Towards European Dimensions of City Resilience

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Abstract. Disaster resilience is becoming more important and raises the highest concerns worldwide, including in Europe. Cities have a vital role for resilience because a majority of the population resides in the cities. Despite the recognition of the importance of city resilience, there is no strong consensus what city resilience is and its dimensions, and how the resilience concept should be transferred into management practice in the cities. In this paper, we conduct a survey of EU sectorial approaches in terms of EU-funded projects related to climate change and critical infrastructure, where urban or city resilience are in focus. The goal is to obtain an overview of how the resilience concept is interpreted, used, and applied in different EU sectors or in cross-sectorial areas. The aim of this paper is to devise a set of schemes on components that should exist as pillars for supporting the European dimension of city resilience. The paper presents three models derived from the concepts, definitions, and applications in different EU-funded research projects. How "urban" resilience has been considered in the European context so far, and how a "resilience backbone" for Europe can be established, are among the issues examined in this paper.

Keywords: City resilience · Resilient dimensions · European dimension of resilience · Disaster resilience

1 Introduction

Disaster resilience is becoming more important and raises the highest concern world-wide, especially in Europe, where resilience is a top priority and a subject to an active campaign, putting city and community resilience in the core [1]. The frequently cited definition of resilience from UNISDR suggests it as "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" [2]. Currently, however, the city resilience as a unit for analysis is still not well defined. Besides, there is no single, agreed-upon definition. The network of 100 Resilient Cities, for instance, defines urban resilience as "the capacity of individuals, communities, institutions, business, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience." The example of the

chronic stress in urban areas can originate from critical infra-structure problems (such as inefficient public transport system, food shortages); climate change (water scarcity, heatwaves) or social problems such as a high rate of unemployment. In Europe, the needs to incorporate resilience into the city plan are evident [3–5], as more and more cities have formulated their city resilience strategies such as in London [6], Copenhagen [7], or Rotterdam [8]. Despite the development of resilience networks worldwide or at European level, there is no strong consensus what city resilience is and its components or dimensions, and how far resilience concept has entered, and been interpreted and implemented in different policy areas. Besides, ideas on how to subsume resilience into management practices are still vague, as diverse problem areas require different definitions of resilience, and in turn, result in various designs of practicing it (See publications of Resilient Cities Series on various urban resilient strategies and experience worldwide in http://resilient-cities.iclei.org/.). How the European dimension should interact in the city resilience context adds complexities of how this concept should be discerned.

One way to understand the fragmented discussions and approaches to resilience in various sectors in Europe is by conducting a desk survey of EU funded projects as done in this paper. This paper examines various resilience conceptual and practical point of view with respect to climate change and critical infrastructure, with urban or city resilience in the core. The goal is to obtain an overview of how the resilience concept is interpreted, used and applied in different EU sectors or a cross-sectorial area. The main contribution of this paper is to devise a set of schemes identifying components that should serve as pillars of a city, that can further be a backbone for supporting European resilience. The paper presents three models derived from the concepts, definitions, and applications in different EU-funded research projects.

In Sect. 2 we describe how cities have been represented and projected within EU policies. In Sect. 3 we propose methods to extract concepts and applications of resilience in different EU-funded research projects. Section 4 summarizes the "keywords" of the general definitions of resilience, filtered from EU project literature and proposals that provided the working definitions of different resilience dimensions. This section also elaborates and discusses the proposal to strengthen the EU dimension of city resilience. Section 5 concludes and summarizes the findings in this article.

2 Existing City Elements in EU Policies

There are various programs, initiatives and policies to provide a vision for "cities" in Europe. We identify that urban areas have been projected as Green Cities, as Open Cities, as Resilient Cities, as Innovative Cities and Creative Cities. By recognizing this, we ensure that the contribution of this article can be relevant and fills the gap between existing policies and approaches to the cities in Europe. In the next section, we summarize the perspective on Green Cities, Open Cities, Innovative-Creative Cities, and Resilient Cities—which is this paper's focus.

