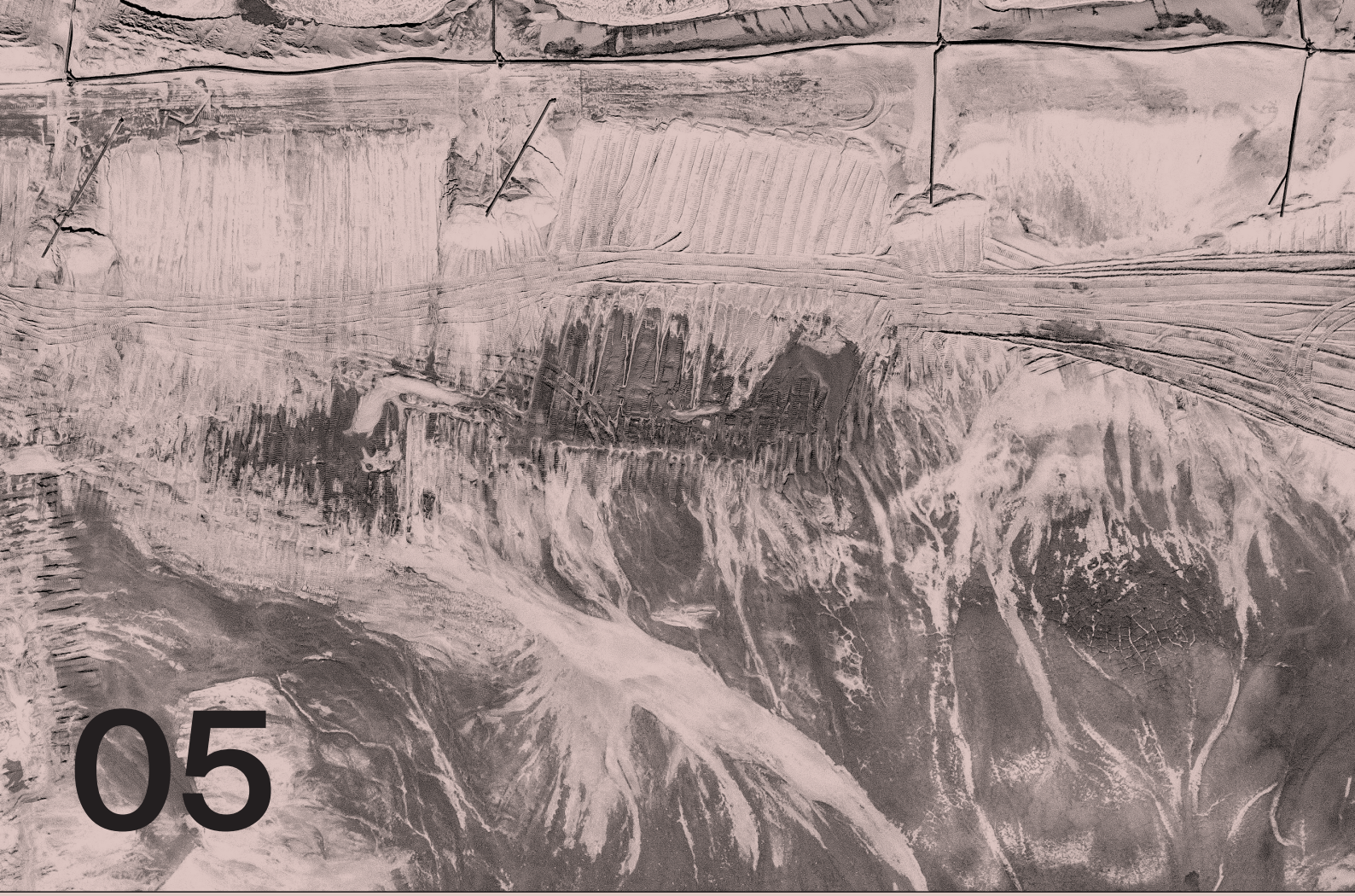
Evaluating Resilience for Forward-Thinking Urban Planning



05

GAIA, territori della biodiversità

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Evaluating Resilience for Forward-Thinking Urban Planning

Grazia Brunetta
Politecnico di Torino
DIST - Dipartimento Interateneo di Scienze, Progetto e Politiche del Territorio
Email: *grazia.brunetta@polito.it*

Ilaria Cazzola
Politecnico di Torino
DIST - Dipartimento Interateneo di Scienze, Progetto e Politiche del Territorio
Email: *ilaria.cazzola@polito.it*

Benedetta Giudice
Politecnico di Torino
DIST - Dipartimento Interateneo di Scienze, Progetto e Politiche del Territorio
Email: *benedetta.giudice@polito.it*

Manuela Rebaudengo
Politecnico di Torino
DIST - Dipartimento Interateneo di Scienze, Progetto e Politiche del Territorio
Email: *manuela.rebaudengo@polito.it*

