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Conceptualizing Dimensions and Characteristics of Urban Resilience: Insights from a Co-Design Process

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Abstract: Resilience is a multi-faceted concept frequently used across a wide range of disciplines, practices, and sectors. There is a growing recognition of the utility of resilience as a bridging concept that can facilitate inter-and transdisciplinary approaches to tackle complexities inherent in decision making under conditions of risk and uncertainty. Such conditions are common in urban planning, infrastructure planning, asset management, emergency planning, crisis management, and development processes where systemic interdependencies and interests at stake influence decisions and outcomes. A major challenge that can undermine the use of resilience for guiding planning activities is the value-laden and contested nature of the concept that can be interpreted in a variety of ways. Because resilience is context-specific and generally depends on local aspirations, this issue can be partially tackled by adopting participatory approaches for the conceptualization of resilience. This paper provides an example of how co-design methods can be employed for conceptualizing resilience. The Structured Interview Matrix was used as a technique to facilitate discussions among a diverse group of researchers and practitioners attending the International Workshop on Tools and Indicators for Assessing Urban Resilience. Participants deliberated on issues related to constituent elements of urban resilience, including its position vis-à-vis concepts such as adaptation and sustainability, institutional factors that can enable/constrain resilience building, and the challenges of conducting and operationalizing urban resilience assessment. This paper can be considered as an initial step towards further exploration of participatory approaches for clarifying the underlying dimensions of complex concepts such as resilience.

Keywords: urban resilience; knowledge co-design; knowledge co-production; bottom-up approach; participatory methods; Structured Interview Matrix; adaptation; sustainability; transdisciplinary

1. Introduction

Today's highly urbanized world is characterized by growing levels of risk and uncertainty. Traditionally, mitigating the risk associated with future uncertainties (related to climate change, economic shocks, population change, etc.) has been one of the main purposes of urban planning activities [1]. Friedmann [2] (p. 482) suggested that "planning is a professional practice that specifically seeks to connect forms of knowledge with forms of action in the public domain". He called for transforming this traditional mode of planning based on instrumental rationality, blueprint implementation, and top-down action into a non-Euclidian (non-engineering) mode. Non-Euclidian planning is "normative, innovative, political, transactive, and based on social learning" [3] (p. 372). While non-Euclidean planning remains limited, resilience has emerged as a major concept that is increasingly used to promote urban planning, management theories, and management practices aimed at addressing issues related to vulnerability, risk, and uncertainty [4]. If we consider vulnerability as the result of exposure to disturbance, system sensitivity, and system resilience (or adaptive capacity) [5–8], then "each community must inevitably deal with the management of multiple and interacting exposures to different threats" [8] (p. 2230). Community resilience could be seen as the capacity of a community to manage current and emerging threats by addressing the ability (or lack thereof) to adapt to changing threats and challenges over time, and drive adaptation pathways towards sustainable futures [8]. Therefore, community resilience has been framed as "both an outcome, especially when linked to improved adaptive capacity of communities, and a process or pathway linked to dynamic changes over time associated with community learning and the willingness of communities to take responsibility and control of their development pathways" [9] (p. 4). "Community resilience is indeed gaining prominence as a targeted process of societal development, both within the scientific literature and policymaking discourses on sustainability" [8] (p. 2230). When community resilience is explored through an urban systems perspective, the framing and understanding of what a resilient city is, and how urban resilience should be conceived and measured is still under debate [10]. Limited knowledge exists on the implications of interlinkages between different urban sub-systems (i.e., environmental, social, economic, and physical) for achieving urban resilience through a multiscale, cross-sector, and multidisciplinary perspective [4,11]. The concept of urban resilience also brings to light emerging societal tensions between "continuity" (the capacity to maintain the performance of roles and functions within a society), "change" (societal evolution), and inclusion and exclusion within a given society [12]. Furthermore, additional clarification is needed to establish how urban resilience relates to other key concepts such as adaptation, recovery, and sustainability in order to maximize synergies and minimize trade-offs among them [13] and avoid potential conceptual confusions.