Green Cities represent ideas, policies, initiatives and projects within sustainable urban mobility environmentally friendly cities targeting zero CO_2 emissions (See http://ec.europa.eu/transport/themes/urban/urban_mobility/; ELTIS, http://www.eltis.

org/, and CIVITAS, http://www.civitas-initiative.org/). Thus, the focus lies upon measures and policies on controlling urban pollution, improving the air quality, promoting urban sustainability and intelligent mobility, and increasing the amount of green spaces in cities. The use of environmentally friendly transport and sustainable products is highly emphasized. The establishment of targets and limits for different pollutants can be used as a tool to control air quality, as well as waste management and urban wastewater treatment. Initiatives at city level have been started; for example, the Covenant of Mayors (www.covenantofmayors.eu) aims to significantly limit CO_2 emissions. Energy efficiency for mobility, and other areas that consume significant amounts of energy have been introduced.

Open cities focus on how to make buildings, cities and environments more age-friendly (to all age groups) (See EU policy for active and healthy ageing http://ec. europa.eu/eip/ageing/actiongroup/index/d4). In addition, open cities also focus on the implementation of EU integration policies (See EU policy for integration, (https://ec. europa.eu/migrant-integration), since cities are responsible for a wide range of services provided to migrants, and they play a major role in shaping the interaction between migrants and the society that welcomes them. Rome is a unique example of this case (See EU and Roma, http://ec.europa.eu/justice/discrimination/roma/).

Innovative and creative cities highlight the richness and diversity of European cultures as a part of EU's aim for smart, sustainable and inclusive cities and stimulus for dynamism, creativity, and social inclusion. Smart cities (See http://ec.europa.eu/eip/ smartcities/) and communities European Innovation Partnership, iCapital (See https://ec. europa.eu/research/innovation-union/index_en.cfm?section=icapital&pg=home), European Capital of Culture (See European Capitals of Culture (https://ec.europa.eu/ programmes/creative-europe/actions/capitals-culture_en), European heritage label (See https://ec.europa.eu/programmes/creative-europe/actions/european-heritage-label_en) are among examples of initiatives under this category.

Resilient cities emphasize how to make cities in Europe more resilient against unexpected events. In April 2013, the EU strategy on adaptation to climate change also committed to making Europe more climate resilient. The effects of climate change will have far-reaching consequences across Europe, and climate adaptation is needed to protect people, buildings, infrastructure, businesses, and ecosystems. We have seen that policy, strategy and actions have been proposed or formulated. However, there is still a lack of clarity regarding how city resilience is operationalized and serves as a backbone across Europe. An EU-funded project Smart Mature Resilience (SMR) is an example of a project extending city resilience toward overall European resilience. In this paper, relevant concepts that can be useful to extend city resilience into over-all European Resilience are gathered, using the method explained in Sect. 3.

3   Methods

A desk survey was conducted to examine how resilience was applied and used in different EU sectors and to extract necessary elements that can be adapted for shaping the city resilience. The search targeted projects related to Critical Infrastructure (CI) and Climate Change (CC). Systematic mapping study was applied, encompassing

the examination of relevant EU policies, EU funded project deliverables, and corresponding journal articles [9–11]. Catalogues of FP7 and H2020 projects were examined, i.e., (1) Catalogue of EU funded projects in Environmental Research 2007-2011 FP7 Theme 6– Environment (including climate change); (2) Catalogue of R&I Projects 2014 Climate action, environment, resource efficiency and raw materials Horizon 2020; (3) Catalogue of Security Research Projects under the 7th Framework Programme for Research, EU Research for a Secure Society: (4) EU policy documents, especially related to CI and CC policies.

The following procedure was performed when searching for relevant EU sectorial projects: (1) Identifying projects where the resilience issues are very likely to be addressed, both under FP 7 and Horizon 2020 calls; (2) Filtering project titles and abstracts using keyword "resilience"; and then "city" or "urban"; and lastly using "critical infrastructure", "protection", or "climate change"; (3) manual filtering by going through the project websites to verify if the identified projects were relevant, e.g. if the project actually is about resilience, or only mentioned it as a part of another irrelevant context; (4) examining more closely the project reports and deliverables to be included in the review. In total, 13 projects related to Environment (Climate Change) FP7, 18 projects under Secure Societies FP 7 calls, 3 projects under Climate Action environment H2020 and 4 projects under Secure Societies H2020 were reviewed. In total, we looked at 170 documents (reports, deliverables and scientific reports of each project, if any). We created a framework for review prior to examination, organized the relevant information into the framework and extracted further content that potentially can contribute shaping understanding of city resilience. In this paper, we only present the most important elements of resilience found in our survey, i.e. the synthesis of the resilience definitions has been applied in various unit of analysis in different research projects, and resilience elements that are transferred into three models of resilience dimensions in Sect. 4.