Angioletta Voghera
Politecnico di Torino
DIST - Dipartimento Interateneo di Scienze, Progetto e Politiche del Territorio
Email: *angioletta.voghera@polito.it*

Abstract
The challenges posed by climate change and biodiversity loss necessitate a shift in urban and spatial planning to incorporate new methods, techniques, and strategies. Among the concepts that have gained prominence in recent years, resilience stands out as a key driver in redefining the disciplinary and technical boundaries of planning activities. Cities, viewed as complex socio-ecological systems, must be assessed based on their anthropogenic, environmental, social, economic, and institutional components, as well as the interconnections among these elements.
While there are many theoretical definitions of resilience in urban and territorial contexts, there have been relatively few practical applications that successfully operationalize this concept. To address this gap, our research, conducted as part of the PNRR RETURN project titled "Multi-Risk Science for Resilient Communities Under a Changing Climate", proposes methods and tools for measuring urban and territorial resilience. This approach integrates various dimensions of resilience and has been tested in the City of Turin.

Keywords: resilience, spatial planning, public policies

1 | Resilience: A holistic and transformative evaluation approach

Resilience is a critical concept in urban development and planning, as cities face an increasing number of challenges and stressors such as climate change, natural hazards, and rapid urbanization. Various resilience concepts have emerged over time in various fields (Davoudi et al., 2012), resulting in the lack of a widely shared definition. The rising prominence of urban resilience is also reflected in the expanding body of literature on the topic. In cities, we can apply the concept of "urban resilience" contextualizing it as a multi-faceted concept that encompasses the ability of cities to withstand and recover from acute shocks and chronic stresses. In particular, we assume the definition given by Meerow, Newell, Stults (2016: 45): «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».
Other issues arise when we try to evaluate urban resilience. Indeed, traditional methods for evaluating urban resilience often focus on specific risks and lack a holistic perspective. In this sense, the above-mentioned

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different dimensions of an urban system cannot find an adequate spot in resilience assessment frameworks (Sharifi & Yagamata, 2016). Furthermore, the transformative character of resilience has the potential to reframe planning practices and interventions (Giovannini et al., 2020) and involves harnessing disturbances as catalysts for positive change and innovation (Asadzadeh et al., 2022). Thus, integrating transformative resilience into planning practices and interventions becomes crucial for a more comprehensive and forward-thinking approach to promoting resilient urban environments.

This new perspective advocates for systemic changes that prioritize radical and non-linear transformations, fostering continuous adaptation and evolution. Resilience is seen as a dynamic force driving institutional, organizational, and social change rather than just passive resistance. Achieving this requires an interdisciplinary approach, leveraging diverse fields to promote systemic modification and adaptation. Flexibility and responsiveness are essential characteristics of governance needed to effectively implement these transformative resilience strategies over the medium-to-long-term at multiple levels across sectors (Brunetta et al., 2019; Brunetta & Voghera, 2023). Additionally, the emphasis on adaptability and maintaining essential functions aligns with the idea of resilience as an ongoing process, where territories continuously learn and evolve to enhance their capacity to overcome future shocks. This fresh perspective lays the groundwork for practical applications and interventions aimed at building and enhancing urban resilience.

This research aims to take a more holistic and comprehensive approach encompassing all dimensions by analyzing the existing literature on urban resilience. Based on the literature review, the research identifies dimensions, selects measurable indicators, and collects data to evaluate a city's strengths and weaknesses across different resilience capacities and the implications for future urban development and planning. The challenge of the research is to emphasize the importance of measuring resilience capacities – a city's inherent strengths that enable it to respond effectively to disruptions.

The starting point is the concept of resilience capacities that offers a promising approach to assess a city's potential to withstand and recover from diverse challenges (Suárez et al., 2016), considering the various dimensions of urban resilience. However, the lack of a universally agreed-upon definition presents a hurdle. Therefore, this research aims to explore the usefulness of this concept in understanding a city's inherent resilience (Foster, 2006) through a holistic evaluation. As it will be discussed, the resilience capacities can be used to interpret the socio-ecological system stressing some characterization: robustness, redundancy, diversity, integration, inclusivity, transparency, flexibility, reflectiveness, and resourcefulness (Ribeiro & Gonçalves, 2019). In fact, a resilient territorial system should be:

- *Robust*, able to manage shocks, without experiencing significant disruptions, emphasizing the aspect related to a well-designed, well-constructed, and well-maintained urban system, capable of enduring hazardous events without incurring substantial damage or losses (Bruneau et al., 2003; Godschalk, 2003; Kim & Lim, 2016).
- *Redundant*, capable of referring to a systemic backup and maintaining crucial services, even if primary systems are compromised (Ahern, 2011; Bruneau et al., 2003; Godschalk, 2003).
- *Diverse*, characterized by plenty of resources, systems, and approaches within a city that can provide alternative solutions or responses to challenges. Systematic diversification allows for an improved ability to adapt across various circumstances (Ahern, 2011; Allan & Bryant, 2011; Desouza & Flanery, 2013; Godschalk, 2003).
- *Integrated,* the connection of all institutional or social activities: from decision-making processes for fostering a broader understanding of challenges and promoting a collaborative approach to resilience building. This approach aligns policies and emergency response mechanisms to develop comprehensive resilience strategies across urban planning, resource management, crisis response, and sustainable solutions (Coaffee, 2008; Godschalk, 2003; Spaans & Waterhout, 2017).
- *Transparent,* the system should be open and effective in all municipal processes and operations, with the goal of ensuring coherent and transparent decision-making. This element is also linked to promoting inclusivity (Tanner et al., 2009; Tyler & Moench, 2012).
- *Flexible,* capable of adjusting or innovating in order to fulfill requirements and accommodate changing initial conditions. Flexibility refers to the system's capability for transformation, development, and adjustment when faced with alterations (Adger, 2010; Godschalk, 2003).
- *Reflective,* capable of reflecting on past experiences, evaluating actions, and applying lessons learned to future resilience planning. This capacity is tied primarily to governance dimensions and its openness to community engagement (Ahern, 2011; Godschalk, 2003; Leichenko, 2011).

- *Resourceful,* capable of integrating diverse resources into urban resilience planning, enabling cities to effectively handle modern challenges and lay a foundation for long-term sustainability (Bruneau et al., 2003; Kim & Lim, 2016; Spaans & Waterhout, 2017).

2 | Exploring existing approaches to evaluate resilience

Understanding the metrics and indicators used to evaluate urban resilience is essential for effectively gauging the progress and impact of resilience-building initiatives. To gain insight into these efforts, a selection of 39 academic papers that address the topic of urban resilience measurement have been analyzed. The records gather findings with different characteristics. The presence of a map often suggests spatially explicit indicators, allowing for a visual representation of resilience patterns across a city. However, this characteristic is not always present, not allowing an immediate interpretation of indicators. Furthermore, many studies lack clear formulas for calculating indicators, relying on descriptions or recognizable justifications (Figure 1). Furthermore, the same indicator may have varying units of measurement and definitions across studies due to differences in interpretations, contexts, and data availability. This underscores the necessity to adapt indicators for specific applications that are sensitive to local conditions. In addition, selected studies consider factors like timeframes and spatial scales (Figure 2), and the different dimensions (Figure 3) and capacities (Figure 4) of resilience.