Given the value-laden nature of resilience, its conceptualization may differ from one (sub)discipline to another and even within (sub)disciplines [4,14,15]. Major divisions exist in viewing resilience as an action in response to identified risks and viewing resilience through a systemic evolutionary lens as a self-organization process. These differences and inconsistencies may render the concept unsuitable for framing and operationalizing planning and policy agendas. Despite these inconsistencies, some scholars consider resilience as a bridging concept [16], a mobile term [17], or a boundary object [1] that can be used to facilitate inter- and transdisciplinary collaborations [18]. As such, resilience may be a useful umbrella concept to develop transdisciplinary projects [19]. Fulfilling such a function will depend on proper use of consensus-based approaches (early in the planning process) for conceptualizing urban resilience. Utilizing bottom-up, negotiatory processes to specify dimensions and characteristics of the urban resilience concept can be regarded as a promising strategy for reducing subjectivity. Conceptualization using negotiation-based, knowledge co-design, and co-production approaches can also facilitate operationalization of the resilience concept, including design, implementation, and monitoring stages [20].

This paper contributes to these gaps in conceptualizing resilience by describing a participatory event that brought together a group of scholars and practitioners to utilize their knowledge, perceptions, and experience. The objectives were to develop a shared understanding of the constituent elements of

urban resilience, identify key themes, highlight research gaps, and identify a list of priority questions that should be further addressed in future work. As a point of departure, urban resilience was initially defined as the continual process of enhancing well-being for all citizens while also striving to prepare for and enhance recovery from acute disruptive events. It is worth mentioning that the issues discussed in this paper are not intended to be exhaustive; they mainly reflect the ideas discussed during the exercise conducted for the purpose of this research.

The paper is organized as follows. Details about the method used to facilitate discussions between the participants are reported in the next section. Findings of the exercise are reported in the third section. The final section discusses the implications of the findings for conceptualizing urban resilience and highlights some gaps in research and practice that need to be addressed.

2. Materials and Methods

The exercise was conducted during the four-day International Workshop on Tools and Indicators for Assessing Urban Resilience, held at The University of Tokyo, Japan in December 2015 (More information about the workshop is available at: http://www.cger.nies.go.jp/gcp/workshop-on-tools-and-indicators-for-assessing-urban-resilience.html). Participants included both researchers and practitioners with proven experience in urban resilience theory and practice. The group comprised 17 experts in sustainability, resilience, public policy, community planning, urban planning, engineering, climate change, energy grids, and impact assessment. Furthermore, the participants were from several developed and developing countries (including Australia, Belgium, Canada, India, Indonesia, Italy, Japan, The Netherlands, Solomon Islands, Spain, Thailand, Russia, United States, and Vietnam) and had experience working within different research and policy contexts. Discussions and presentations during the first three days of the workshop provided the context for the exercise. The attendees had the opportunity to present their work related to urban resilience assessment and were asked to conclude their presentations by raising key questions related to defining and operationalizing resilience. These questions were distributed to the workshop participants at the end of the third day and all were asked to deliberate on the collected questions before attending the last day of the workshop. The last day was reserved to hold a participatory exercise and generate some conclusions around the conceptualization of urban resilience.

Many participatory methods are available for organizing workshops aimed at sharing and generating knowledge (e.g., World Café, Charrette, Concept Mapping, Delphi method, Mind Mapping, Marketplace/Poster Exhibition, and Storytelling). The objectives, strengths, and weaknesses of some of these methods are summarized in Table 1.

Table 1. Selected participatory methods for organizing workshops (developed based on authors' experience and the information provided in [21] and [22]).

Method	Objectives	Strengths	Weaknesses
World Café	Participants are divided into small table groups and discuss issues in multiple rounds. Participants (except for the table facilitator) move to a new group at regular intervals and this enables cross-fertilization of ideas. Table hosts summarize and present the main ideas in a plenary session.	Suitable for sharing and generating knowledge Can accommodate a large number of participants Suitable for engaging a wide range of participants Moderate resource requirements (venue, trained facilitators, costs) Short to medium time requirements	Needs clear questions Concrete decisions and action plans cannot necessarily be derived at the end of the process Challenge to facilitators to avoid vocal speakers dominating the conversation.
Charrette	This method is applied to create consensus for projects in communities through direct involvement of citizens in the planning process.	Suitable for generating and sharing knowledge Can accommodate a large number of participants Suitable for engaging a wide range of participants	Experts may dominate the process Medium-high resource requirements, depending on the length of the process Consensus building may take time
Concept Mapping	Facilitates knowledge gathering and information sharing between a group of people. It can provide useful information on the relationship between key concepts discussed. The technique allows individuals to get involved in effective group discussions without losing detailed individual ideas.	Dominating participants can be avoided Suitable for sharing and generating knowledge Suitable for engaging a wide range of participants	Medium-high resource requirements High time requirements Not suitable for accommodating a large number of participants The process can be complicated for some participants Reaching consensus is not easy
Delphi Method	This method is used to extract opinions of a group of experts on a certain topic. Experts take part by answering questionnaires and revising their answers in several rounds.	Dominating participants can be avoided Costs are low	Medium-high time requirements Mainly targeting experts Not suitable for accommodating a large number of participants Lacks dialogue between participants
Structured Interview Matrix	This technique is used to facilitate discussions between several groups of participants to elicit knowledge from them. Knowledge is generated and shared through engagement in one-on-one interviews and groups and plenary discussions. Similar to World Cafe but employs interviewing strategies rather than general conversation.	Dominating participants can be avoided Suitable for sharing and generating knowledge Suitable for engaging a wide range of participants Moderate resource requirements (venue, trained facilitators, costs) Short to medium time requirements	Needs clear questions Not suitable for accommodating a large number of participants Relatively new and not frequently used