4   City Resilience Dimensions and Definition

4.1   Resilience Dimensions and Definitions

Note, the goal of this section is not to discuss deeply the various definition of resilience in the literature. We rather try to identify the unit of analysis when the resilience concept is applied, which is then called "dimensions" in this paper. Through the review efforts, we have collected and filtered different definitions of resilience both from different authors and projects' operational definition that have been cited in the selections of EU project deliverables.

There is a batch of definitions, with many coming from the same sources, and some try to adapt in accordance with the context (i.e. resilience to what? for example, the resilience to flooding). The definitions compiled in this section are presented as the collection of main keywords that are frequently used and become the main essence of the resilience concept. We extract the main concepts from the definitions and try to find the occurrence of a set of keywords in all identified definitions from literature, to understand the common words describing resilience. We present two collections of

keywords summarized in two charts in Fig. 1: the left figure is the keywords derived from CI literature and the right figure derived from CC literature. We collected 111 definitions from CI literature and 58 definitions in CC literature. From the charts, we have seen that the terms ability/capability, adapt, recover, absorb, change, and resists are the most popular words to capture resilience (to hazards, disturbances, unexpected events, abnormal situations). The following terms have been used in the literature as a unit of analysis when applying resilience concept:

- Urban/city resilience. The terms such as space or spatial resilience are also found to refer to a city or urban area. It also covers urban built infrastructure resilience.
- Ecological, socio-ecological resilience.
- Critical infrastructure, smart grid, technical, communication resilience [12–16].
- Cyber-security resilience [17].
- Chemical, biological, radiological, nuclear and explosive (CBRNE) resilience [18–20].
- Economic resilience [16].
- Organisational/local government resilience [21].
- Community/societal resilience/public/neighbourhood resilience [22–25].
- Individual resilience, psychosocial, psychological resilience [26].

The summary of this tentative definition of each dimension is shown in Table 1. Note that these definitions are squeezed out of a cluster of definitions on a specific unit of analysis or dimension. In other words, the definitions have been grouped and categorized before they are merged and extracted, both definitions stemming from CI and CC literature.
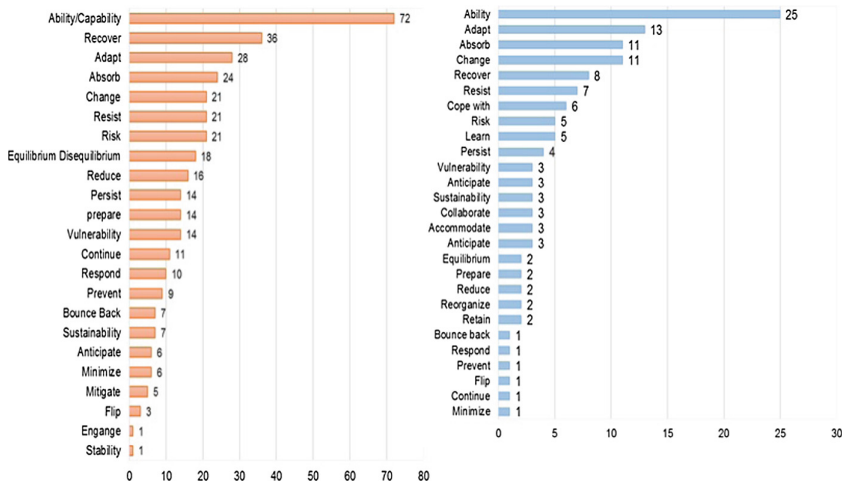

Fig. 1. Common keywords of resilience definitions cited in EU-CI literature (left) and EU-CC literature (right).

Table 1. The summary of the definition of each resilience's dimension.