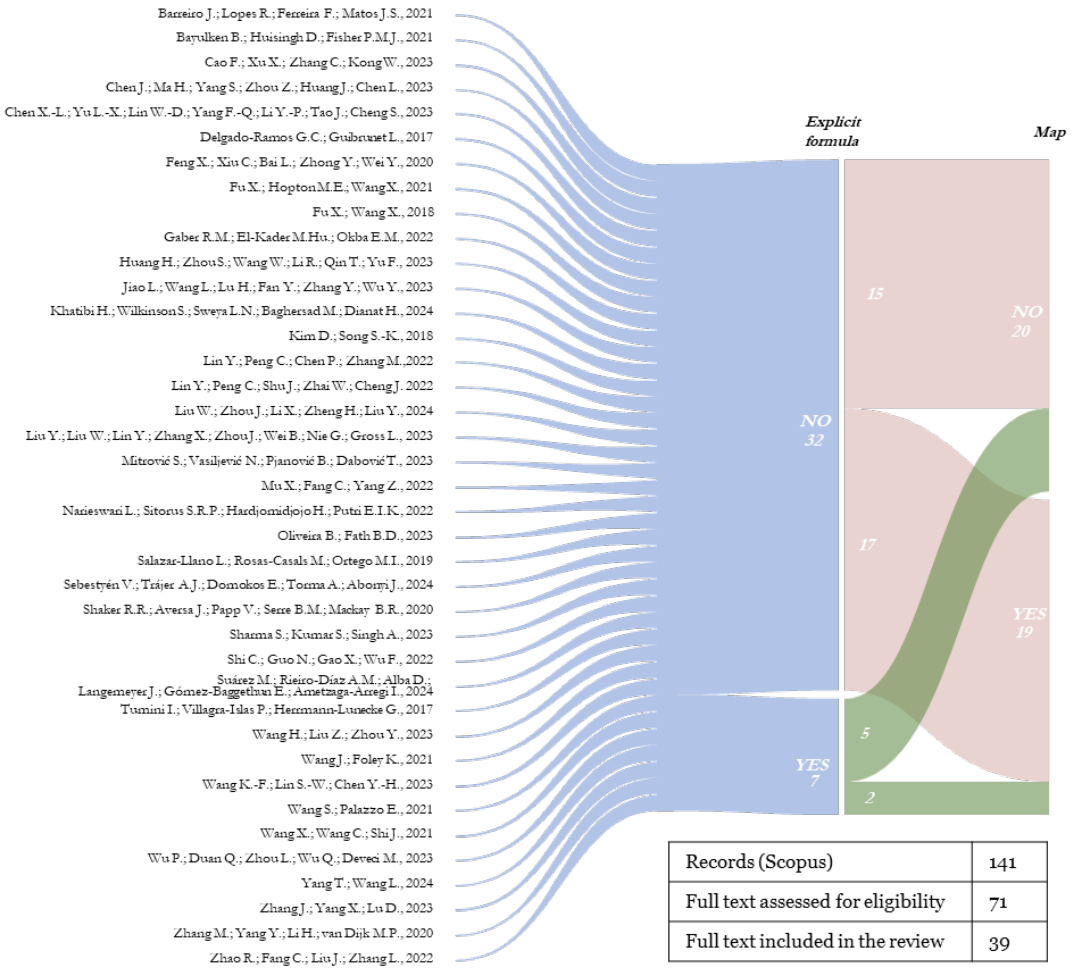

Figure 1 | Categorization of selected records by Explicit Formula and Presence of Map.
Source: authors' elaboration.

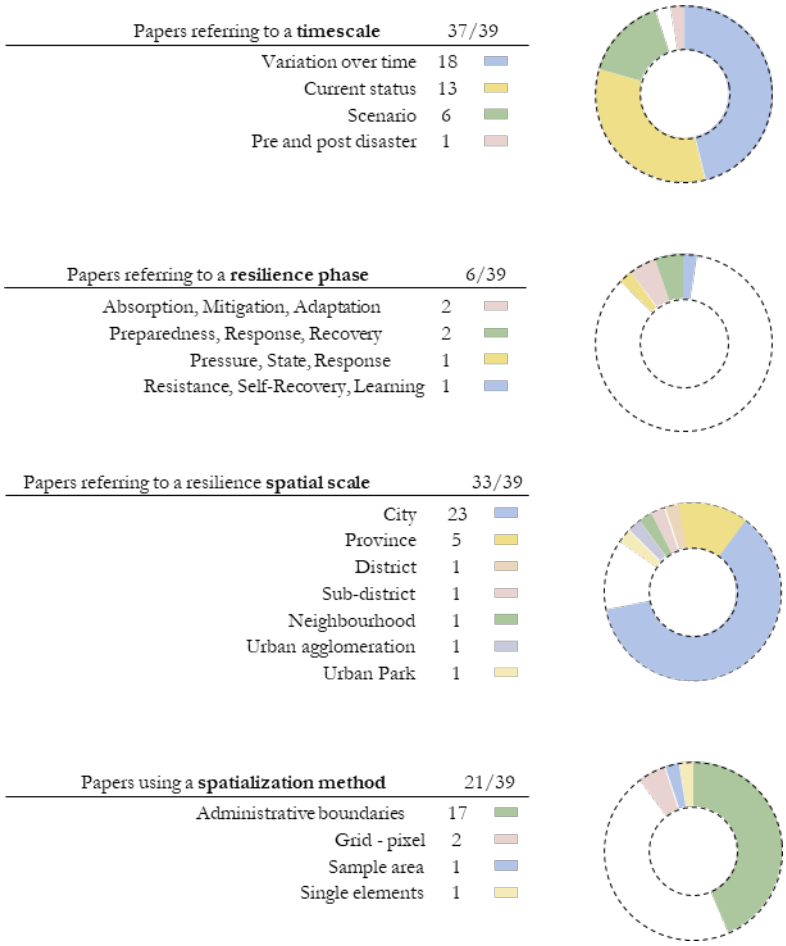

Figure 21 | Resilience timescales, phases, spatial scales and spatialization methods in the selected literature. Source: authors' elaboration.