For the purpose of this study, a method was sought that is easy to work with, can minimize dominant participants (as several participants were early-career researchers and capacity building was one of the objectives of the workshop), and can facilitate sharing and generating knowledge between a small group of participants within a short-medium time period. As can be seen from Table 1, the Structured Interview Matrix (SIM) fulfills these requirements and, therefore, was selected to structure the discussions. The SIM sessions were conducted according to the methodology outlined in O'Sullivan and Kuziemsky [23] and O'Sullivan and Corneil [24]. Although this method has previously been used mostly for community asset mapping, in this study SIM was used as a technique to facilitate discussions between several groups of experts and to elicit knowledge from them. The method generally consists of the following steps (see Figure 1):

Step 1　　Participants are grouped into small teams, A, B, C, D, each given a different topic (question).

Step 2　　Members of each group perform one-on-one interviews with a member from each of the other groups to obtain answers to their assigned questions.

Step 3　　Participants return to their original groups and discuss their originally assigned questions/topics based on the interview results.

Step 4　　Groups synthesize key ideas and report back to the whole group.
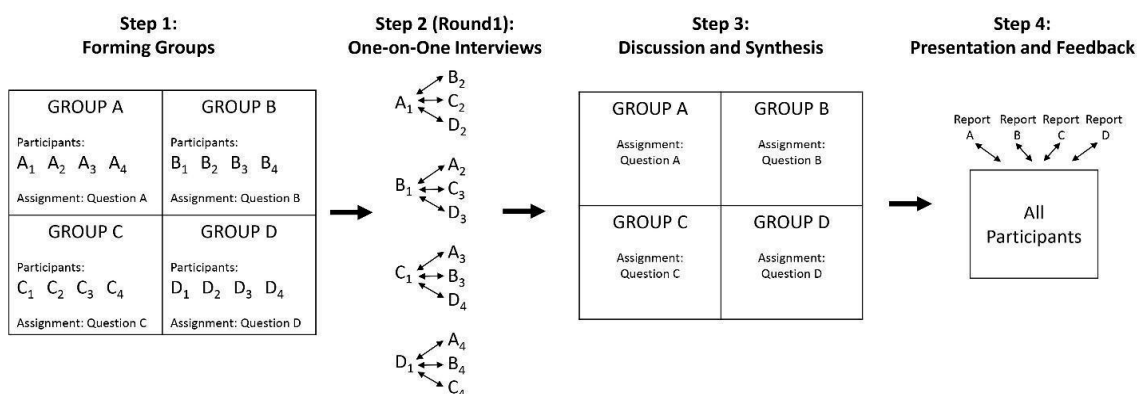
Figure 1. Schematic overview of the Structured Interview Matrix (SIM) process.

Before starting the SIM exercise, a brainstorming session was held to identify (and re-formulate) the four most prominent questions to be addressed during the exercise. Care was taken to formulate broad and open-ended questions that covered most of the concerns and challenges raised during the workshop and that would facilitate further deliberation by the participants. The following four questions were selected for the exercise:

A.　　How does urban resilience relate to adaptation, recovery, and sustainability? What are the synergies/tensions?

B.　　What are the elements of the built environment that influence community resilience?

C.　　What are the elements of the institutional/regulatory context that enable and/or constrain building resilience?

D.　　What are the challenges of conducting resilience assessment and utilizing results to inform decision making?

The exercise was conducted in four steps following the sequential process illustrated in Figure 1. First, the attendees were divided into four groups. Due to the odd number of participants, Group C was given five members, two of whom were paired for the purpose of consistency. Each group was assigned a unique question (A, B, C, or D) and a matrix was set up so that individuals in each group collect answers for their unique question by conducting one-on-one interviews with members from other groups (Step 2). The maximum allowable time for one interview was ten minutes. At the

end of this step, everyone had been interviewed by three individuals from three distinct groups on questions/topics different from the one they had been originally assigned, and in return had interviewed three individuals on the subject of their assigned question.

