urban resilience capacities at the same time. Fig. 6 represents the matrix that illustrates the connections between urban components and urban resilience capacities. This matrix is useful to identify which urban resilience capacities can be reached by different urban components. For instance, the urban component related to health coverage can affect different capacities at the same time.

Moreover, to better describe the functioning of the provided framework an example can be reported. For instance, when dealing with the social dimension of urban resilience, it is recommended to investigate population and demographic as key factors. These key factors can be explored by addressing, for instance, the component referred to vulnerable people that is related to the inclusivity and resourceful capacities.

More in detail, this framework has been conceived as an operative instrument to support researchers and evaluators in structuring the appropriate evaluation framework, according to the evaluation demand of urban resilience as a transformative approach. In fact, the urban components that are included in the proposed framework have been selected and listed to support the identification of suitable indicators to structure the appropriate evaluation framework according to the evaluation demand, respecting and including all the features of urban resilience as transformative approach in the evaluation (Zhao, Fang, Liu, & Zhang, 2022).

7. Conclusion

Urban resilience concept has become a central paradigm to define urban policy with the aim of making cities resilient. This paper explores

		URBAN RESILIENCE CAPACITIES									
		Robustness	Redundancy	Diversity	Integration	Resourceful	Inclusive	Reflective	Flexible	Transparency	Reference
SOCIETY	Human capital										Adapted from (Cutter et al., 2010; Tabibian & Rezapour, 2016; Zheng et al., 2018)
	Well-being										Adapted from (Cutter et al., 2010; Tabibian & Rezapour, 2016; Zheng et al., 2018)
	Accessibility to essential services										Adapted from (Cutter et al., 2010; Tabibian & Rezapour, 2016; Zheng et al., 2018)
	Demographic behavior										Adapted from (Cutter et al., 2010; Tabibian & Rezapour, 2016; Zheng et al., 2018)
	Health coverage										(Cutter et al., 2010; Figueiredo et al., 2018; Morrow, 2008; Norris et al., 2008)
	Civic engagement / social inclusion										(Cutter et al., 2010; Feldmeyer et al., 2019)
	Vulnerable people										Adapted from (Cutter et al., 2010; Tabibian & Rezapour, 2016; Zheng et al., 2018)
ECONOMY	Employment level										(Cutter et al., 2010; Feldmeyer et al., 2019)
	Economic mixite										(Adger, 2000; Campanella, 2006; Cutter et al., 2010; Feldmeyer et al., 2019; Suárez et al., 2016)
	Business sector										(Adger, 2000; Campanella, 2006; Cutter et al., 2010; Feldmeyer et al., 2019; Suárez et al., 2016)
	Economic vitality										(Cutter et al., 2010; Feldmeyer et al., 2019)
	Diversity and equity										(Cutter et al., 2010; Feldmeyer et al., 2019)
NATURAL	Land Use										(Feldmeyer et al., 2019; Fischer et al., 2018)
	Risk Analysis										(Feldmeyer et al., 2019; Gencer, 2017; Shi et al., 2021)
	Waste and water										(Feldmeyer et al., 2019; Tabibian & Rezapour, 2016)
PHYSIC	Physical infrastructure										(Cutter et al., 2014; Figueiredo et al., 2018)
	Energy infrastructure										(Feldmeyer et al., 2019)
	Critical services										(Cutter et al., 2014; Figueiredo et al., 2018)
	Housing										(Cutter et al., 2014; Figueiredo et al., 2018)
	Transport										(Cutter et al., 2014; Figueiredo et al., 2018)
INSTITUTIONAL	Organized governmental service										(Feldmeyer et al., 2019; Tabibian & Rezapour, 2016)
	Warning and evacuation										(Feldmeyer et al., 2019; Tabibian & Rezapour, 2016)
	Emergy response										(Feldmeyer et al., 2019; Tabibian & Rezapour, 2016)
	Disaster recovery										(Feldmeyer et al., 2019; Tabibian & Rezapour, 2016)

Fig. 6. Matrix to represent the connections between urban components and urban resilience capacities.

this challenge with a specific focus on implications concerning the assessment field. Despite the great attention given to the topic of urban resilience assessment (Amirzadeh et al., 2022), the literature does not provide a homogenous framework that comprehensively defines what elements should be considered in assessing urban resilience as a transformation approach considering all its peculiarities. Therefore, this research sets as its core the proposal of a comprehensive framework that includes all the elements to be considered in the evaluation of urban resilience as a transformative approach, in order to support in an operational way, the definition of appropriate valuation models.

To enrich this objective, the paper provides three different literature reviews supported by critical analysis to find answers to research questions and objectives and identify all the features and aspects to be included in the framework. Therefore, the main contribution of the proposed research is the comprehensive framework (Fig. 5) that defines dimensions, key factors, urban components, and urban resilience capacities, conceived to support researchers and evaluators in defining an appropriate evaluation framework able to consider both the features of urban resilience as a transformative approach and the specific requests of the evaluation demand.

However, behind this main result, some other evidence discussed in the proposed study can be summarized as follow:

- The analysis of conceptual differences of static end evolutionary approach of resilience has been useful to identify the conceptual basis of urban resilience as a transformative approach (Yamagata & Maruyama, 2016) to address its main characteristics to be engaged in the evaluation;
- The implication of conceptualising cities as econosystems (Douglas, 1981), among others, to use urban resilience as a transformative approach in urban planning;
- The encouragement of a long-term perspective in policy definition (Sellberg, Wilkinson, & Peterson, 2015; Stanganelli, Torrieri, Gerundo, & Rossitti, 2020), according to the perspective of implementing the initial conditions through urban resilience as a transformative approach.

Finally, some recommendations and suggestions can be provided to encourage and support the integration of the proposed framework in the urban resilience assessment tool. According to the discussed evidence, it is clear that tools able to analyse cities through a holistic perspective and to focus on their dynamics are required (Fu & Wang, 2018; Schwind, Minami, Maruyama, Ilmola, & Inoue, 2016). In this context, different simulation models are applied to investigate and evaluate the effects of strategic scenarios in achieving resilience over time (Assumma, Bottero, Datola, De Angelis, & Monaco, 2020; Miles & Chang, 2007; Peck, 2019; Simonovic & Peck, 2013). In the field of simulation models applied for urban resilience assessment, System Dynamics Models (SDM) represent valuable simulation and evaluation tool among others (Datola, Bottero, De Angelis, & Romagnoli, 2022; Feofilovs & Romagnoli, 2021; Lara, Pfaffenbichler, & Rodrigues da Silva, 2023; Li et al., 2023; Liang & Li, 2020; Simonovic & Peck, 2013) because of their ability to consider and represent the multidimensionality and complexity of the urban system (for more details see (Forrester, 1979)).

Therefore, according to the promising implementation of SDM for urban resilience assessment within the engagement of both complexity and multidimensionality, the future implementation of the illustrated evaluation framework (Fig. 5) concerns the implementation of an indicator-based SDM approach integrated with Multi-Criteria Analysis (MCA) (Bottero, Datola, & De Angelis, 2020). The SDM-based approach will be structured and organized starting from the proposed framework to address the effects of different urban strategies according to their effects over time, assessing thus their contribution to urban resilience enhancement.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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