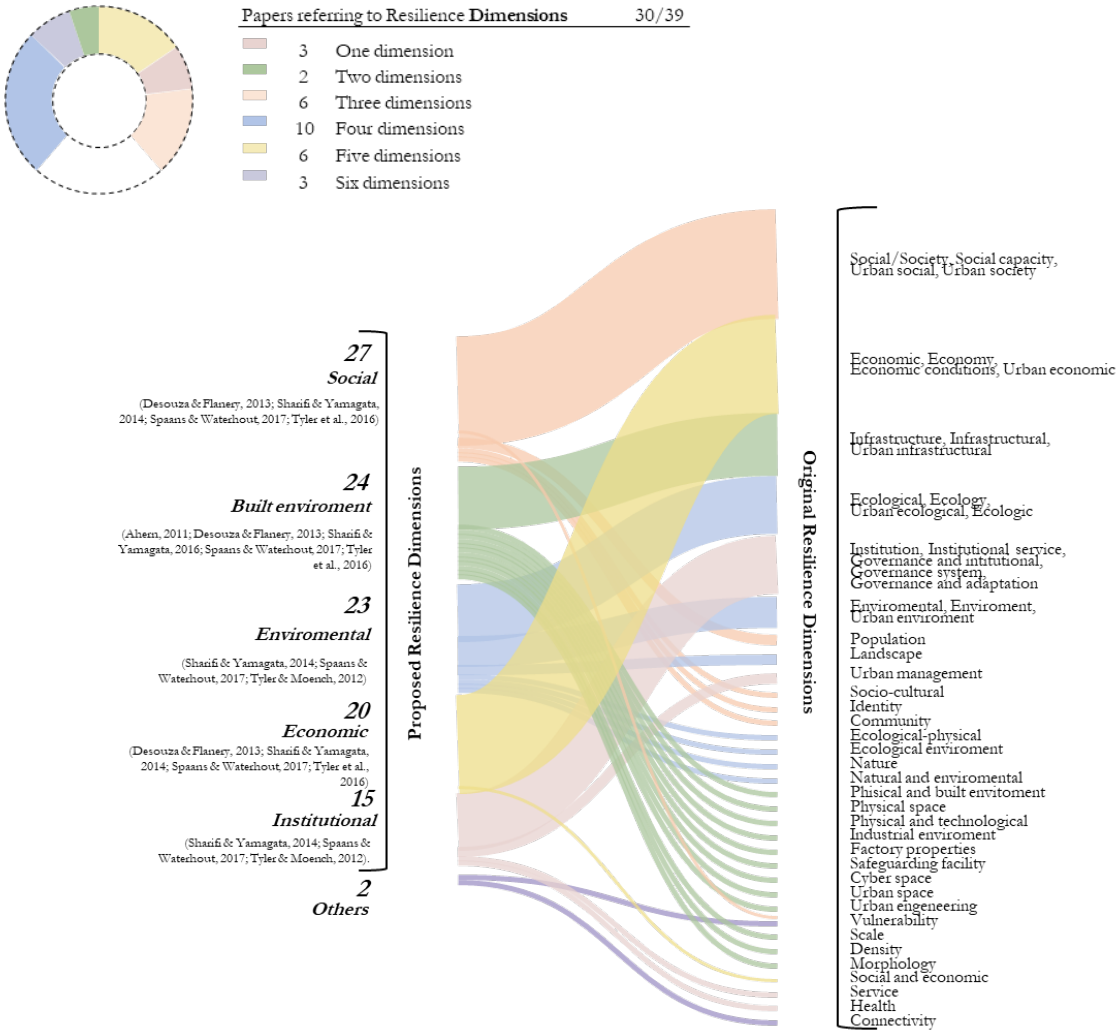

Figure 3 | Number of resilience dimensions used in the selected literature and harmonized resilience dimensions. Source: authors' elaboration.