When the second step was complete, participants returned to their original tables to elaborate on the responses they had collected (Step 3, Figure 2). Here, they were also asked to add their own input, synthesize the discussions, and reach consensus on a list of themes related to their assigned questions. The final step (Step 4) involved a plenary session, wherein participants reported back the results of their discussions to all participants and received feedback from the audience.

Figure 2. Participants completing the third step of the exercise.

Each participant was asked to take notes during the interviews. Also, all the conversations were recorded using digital audio recorders. At the end of the day, these materials were collected by group representatives to prepare a synthesis of the discussions to be shared with the rest of the participants. Refined versions of these synthesis reports can be found in Section 3.

3. Results

The arguments that were developed in response to the four questions posed in the previous section are presented in the following four sub-sections, respectively, and are contextualized by the current literature where appropriate.

3.1. Relationship between Resilience and Adaptation, Recovery, and Sustainability

In the urban context, resilience initially emerged as a concept mainly related to disasters [25] or climate change related challenges [26]. The capacities to recover and bounce back to pre-disaster conditions have been mainstream characteristics underlying the concept of urban resilience [27]. Only recently has greater attention been devoted to exploring the possibility of broadening resilience approaches in order to include transformational capacities [28]. With the rapid evolution of resilience as an overarching concept [16], possible synergies and conflicts with other key existing concepts and approaches to urban planning and development have to be identified in order to integrate resilience meaningfully and critically into urban theory and practice. How does the concept of urban resilience relate to adaptation, recovery, and sustainability? How can resilience be communicated in a way that will not lead to confusion with other concepts, thus diffusing its meaning and increasing ambiguity and skepticism? These questions were discussed with regard to possible synergies and tensions between urban resilience and adaptation, recovery, and sustainability.

Resilience was described by the group as a proactive approach, emphasizing being prepared to address possible shocks, crises, or stressors. Important aspects of resilience were named, such as

robustness, adaptability, and transformability. Initially, it was acknowledged that all three concepts fit together and were related. These are overlapping parts of the resilience concept and it was emphasized that resilience should incorporate them. However, the question arose in how far each—adaptation, recovery, and sustainability—are interrelated with resilience and the significance of each of them in this context.

It was stressed that increasing resilience (as a high order goal) can be facilitated through continuous and incremental adaptation efforts. Moreover, the participants argued that the processes of recovery as well as disaster risk reduction actions provide support to achieve adaptation. Adaptation is a mid- to long-term process, based on predictions regarding possible stressors or shocks (it was defined as 'predict and act'), whereas recovery is a short- to mid-term reaction to crisis, disturbances, or shocks. An emerging field of recovery planning also offers strong synergies with adaptation. Recovery planning is based on creating a collective vision before a disaster strikes, to establish a framework for multi-stakeholder and inter-organizational action. Group members emphasized that incremental adaptation helps to prepare for recovery from stressors or shocks and can be defined as a component of resilience. It was also pointed out that there is a relationship between adaptation and recovery due to the assumption that after recovery, an adaptation process usually starts. In this context, resilience as the preparedness for crises or shocks is a proactive approach which closely links recovery, as the reaction to a crisis, and adaptation, as responding to predictions ('predict and act'). It was also stated that resilience is about learning how to perform fundamental functions differently and, therefore, should consider climate adaptation, recovery, as well as disaster risk reduction as equally important and equally balanced. This balance further emerged as an important topic in the discussion, especially when focusing on the preparedness of a community. Participants emphasized the importance of having a balance between small incremental adaptation actions/measures and a focused transformative adaptation. Adaptation measures are often incremental and in response to minor disruptions. However, when a highly vulnerable system faces relatively severe shocks at short time intervals, it may cross thresholds and shift into completely different regimes. Under such conditions, incremental adaptation may not be sufficient and transformative adaptations would be needed to facilitate the transition of the system from one stability domain to another [15,28,29].