Definitions
Urban or City Resilience consists of a mixture of resilient built-in environments, resilient design, resilient citizens, and resilient organisations. Resiliently built environments should be designed, located, built, operated and maintained in a way that maximizes the ability of built assets, associated support systems (physical and institutional) and the people that reside or work within these built assets, to withstand, recover from, and mitigate the impacts of extreme natural hazards and human-induced threats. The citizens in the city should be able to handle and respond to unexpected situations resulting from malfunctioning CIs, changes of social, economic and environmental stresses, and also be proactive during a crisis and have the ability to recover by themselves. The organisations at the city level have the capacity to support any transformations by rapid changes taking place in urban key areas.
CI resilience: Resilient infrastructure can resist damage and loss of function, absorb, adapt to, or rapidly recover from a potentially disruptive event, can quickly restore its continuity and support the city's CI-based services. It also covers the ability and reliability of the CIs to cope with the potential damage from extreme weather events, and the capacity to manage the CC impacts on the variability in the available resources.
Community and Social Resilience refers to the capacity of individuals, communities or societies potentially exposed to hazards to adapt, be flexible, and bounce-back by resisting or changing behaviour, taking-up innovations, organising itself to continuously exist, reach and maintain an acceptable level of functioning and structure. This capacity also covers the capability to combat social vulnerability, enhance perceived risk and sense of responsibility, and learn from the previous hazards. This capacity can be improved through education and training.
Socio-ecological system Resilience can be interpreted in two ways: The time it takes for recovering to a quasi-equilibrium state following a disturbance ('engineering resilience' or 'elasticity'), or the capacity of ecosystems to absorb disturbance without collapsing into a qualitatively different state that is controlled by a different set of ecological processes. It is the ability to learn from catastrophic events and to adapt reactively and proactively to changing environmental conditions, to learn what disturbance, inherent discontinuities, and uncertainties that can be tolerated so that the system can be adapted and adjusted so that it still functionally persists.
Organisational Resilience covers all management capacities such as planning, leadership, training, experience, and information management. It includes the capacity to improvise, innovate and expand the operations between impact and early recovery and the capability to conduct a proper risk assessment and risk management.
Local Government Resilience is the capability of an organisation to coordinate and sustain on multiple levels, a multi-stakeholders platform to promote disaster risk reduction. It also includes the capability to engage local communities and citizens in disaster risk reduction activities; the capability to strengthen the institution, capacities and implement practical disaster risk reduction actions; and the capacity to implement tools and techniques for disaster risk in the prevention, preparedness, response, and recovery.
Individual Resilience is a person's own resilient capabilities; the adaptive capacity of individuals to react or adapt positively to hazards or unexpected events.
Economic resilience is the capacity to reduce direct and indirect losses, maintaining functions such as continuous production. It is also the ability of society to adapt to the impacts of e.g. climate change, and damages from hazards which also depend on wealth in addition to society, culture, norms, and practices. It should be able to maintain economic vitality and meet climate targets.
CBRNE resilience is the capability of the responders to detect CBRNE events, to respond and to recover from occurring incidents.

It is worth to mention that we also found the terms "Holistic resilience" and "Pan-European" resilience. However, the notions of these two terms are not fully well defined as units of analysis. Yet, in this paper, we argue that to attach cities onto future European resilience backbones, resilience in all abovementioned dimensions should be accomplished, which then can be considered as holistic resilience. When a holistic city resilience is transmitted, replicated and referred as a role model across regions and nations, then Pan-European resilience will gradually be attained. Note, as the essence of this article, is exploration; at this point, we do not propose a single new definition of city resilience. We are also aware of the scientific literature on resilience [27–36], but we only focus on reports and works on resilience that have been applied for EU research projects. We utilize the aforementioned synthesized definitions and related concepts to propose three upcoming models of European dimensions of resilience in the next sub-section.

4.2   Model of Resilient Dimensions

As mentioned earlier, concepts and relevant elements of resilience in the literature were collected, categorized and grouped. In this section, we have synthesized some findings from the literature and try to propose them as a model of resilient dimensions. Frequently used concepts and definitions to describe resilience are reused for proposing three different models containing elements to achieve European City Resilience.

1. Model of Capacity: ensuring all elements in a city, country, and Europe (actors, entities, environment, physical buildings, and infrastructures) are resilient. In this model, the crucial issue is capacity needed in different resilience dimensions.
2. Model of Adaptive and Risk Governance: Ensuring that risks, institutional arrangement, tasks, and responsibilities are distributed across sectors, actors, entities, and in different resilience dimensions, and geographical boundaries.
3. Model of Networking and Learning: ensuring that spread of resilience across dimensions, entities, actors and geographical boundaries are granted through networking, learning, and sharing circles.