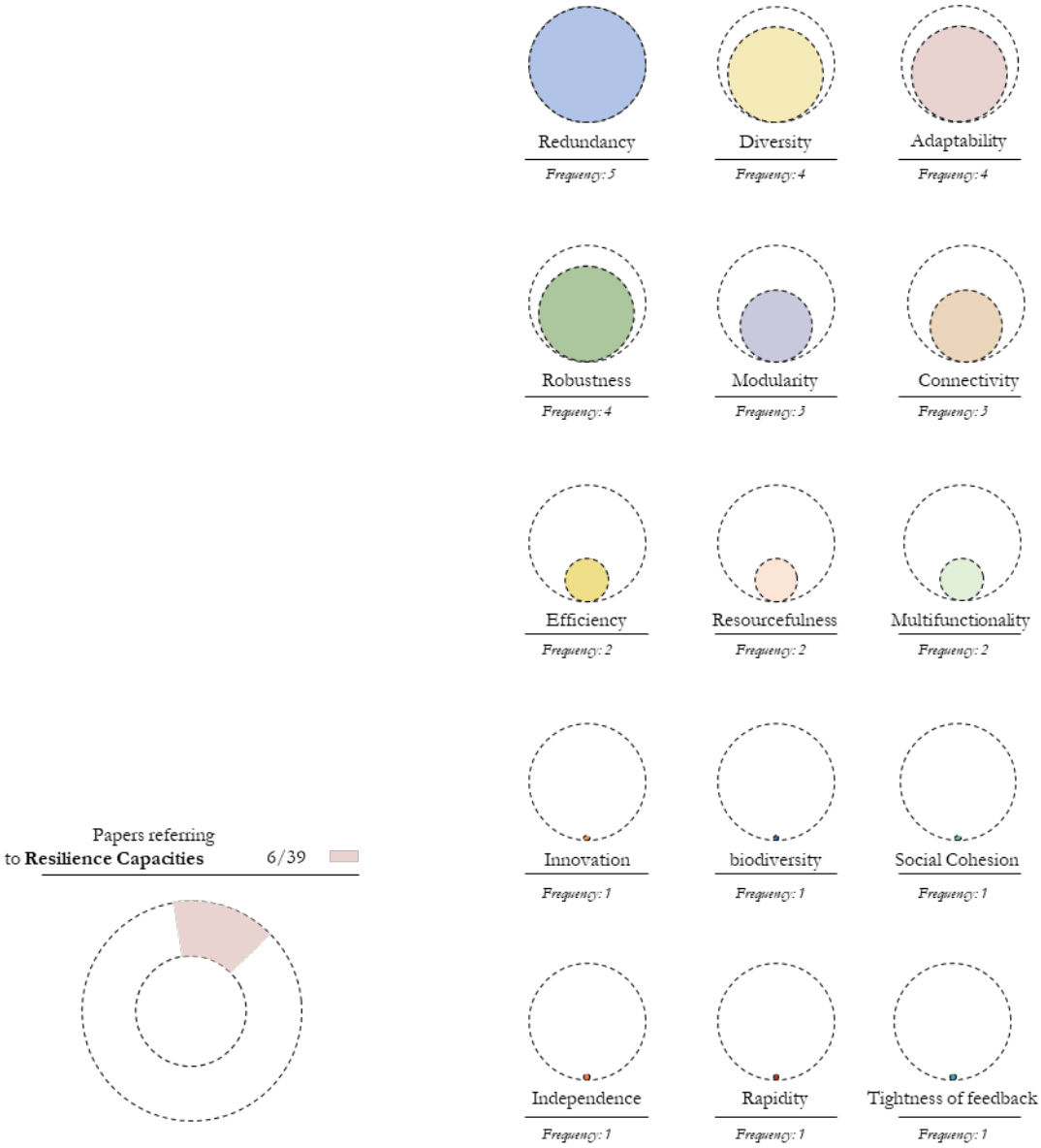

Figure 4 | Resilience capacities in the selected literature and their frequency.
Source: authors' elaboration.

3 | Multidimensional Framework for Resilience Evaluation

A significant portion of existing research neglects the holistic nature of urban ecosystems (Rus, Kilar, Koren, 2018). This results in assessments that are limited to specific systems, failing to capture the complex interplay between environmental, social, economic and institutional aspects of urban resilience. The prevalent approach of focusing on selected urban components when assessing resilience in the face of specific disasters generates incomplete results (Rus et al., 2018). Starting from this assumption, this research aims to integrate the different dimensions of the urban system into a single framework for measuring resilience.
Based on the proposed taxonomy (WP 5.2.1 of the RETURN project), we propose integrating and re-organizing the urban components considered according to the five dimensions of resilience: the built environment, the environmental, the social, the economic, and the institutional dimension (Figure 5).

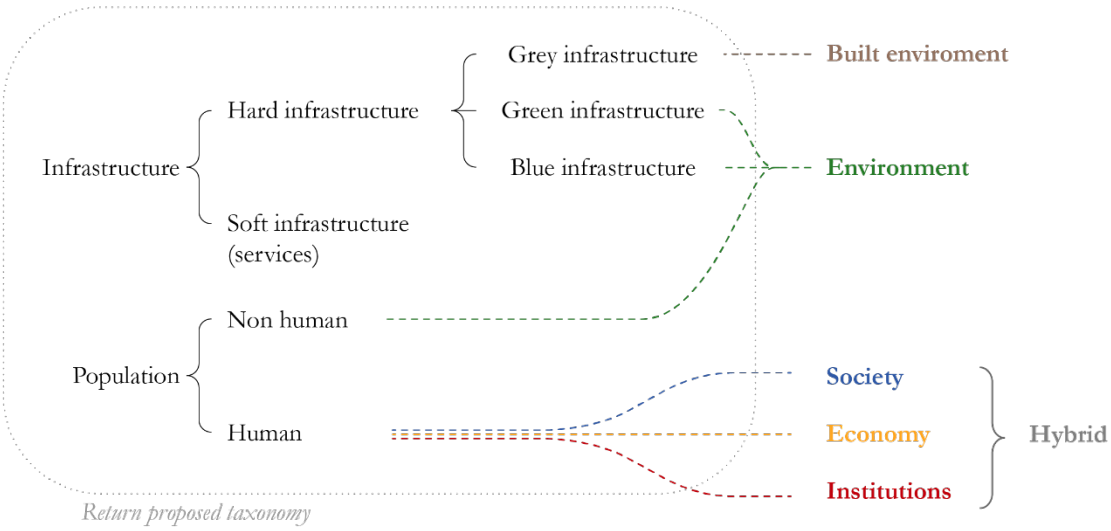

Figure 5 | Re-organization of the taxonomy proposed by WP 5.2.1
Source: authors' elaboration.