In the context of adaptation, the group members specifically discussed the need to preserve ecosystems and ecosystem services to enhance the ability to adapt. Additionally, the synergy of ecosystem preservation with socio-ecological resilience and sustainability were emphasized. It was stressed that the maintenance of ecosystems and ecosystem health is imperative for the resilience of human societies. As was reiterated by some group members, a disregard of ecosystem services in the long run could lead to conflicts arising from ecosystem fragmentation and biodiversity loss; ultimately, the sustainability of the ecosystem itself and the associated ecosystem services will be undermined [30–32]. Climate mitigation was also highlighted as important for sustainability and fitting within the broader frame of resilience. Enhancing mitigation in the long-run (e.g., climate change mitigation) reduces the need for adaptation, since disasters or climate change impacts will be reduced [33]. Thus, resilience is directly enhanced as well [15].

The participants articulated that sustainability and resilience are distinct and not interchangeable. A community which seems to be safeguarding the needs of both current and future generations may not necessarily be resilient to shocks or crises. As described above, resilience is about dealing with uncertainties and learning how to maintain the functionality of the system under constantly changing conditions and dynamics. Therefore, communities that seem to be sustainable but have not experienced crises or shocks in recent history may not have learned how to prepare themselves against these threats to their social functioning. It is also vice versa—a community can be resilient but not sustainable.

In addition, specifically addressing disaster resilience, a concern was raised about conflicts that can emerge when attempting to quickly recover from shocks. A community needs to adapt quickly after a shock or crisis, but adaptation does not ensure long term sustainability for the community. Moreover, it was contended that long-term sustainability cannot be achieved with certain resilience measures.

For example, further investment on centralized, redundant fossil fuel-based energy generation plants can enhance short-term resilience (through improving robustness), but it has negative implications for sustainability. Alternatively, sustainability measures do not necessarily prepare for future shocks and enhance resilience, due to a shorter temporal scale of the latter. The participants identified these potential conflicts between sustainability and resilience priorities as a barrier to decision making. Some suggested that the imperative of sustainability had lost momentum due to the increasing attention paid to climate adaptation and resilience within expert communities and thus, led to further tensions between these planning groups.

Regarding the management of community resilience in cities, the opportunity to create synergies by working together as a community and creating collaborative networks of experts and community members was identified. Establishing collaborative networks can facilitate coordination between different governmental and non-governmental stakeholders. This may include groups with different interests. Networking activities should not necessarily be restricted within city boundaries. The importance of establishing global networks for the promotion of collaborations between cities is gaining increasing attention. Such networks can bolster urban resilience by providing mutual support and creating a platform for sharing knowledge and experience and facilitating peer to peer learning [34], even in the absence of action at the higher levels of government.

In all, there was consensus that the concepts of focus had more synergies than tensions. The key concerns were regarding tensions in expert communities and the need to better articulate potential conflicts of priorities between different approaches. Concepts like climate change mitigation and disaster risk reduction were also acknowledged as important components of resilience by the group. Therefore, addressing various socio-economic and environmental dimensions of resilience is essential for enhancing preparation, absorption, recovery, and adaptation capacities of human communities. From an urban planning perspective, adaptation, recovery, resilience, disaster risk reduction, climate change mitigation, and sustainability (and their underpinning processes) are all interrelated and interdependent concepts that, ideally, should not be investigated in isolation.

3.2. Community Resilience and the Built Environment

The built environment plays a key role in community by providing support for sustaining different social needs such as housing, socio-economic activities, recreation, industry, and other critical services [35]. According to Hassler and Kohler [18], buildings and infrastructure stocks are the main components of the built environment. The physical, environmental, social, economic, and cultural resources of the city are developed as a result of interactions between humans and these components [18]. Hassler and Kohler [18] also characterize urban structure as a "complex socio-technical system" composed of different scales, ranging from buildings, to blocks, neighborhoods, cities, and regions. Each of these scales is characterized by different agents, temporal dynamics, and institutional systems [18]. According to this definition, the built environment is not just a physical construct. Instead, it is a "social construct" with distinctive physical (e.g., building and infrastructure stocks, transportation networks, etc.) and non-physical components (e.g., laws and regulations, socio-economic relations, social capital, values, institutions, etc.) [18].

As this paper confirms through the following subsections, the built environment only makes sense in relation to social processes and within legislative and institutional frameworks. In this section, we report the findings of Group B, which discussed the elements of the built environment that influence community resilience in cities. Participants' initial discussions on linking the urban built environment and community through resilience capacities were related to *building resistance to shocks (robustness through building codes)* and the capacity of streets and squares to accommodate inhabitants in case of emergency. Aligning urban form and the building codes with resilience principles can indeed minimize the exposure to threats and enhance robustness of the system, thereby contributing to community safety and resilience. Through related reasoning, resilience was described as the *capacity for "accessing" the city and its services*. Accessibility of infrastructures and urban services is indeed

a key factor, both from the physical point of view (having the infrastructures in place, and being resistant/robust to different potential impacts) and the socio-economic point of view (having equitable access to infrastructures and related services).