The dimensions incorporated in these three proposed resilient models are based on the lists that have been identified earlier in Sect. 4.1. The models are shown in Figs. 2, 3 and 4. It is essentially an interaction of resilience of different components of the city's system that eventually will be reflected as overall city resilience. In this model, the local government organisations are central as transition hubs towards resilience within the different dimensions of a city. All three models encompass the same elements. In the left side, there is an arrow depicting the efforts for establishing holistic resilience as we have defined earlier in Sect. 4.1. The three blocks in the middle represent different levels of governance: city level, national level, and international level. They also represent different stages of resilience: in the preparedness, response, recovery, and mitigation, as these emergency management stages are highly related to resilience. The ellipse above each block represents the continuous process of designing frameworks for managing, implementing, monitoring and improving resilience in each emergency management stage. During the desk survey, various themes linked to resilience has been explored such as public-private partnerships [12, 37, 38], socio-ecological environments [39] and

vulnerabilities [22–25], multilevel governance, adaptive governance, social capacity, risk governance, risk communication and education, collaboration, mutual learning from experience, interdependencies between critical infrastructures, mobilization of social capitals, collaborative decision making, and more. In our models, we map necessary elements and their interactions found in the literature above and locate them in these three frameworks. These elements are represented by small arrows, which link different blocks of governance levels. We will explain further each specific model in the next sub-sections.
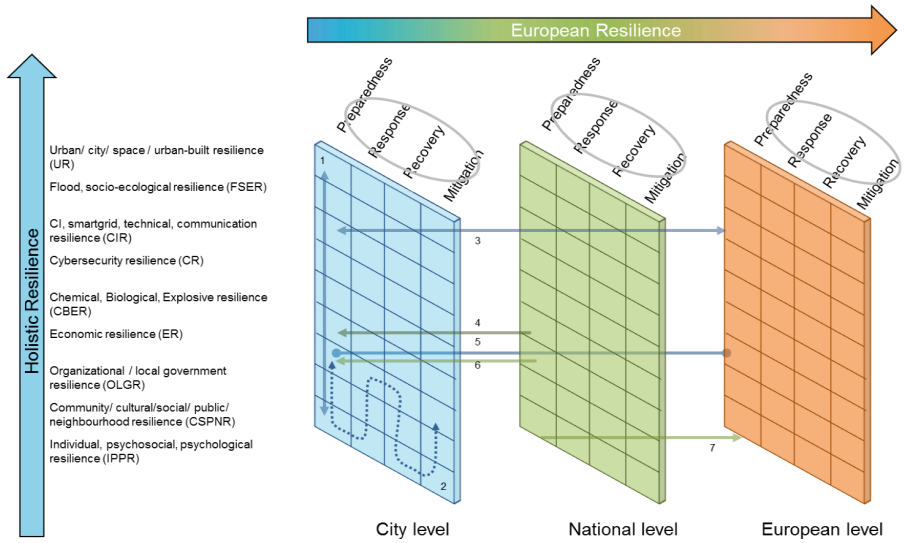

Fig. 2. Model 1: resilience dimensions and capacity

Model of Capacity highlights the capacity as a prerequisite for transforming resilience from cities to Europe. In this model, the capacity refers to the ability to receive, hold or absorb unexpected events in all elements (individuals, private and public entities, physical environments, buildings, and infrastructures) in a city, country, and Europe. Capacity is apparently an important notion that to a certain degree captures the essence of resilience, as also seen in the charts in Fig. 1. In model 1, the capabilities to withstand hazards should be developed in each unit listed on the left side of Fig. 2. The role of local government in the city level is very central and functions as glue for the resilience of other units. The numbered arrows in Fig. 2 show the resilience elements linking cities, nations, and Europe. The number of each arrow represents the following ideas:

1. Representing the capacities that should be built and nurtured in each dimension. The arrow 1 is located in the "preparedness" column as these capacities are instituted in the cities, which can be unique from place to place depending upon each city's risk pictures. Examples of capacities found in the literature are summarized in the capacity matrix (see Table 2).

2. Representing the continuous interaction process between a local government with the community and the individual in all disaster phases: preparedness, response, recovery, and mitigation. The local government educates community and individuals about disaster preparedness and risk perception. Individuals develop self-resilience, ability to collaborate with neighbours and community, or even provide support to the local government. Community can help mobilizing resources and communicate among important entities in crisis.

3. Capability to understand CI dependencies, interdependencies and cascading effects within and across the sectors. The arrow 3 is linked through the national and European level, as CI services such as power supply and energy production, transportation, water are often closely link to the national government and can encompass several European cities. The failures at providing CI services can result in cascading disasters across other services that rely on this specific service, which geographically can spread beyond the national border, e.g. between cities nearby the national border. Alternatively, the water pollution in a city, for instance, with time will probably cross the national border. Accordingly, arrow 3 also depicts the capacity to deal with these three governance levels with respect to CIs.