Each dimension plays a significant role in enhancing a city's resilience (Chen et al., 2019; Ostadtaghizadeh et al., 2015; Patel & Nosal, 2016; Ribeiro & Gonçalves, 2019):

- *Built environment*
  This dimension of urban resilience focuses on the built environment and infrastructure of a city. It examines the capacity of physical structures, such as buildings, transportation systems, and utilities, to withstand and recover from acute shocks, including natural disasters and infrastructure failures. This dimension also encompasses the importance of resilient urban design and architecture to mitigate the impact of external hazards and ensure the safety and functionality of urban spaces (Ahern, 2011; Desouza & Flanery, 2013; Sharifi & Yamagata, 2016; Spaans & Waterhout, 2017; Tyler et al., 2016).
- *Environmental dimension*
  The environmental dimension of urban resilience involves the city's ability to mitigate and adapt to environmental risks and challenges such as natural disasters, climate change, and pollution. It includes the preservation of green spaces, sustainable land use planning, measures to protect air and water quality, the preservation and restoration of natural ecosystems, the implementation of sustainable resource management practices, and the reduction of environmental risks to enhance a city's overall resilience to environmental stressors (Sharifi & Yamagata, 2014; Spaans & Waterhout, 2017; Tyler & Moench, 2012).
- *Economic dimension*
  The economic dimension of urban resilience focuses on the financial stability and adaptive capacity of cities in the face of economic shocks and disruptions. It includes strategies for economic diversification, job creation, and investment in resilient business practices, aiming to build a robust economy that can withstand and recover from economic downturns and crises (Desouza & Flanery, 2013; Sharifi & Yamagata, 2014; Spaans & Waterhout, 2017; Tyler et al., 2016).
- *Social dimension*
  The social dimension underscores the importance of community cohesion, social equity, and inclusivity in building resilient cities. It involves fostering strong social networks, promoting community engagement, and addressing social disparities to ensure that all segments of the population can effectively cope with and recover from social and economic challenges (Ahern, 2011; Allan & Bryant, 2011; Desouza & Flanery, 2013; Sharifi & Yamagata, 2014; Spaans & Waterhout, 2017; Tyler et al., 2016).
- *Institutional dimension*
  The institutional dimension of urban resilience revolves around governance, policy frameworks, and institutional capacities. It assesses the effectiveness of urban governance structures, emergency response mechanisms, and regulatory frameworks in facilitating coordinated and efficient responses to crises and in enabling long-term resilience planning and implementation (Coaffee, 2008; Desouza & Flanery, 2013; Leichenko, 2011; Sharifi & Yamagata, 2014; Spaans & Waterhout, 2017; Tyler & Moench, 2012).

These dimensions must be interpreted as interconnected entities rather than isolated fields since urban elements frequently span multiple dimensions instead of fitting neatly into just one (Table I).

Table I | Categories and their relationship with resilience dimensions.

	Dimensions				
Categories	BUILT ENVIROMENT	ENVIRONMENTAL	ECONOMIC	SOCIAL	INSTITUTIONAL
Buildings	X	X			X
Infrastructures	X			X	
Consumptions	X				
Education	X			X	
Ecosystem services		X	X		
Land Use	X	X			
Green Areas	X	X		X	X
Resources		X			
Pollution		X			
Heritage	X	X		X	
Landscape		X			
Income			X	X	X
Expenditure			X		X
Employment			X	X	
Demography	X		X	X	X
Social Equity			X	X	
Planning	X	X		X	X
Emergency	X			X	X
Health	X				X

4 | From the review to the proposal

The evaluation of the resilience capacity is based on an interdisciplinary approach dealing with the literature review (n. 39 papers selected, 970 indicators/indexes collected, 115 indicators/indexes included in a first selection). Starting with the taxonomy proposed by the project (WP 5.2.1), the catalogue of indicators is composed of a set of indicators/indexes that can be used to evaluate the dimensions of the built environment and the environmental, economic, social, and institutional characterization of territories. Indeed, resilience capacity evaluation is a complex topic due to the various disciplines involved. Different indicators are associated with distinct "taxonomy fields", each with its own goals and types of applications. The method can focus on multiple dimensions of the resilience capacity of a socio-ecological system, employing a range of assessments and/or evaluation techniques, both qualitative and quantitative. The set of indicators or indexes can be used to "interpret" the current state of the art and the potential transformation scenarios and monitor and measure conditions and processes relevant to the evaluation.
Additionally, the indicators/indexes can be used to "evaluate the resilience functions" by quantifying the local conditions, considering the processes and the human and institutional actions/policies and their effects on territorial resilience. The objective is to evaluate the resilience capacity to define policies at the territorial, local, and district scales. These indicators or indexes can guide specific "resilience capacities/functions", thereby supporting policy actions. All of these functions are effectively represented throughout the phases of the Strategic Environmental Assessment (SEA) process: screening, scoping, and monitoring.