The linkages among access, resilience, and the built environment have also been framed as the interactions between infrastructures' "*physical form*" and their management models. Centralization or decentralization of urban infrastructures is a key aspect limiting or facilitating community resilience, in relation to urban metabolism, and induced by the (economic) management model of the city. Water and energy providers could manage infrastructures in either a centralized or decentralized way. Similarly, waste, food, and communications can also be managed by relying on a dominant provider, controlling the level of and access to the service provided, or through infrastructures that are co-shared and co-managed at a household or community level. There was consensus among participants that decentralized infrastructures are not only more resilient to both short- and long-term shocks (because of the physical redundancy of the networks which distributes risk and reduces vulnerability to supply chain disruptions), but also contribute to sustainability transitions, if framed according to a more renewable resources paradigm. Simultaneously, other resilience co-benefits can be accrued from distributed and decentralized infrastructure [15,36,37]. Decentralization improves access, enables local control over planning and resource management, and provides learning opportunities by engaging different stakeholders in the co-management of the infrastructure and related services [15,36,37]. These decentralized-distribution options can also contribute to empowerment toward a socio-economic transformation (e.g., evidence shows that promotion of decentralized energy systems enhances energy affordability, improves local awareness, and promotes local involvement in planning and decision making [15,38]). During such a transformation, the community will experience a redistribution of benefits and responsibilities, while also contributing to an increase in the diversity, modularity, and redundancy of the networks providing the basic services to urban life. On the contrary, according to participants, a centralized approach to the management of infrastructures leads to infrastructure lock-in and path dependencies, even if contributing to a more efficient management of investments.

From another point of view, but again linked to the debate on centralization versus dispersal, or resilience versus efficiency, the relationship between 'density' and resilience was also discussed, revealing the nuanced nature of trade-offs involved in urban resilience praxis. It was not clear from the discussions, whether urban density per se, while contributing to economic efficiency, contributes positively or negatively to resilience. It was argued that when building codes and capacities to enforce them are available, high density could indirectly allow the economically feasible application of advanced construction techniques (e.g., building reinforcement, anti-seismic measures, etc.), which can help improve resilience. Density, however, can also present a challenge during disasters, due to the high dependence on functioning of centralized infrastructure (e.g., a single mass transit corridor, or elevators (and thus electricity) in high rises). Increasing density in disaster-prone locations can degrade resilience by exposing a larger population to risk (e.g., dense low income housing in low-lying flood prone areas or in hilly seismically-active or landslide-prone areas) [39]. In poor urban areas, high density is often associated with increased vulnerability (mainly due to the lack of financial and knowledge resources, or lack of proper spaces and accesses during potential emergency situations) which presents a more challenging pathway to enhancing urban resilience.

Disaster resilience in dense urban areas also led to the mention of *street networks* (in the context of urban form) and *mobility* as other essential recurring elements during the SIM session discussions. Participants highlighted the need for increased mobility efficiency within urban systems in order to increase community resilience. A resilient street network should facilitate the smooth and unobstructed movement of people and vehicles to enhance both everyday performance and emergency response. Specific morphological aspects could be related to resilience. This requires a careful consideration of the trade-offs involved, for example, between increasing the number of bike lanes along major arteries vs. space needed to ensure the appropriate turning radius of an emergency vehicle (e.g., a fire truck). The street network and its associated elements (e.g., squares) should be designed in a way that not

only facilitates safe and rapid evacuation following disasters, but also provide temporary shelter in emergency situations [40]. An appropriate design margin is needed in order to accommodate possible future demands. Street networks offer an opportunity to build in climate responsiveness through integration of green and blue infrastructures. Climate-sensitive street design enhances resilience by providing various environmental, economic, social, and cultural benefits and ecosystem services [41]. Street networks should also facilitate landscape connectivity by creating linkages between different urban scales (from urban neighborhoods to the hinterlands). Landscape connectivity and ecological networks are essential for the movement of species and circulation of energy and matter needed for proper urban functioning [42].

As introduced at the beginning of this section, the built environment is a social construct with both physical and non-physical aspects [18]. A non-physical attribute of resilience, bridging the built environment characteristics and community adaptive capacities, is represented by the *sense of place*. From the perspective of those who participated in this exercise, the sense of place was defined as the dynamic process linking social life and characteristics of a community to a shared geographical area (e.g., a neighborhood). Viewed through this lens, places where people feel comfortable are characterized by active engagement of residents in the management and maintenance of the quality of the built environment.