4. The capability of the national government to support economic resilience through various robust, supportive regulations where cities may be affected, especially the business entities.

5. Training and personnel exchanges across geographical boundaries as a part of a preparedness plan to increase the capability of local government in emergency management and resilience building. It can be enhancing the capability to coordinate with national government as well as other European cities especially when dealing with larger scale or cross-boundary of disasters.

6. The capability of the national government to support the local government with necessary regulations, and to convey the EU strategies and guidelines such as "EU Domestic action on resilience" into action at the city level. This element will support further the city's preparedness, as represented by the arrow 6.

7. The capability of national government to follow the development at the EU level and to bring local initiative and interest into EU policies; capacity to make international agreement in the area of resilient cities; capability to harmonise resilience policy with other EU member states.

We notice mutuality or reciprocal relations between each dimension in terms of capacity; and therefore, a matrix of resilience capacity is introduced here, which is again derived from elements extracted from literature identified in Sect. 2. The capacity matrix mentioned in point 1 (Table 2) shows the required capabilities in different dimensions, (from, to or within the dimension itself). The heading "Capacity from Dimension" in the left part of the Table illustrates the capacities needed in different resilience dimensions included in model 1. The heading "To Dimension" in the upper part of the table represents the intended focus or application area of the resilience capacity building. For example, the box linking OLGR (Organizational/Local Government Resilience) dimension column and UR (Urban Resilience) dimension

row, contains "Regulations, resilience budget, technology". It is read as the capacity of organization or local government to provide regulations, resilience budget and technology that will strengthen the resilience of the urban environment.

Table 2. Capacity matrix

| | | TO DIMENSION | | | | | | | |
		UR	FSER	CIR	CR	CBRNE	ER	OLGR	CSPNR	IPPR
CAPACITY FROM DIMENSION	UR	Adapt built- environment	Adaptive to extreme weather	Less hazard prone CI location	Secured by design Urban CIs	minimizes CBRNE events	Urban economy keep adapt to threats	Built assets support institutional	Built assets support Community	Built assets support safe environment
	FSER	Robust to flood or other natural and ecological threats	Adaptive to ecological threats and dependencies	Resilient CIs to ecological threats		Recover from CBRNE events that affect environment				
	CIR	Robust ICT support		dependency			Robust ICT support	Robust ICT support	Robust ICT support	Robust ICT support
	CR	Robustness to cyber-attacks on ICT-based CIs		Robustness to cyber-attacks on ICT-based CIs	Minimize dependency, cascading effects		Robust to cyber-attacks on ICT-based CIs	Robustness to cyber-attacks on ICT-based CIs		
	CBRNE	Capacity to detect event						Robust tech to provide alerts		
	ER	Adaptive to economic stress					Cost and losses	Adaptive to economic stress	Adaptive to economic stress	Adaptive to economic stress
	OLGR	Regulations, resilience budget, technology	Technology support, robust spatial design, Advice for resilient technology usage	Minimize interdependency risk and impacts, Sustainable CIs, Securing CIs	CR events or know resource to contact	Detect and respond CBRNE event or Know resources to respond CBRNE	Regulations	Support relevant entities Establish PuP, Collaborate, share, learn, network, leadership	DRR education PPP Awareness education	Risk education Support counselling Advice for resilient technology usage
	CSPNR	Proactive to urban events	Adaptive to ecological threats	Securing CIs	Prevent, respond and recover from CR events	Detect and inform abnormality	Adapt and recover from economic events	Mobilise resource To inform local authorities	Risk and resilient culture, learn, share, self- organise	Cooperate, support individuals
	IPPR	Risk perception, self-resilience	Risk perception, self-resilience	Risk perception, self-resilience	Inform abnormality	Inform abnormality		Support, engage, volunteering	Build cohesion, In-form abnormality	Self-resilience

UR: Urban Resilience; FSER: Flood, Socio-Ecological Resilience; CIR: Critical Infrastructure Resilience; CR: Cyber Security Resilience; CBER: Chemical, Biological, Explosive Resilience; ER: Economic Resilience; OLGR: Organisational/ Local Government Resilience; CSPNR: Community, Cultural, Public, Neighbourhood Resilience; IPPR: Individual, Psychosocial; Psychological Resilience