Built Environment	Environmental	Social	Economic	Institutional	ID	Resilience indicators	Topic	Definition	Frequence of Sources	Source ID	Direction	Formula	Unit
					61	**Forest cover**	**Natural/green spaces**	proportion of forest coverage over the total area	3	37, 48, 214	positive	$N = \frac{A_f}{A}$ *N= Green coverage, expressed as a percentage* A_f *= global surface of the forest coverage* *A= surface of the selected area*	%
					62	**Green coverage (natural and seminatural areas)**	**Natural/green spaces**	proportion of green coverage of a selected area	5	37, 48, 58, 126, 173	positive	$N = \frac{A_g}{A}$ *N= Green coverage, expressed as a percentage* A_g *= global surface of greening coverage* *A= surface of the selected area*	%
					63	**NDVI**	**Natural/green spaces**	normalized difference vegetation Index	3	100, 177, 182	positive	$N = \frac{NIR - Red}{NIR + Red}$ *N= Normalized Difference Vegetation Index where Red and NIR stand for the spectral reflectance measurements acquired in the red (visible) and near-infrared regions, respectively*	adimensional
					64	**Permeable surface**	**Natural/green spaces**	proportion of permeable surface over the total area	4	36,44,14 9,178	positive	$N = \frac{A_p}{A}$ *P= Permeable surface* A_g *= global surface of the permeable area* *A= surface of the selected area*	%
					65	**Protected areas**	**Natural/green spaces**	protected areas in percentage of total land	1	30	positive	$N = \frac{A_p}{A}$ *N= Protected areas, expressed as a percentage* A_g *= global surface of the protected areas A= surface of the selected area*	%
					66	**Public Urban Trees**	**Natural/green spaces**	presence of trees planted along streets, roadsides and sidewalks, etc.	1	120	positive	$N = \frac{L_{tr}}{L_t}$ *N= Street trees* L_t *= lenght of street trees in the selected area* L_t *=total streets/roads lenght in the selected area*	%
					67	**Tree cover density**	**Natural/green spaces**	extent of land area covered by the canopy of trees	2	9, 173	positive	$N = \frac{A_c}{A}$ *N= Tree cover density* A_c *= area covered by tree canopy* *A= surface of the selected area*	%
					68	**Wetland area ratio**	**Natural/green spaces**	ratio of wetland area to the jurisdictional area	2	28, 214	positive	$N = \frac{A_w}{A_l}$ *N= Wetland area ratio, expressed as a percentage* A_r *= surface of wetland area* A_l *= global surface of the selected area*	%

Figure 6 | An example of the indicators/indexes proposed.
Source: author's elaboration.

However, since « A compatible set of indicators may be difficult to achieve and, frequently, the assessment process may reveal inconsistencies» (Fischer, 2007: 40), it will be necessary to adapt the catalogue for each local condition of the chosen case studies. Still, the choice also depends on:

1. the type of application (from assessment of the current resilience capacity -state of the art- to the evaluation of the possible scenarios of transformation related to planning scopes or diverse institutional policies);
2. the characteristics of the territory and the conditions of the built environment, and the environmental, economic, social and institutional conditions and the relevant territorial risks and vulnerabilities;
3. the presence of existing open databases in order to have a good level of transferability.

The indicators will help measure various territorial conditions at different scales. Indeed, to effectively aid in policy development and design, the catalogue serves as a flexible tool that incorporates multiple layers of knowledge. It also establishes a minimum scale of significance to determine when an indicator can contribute to achieving the resilience capacity of a territory.

5 | Final considerations

While the initial set of indicators derived from the literature database provides a valuable foundation, its focus on Scopus-indexed literature limits its ability to capture the unique features of a specific place, particularly in terms of understanding that contributes to resilience capacities. Resilience is inherently place-based and site-specific, which poses a challenge for evaluation approaches that aim to measure the diverse aspects in a GIS-based map. Conducting resilience mapping could be an essential path to supporting decision-makers and policy and planning design.

In addition to selecting the most appropriate indicators, it is essential to compare them to data availability and reference scale to ensure they align with the specific application and intended policy objectives. Currently, there is an imbalance in the distribution of indicators. Key aspects, such as heritage, cultural memory, and identity – crucial for interpreting territorial resilience – are significantly underrepresented.

To achieve a more comprehensive evaluation, this catalogue should be expanded to include diverse sources beyond Scopus, including grey literature, institutional documents, and publications from relevant non-indexed journals. Many other recognized sources and findings stem from previous research projects and it is also important to consider the potential of local databases. The database setting is a strategic aspect of the activity of evaluation: the data set selection needs to be based on structured and continuously updated databases. Indeed, evaluating territorial resilience capacities should accompany the planning activities throughout their diverse phases (ex-ante, in itinere, and ex-post). A major challenge of the evaluation process is identifying effective and sensible indicators or indexes that can be used for monitoring.

The next step should involve selecting a suitable catalogue of indicators and indexes that can be tested across the various case studies of RETURN (from Bisenzio to Po rivers, as well as interpreting the transformations in areas like Bagnoli, Cagliari and Bolzano).

Attributions

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Note

0. Indice

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