Participants identified several trade-offs that can arise when making policies and planning decisions around the elements identified above. Among these, a recurring concern was related to possible conflicts between economic growth plans and environmental and social resilience of communities. For example, as one participant noted, building an airport enhances the community economic resilience by increasing market connectivity and opening opportunities for internationalization, learning, and the sharing of resources. However, it could, at the same time, have social-environmental consequences and impacts (from gentrification to pollution) which will simultaneously decrease other facets of community resilience. A long debate around potential trade-offs concluded that, in order to systematically explore the relationship between social processes and the built environment through a resilience lens, a clearer conceptual framing of (urban) community resilience is needed. Indeed, defining urban community, its capacities, and hierarchies which emerge within the community, remains a major challenge for urban resilience research. Also, elaborating on the concept of community resilience could help to assess how it is linked to other resilience domains (built environment resilience, ecological resilience, economic resilience). Such a conceptual framing could assist in determining whether and how (and on what grounds) any trade-offs between different resilience characteristics can be justified in the context of broader planning visions and objectives.

3.3. Institutional Elements that Enable and/or Constrain Building Resilience

The foundation of resilience building rests on the institutional capacity to understand and anticipate future events, plan and manage resources to meet these challenges, and enhance institutional capacities to deliver the outcomes. This involves decisions over land-use and resources, quality of provision and coverage of infrastructure and services, priority of new investments, and integration of the needs of the present and future communities in local plans and policies [43,44]. Urban planning actions for resilience building may be incremental and continuous or large-scale and transformative. As the nature of urban risks evolves, governance and institutional responses will require a re-framing of traditional approaches to urban governance. Discussions focused on the elements of the governance and institutional framework that are central to enabling resilience.

The importance of multi-level governance for urban sustainability and especially for climate change has been established in the literature [45,46]. Not surprisingly, integrated synergistic collaboration between governments and among departments within the government (horizontally and vertically) was identified as a significant factor influencing resilience. For example, the management of shared water resources between a state and local government or between two local governments calls for collaborative planning, both for resource sustainability as well as disaster

resilience. The participants discussed the many challenges that arise when implementing such a coordinated approach, especially when dealing with resilience to multiple hazards and, in particular, in developing countries. Although there are plenty of examples of successful collaboration, these are often the result of individuals (or champions) in different departments or organizations that put in significant effort to build trust and relationships beforehand.

Given that resilience strategies involve multiple institutions and agencies, a clear understanding of roles and responsibilities at different levels is essential for the implementation of actions. In cases where jurisdictions overlap, the lack of clarity could delay responses and undermine resilience. For instance, decisions for emergency flood management in cities could get delayed where regional watershed management authorities have significant influence. Similarly, local decisions to evacuate due to tsunami can be constrained by alerting systems operating at national and international scales. Participants identified other possible interfaces involving decisions that cross traditional community or city boundaries including regional ecological areas (i.e., catchments), large infrastructure networks, and energy supply systems.

Beilin and Wilkinson [47] describe forms of resilience governance ranging from top-down, state-directed policies to bottom-up community-led actions and hybrid models involving the interactions between these. The persistent but uncertain nature of urban disasters calls for flexible urban governance systems where decision-making systems comprise several scales and actors [48]. Resilience measures span across sectors and consequently affect diverse groups in different ways. Multi-stakeholder planning and decision making, including a shared and integrated long-term vision, can ensure higher buy-in and reduce implementation barriers at later stages (for example through government-facilitated and community-led resilience planning mechanisms). As with other sustainable development actions, the presence of strong local leadership can make a significant positive impact. At the implementation stage, building and strengthening local responses requires coordination between the government and non-governmental actors including the private sector, communities, and citizen groups. The importance of informal networks and actors in transforming and influencing urban resilience actions was an important point that emerged during the discussions. Participatory governance is therefore an important criterion influencing resilience.

Discussions continued with elaboration on indicators for good governance, including transparency, accountability, and participation in public budgets as highly influential factors in building resilient cities. Participants agreed that clear regulations and their proper enforcement would facilitate more resilient communities. Resilience mainstreamed into local regulatory processes can motivate private actors and facilitate the creation of partnerships between government and private stakeholders. Clear directive policies and regulations also ensure that resilience building remains a priority regardless of short-term political cycles.