Model of Adaptive and Risk Governance. This second model in Fig. 3 captures the adaptive governance, risk governance, and multilevel governance. The upwards arrow on the left side represents the actors and networks in each corresponding resilience, while the right arrow dimension captures the notion of risk governance, and multilevel governance at a different level. Governance is basically a continuing process through which conflicting or diverse interests may be accommodated, and co-operative action may be taken. It includes formal institutions and regimes empowered to enforce compliance, as well as informal arrangements that people and institutions either have agreed to or perceive to be in their interest (CGC). Risk governance looks at the complex networks of actors, rules, conventions, processes and mechanisms concerned with how relevant risk information is collected, analysed and communicated, and how management decisions are taken. Multilevel governance refers to a creative process in which both authority and policy making influences are shared across multiple levels of government. Similarly to the Fig. 2, the numbered arrows (Fig. 3) depict relevant elements found in the literature with respect to governance. The number of each arrow represents the following ideas:

1. The arrangement of risk and responsibility sharing among various local stake-holders at different dimensions. The arrow 1 is located in the "preparedness" column as an arrangement in a city can be established in and between different actors in different dimensions of resilience. The common interest could be the basis for this, with the common goal to increase preparedness.
2. Participations among actors in different groups (city, national, European levels) and communications among them on the arrangement as represented by each arrow in each governance level covers all different identified stakeholders, in various stages of emergency management.
3. Risk perception, and sharing of responsibilities among local actors and stakeholders to minimize the potential negative impacts of the risks.
4. Trust to the regulatory framework for governance.
5. Risk perception, communication and sharing of responsibilities with national stakeholders and international stakeholders to minimize the potential negative impacts of the risks. Governance, Multilevel governance, Public-private partnership (PPP) and Public-public Partnership are ways to deal with the risk, which will be further discussed in the third model.
6. Representing facilitation for international agreement with respect to governance and shared responsibilities, particularly if the risks will involve international networks. International agreements, cooperation between nations, regional, and local networks.
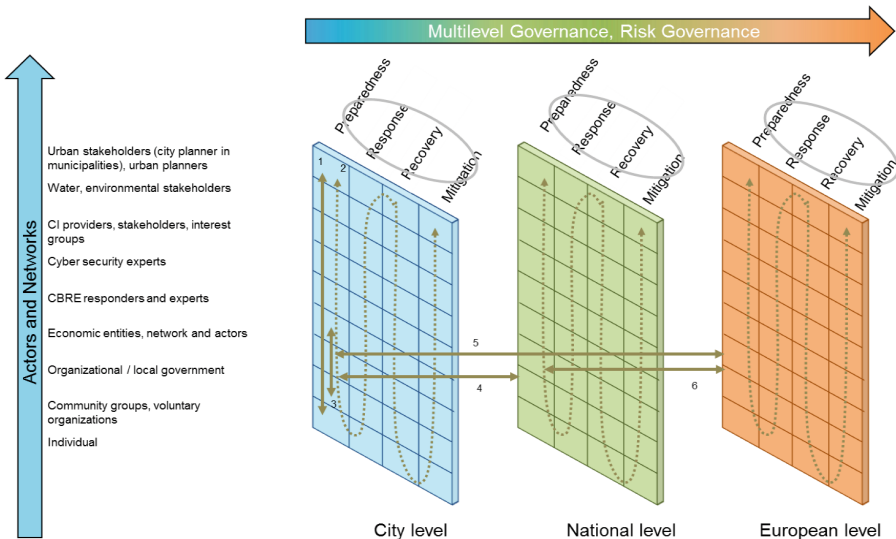

Fig. 3. Model 2: resilience dimensions and governance

Model of Networking and Learning. This model captures the networks of actors establishing the learning and sharing links in different parts of the resilience dimensions. One of the networking models discussed in the literature is public-private partnerships (PPP) where the aim is to establish a kind of cooperation with respect to

financing, constructing, renovating, managing and maintaining important infrastructures for society. The partnerships are keys for implementing multilevel governance where the numbers below refer to the numbered lines in Fig. 4:

1. Networking between local government and CI stakeholders-providers as well as economic entities through PPP. The partnership is voluntary but enforceable commitments between public authorities and private enterprises, which can be short-term or long-term. The partnerships are essentially founded on the principle of sharing the same goal in order to reduce risk and gain mutual benefit. Good partnerships comprise the integration of activities, shared vision, consensus, negotiation, participation, collective action, representation, inclusion, accountability, volunteerism, and trust.
2. Public-public Partnership (PuP), where the focus is the partnership between public authorities and citizens in general, aiming at strengthening resilience through community engagements. It is represented by arrow 2. The form could be the community helping the local government through resource mobilization, or the local government updating and educating the community with respect to the resilience practices and actions.
3. Local community networks for emergency preparedness. These are kind of self-organized communities, between neighbourhoods, special interest groups and other local organizations initiated by and for the community. It is represented by arrow 3 that links the CSPNR and IPPR columns.
4. PPP in CI areas at European level, as represented by arrow 4. In this case, in the literature, CIs often have interdependencies with other CIs, which are sometimes located geographically outside a country. Failure in one component or one CI can result in cascading failures in all other CI components or other CI sectors in other countries. Therefore, PPP does occur not only locally, but also nationally and internationally within the European region.
5. Facilitation from the national government to the local administration for networking with national actors. It connects economic sectors at local and national levels. The networking is intended for strengthening economic entities and businesses in various levels of government.
6. International and European resilient city networks, best practice sharing, as so far have been promoted through e.g. Durban Adaptation Charter [40], Mayor Adapt [41], world mayors council [42], Compact of Mayors [43].
7. Networking with national actors for emergency preparedness to increase resilience especially in facing of an escalated unexpected event, which is too big to be handled by local resources.
8. Facilitation from the national government for international networking, e.g. through various regulations, or training on agreement making and diplomacy.

The three models proposed earlier suggest different elements as capacity, governance, and learning-networking which have been extracted from different EU funded research projects to improve resilience. The elements of resilience presented in this paper is exploration in nature but to be able to be applied as a part of the city resilience, the applicability of each element in the city level should be validated so that they are accepted as valid component of resilience, and a backbone of European resilience.
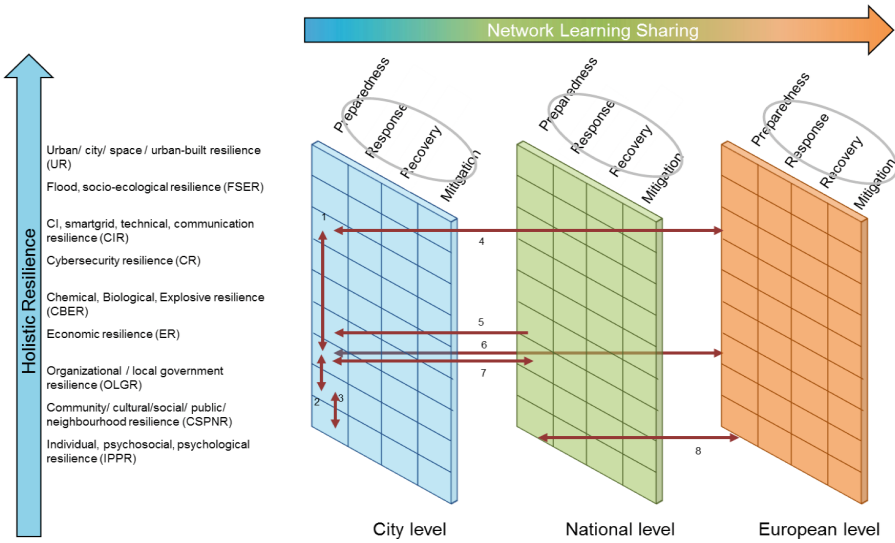
Fig. 4. Resilience dimension and learning-sharing network

5   Conclusions

In this paper, we summarize elements from various EU projects to contribute towards the area of Resilient Cities and propose a "resilience backbone" for Europe. Our contributions are twofold. First, we summarize and synthesize the definition of resilience in different dimensions found in the CI and CC literature to ensure that current approaches to resilience are captured in our EU sectorial approach review.

Second contribution is the proposal to tie together different elements of resilience found in the literature, which can be incorporated as parts of a city resilience framework. We have proposed three different models of European City Resilience, i.e. Model of Capacity, Model of Adaptive and Risk Governance, and Model of Networking and Learning. These provide an overview that can be used as input to operationalize further the resilience concept. These three models and each component are intertwined and will contribute to the spread of the city resilience building to the state, and European level. Eventually, the European backbones for resilience are fully established, and resilience of a city can be measured.

As the identification of elements of European backbones for resilience is based on literature, for the next step, the triangulation with other parallel efforts such as experts' opinion collections in a series of workshops can be a method to harmonize and confirm the results from this literature review.

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