As mentioned in the previous sections, urban resilience building is a continuous, evolving, and long-term process and this may pose challenges at multiple levels of governance. Participants agreed that inherent trade-offs exist between local and more immediate measures versus long-term measures for resilience building. The temporal dimension to resilience emerged as a strong consideration influencing decision making. For instance, conflicting priorities for the near-term focus on economic growth may constrain resource allocations for long-term priorities such as resilience. Similarly, regulations for disaster management often come in response to a disaster. However such regulations, such as knee-jerk political reactions, may not necessarily contribute to long-term resilience. Participants voiced concern that maintaining continuity of urban resilience policies and implementation on the local policy agenda is most challenging because of the short-term nature of political cycles. One approach to address this is to develop a robust monitoring and evaluation process backed by institutional support.

Short term resilience-building actions involve robust disaster management and response strategies. Indicators used in resilience assessment include the availability and accessibility of contingency plans, disaster mitigation plans, presence of early warning systems and evacuation plans, and the accessibility of the relevant information in real-time during disasters.

Group members emphasized information capacity building as an essential condition to building resilience at different scales. This includes the knowledge and information that institutions need to take account with regard to existing and future risks and coping mechanisms, as well as the capacity to interpret and analyze the information and possible alternative responses. The availability of skilled personnel and emergency practitioners within the local staff to deal with emergency responses is an important indicator of local capacity. Financial capacity was also seen as a major challenge by the group, especially in developing countries. Provision of training and guidelines to support local institutions in developing countries can enhance urban capacity and contribute positively to resilience building. Many participants strongly felt that bottom-up organizations, especially informal networks and groups, have a key role to play in enhancing community resilience both in developed and developing countries.

The discussions converged on the fact that decision making for urban resilience involves multiple scales, sectors, institutions, and actors, and it is influenced by the interactions among these.

3.4. Challenges for Resilience Planning and Assessment

Many questions and challenges remain for resilience planning and assessments that are crucial to answer as the field of study continues to evolve and practitioners look to implement strategies and tools that are being developed. During their session, Group D discussed the difficulties and outstanding problems of making decisions about adopting and implementing urban resilience assessments. Perhaps not surprisingly, the group recognized that the challenges surrounding the implementation of assessments are similar to those of many urban and regional planning processes: defining the system, data availability, political buy-in, identifying all relevant stakeholders, results framing, and communication. The international planning community has also had long experience with siloed initiatives and resilience adds another feature to be integrated. Resilience, as an improvement of disaster preparation and management, is also only one component of the well-being of populations [49]; any good assessment will also consider the co-benefits for other aspects of the community.

Group members emphasized that the overarching goal of resilience planning and assessment is to produce relevant and actionable information; therefore, the discussion spanned the aspects of a tool that would facilitate such information. A question arose as to whether it is even possible to design resilience assessment tools that are both generalized (suitable for application in different contexts) and at the same time useful for context-specific applications. Again, as outlined in the previous sections through other groups' discussions, the issue of scale, both spatial and temporal, emerged as an important theme. Defining the system, potentially in terms of sectors or domains, or with respect to identified risks, will dictate the assessment processes going forward. Choosing what to include or exclude is a challenge, particularly in non-physical realms, such as economic markets and political influence, but also for physical services that are administered at different scales. For example, as participants noted, it may be possible to define a region that has a single water source and water distribution system, governed by a local entity, but the same geographical region may receive electricity as part of a much larger national grid, managed by a federal agency with a different set of priorities. The temporal scale poses an additional set of challenges for resilience improvement decisions [50]. The time scale-related issues discussed include the static nature of assessments versus the dynamic nature of social systems and threats; the mismatch between shorter term electoral cycles and the necessarily longer time horizon of resilience planning; and choosing between short-term improvements and long term development goals. In the end, it is likely to be "resilience to what" [50] that drives the scale of assessment. Resilience to major coastal storms, hurricanes, and tsunamis will involve the flood zone and immediately adjacent areas. Resilience to electrical black and brown-outs will involve the extent of the power distribution system. As a result, multi-hazard assessments will be particularly difficult and the system of concern will not be the same for all. In fact, recent resilience assessments have stressed the question of 'resilience for whom' as a fundamental element for resilience assessments [51,52].

The form of the resilience assessment will inform the options for operationalizing and implementing resilience and it was determined that regions with different levels of development will have different

needs. Group B described how the urban form (the streets and squares) should ideally be designed. However, several participants in this group argued that most cities in most developed countries have existing infrastructure and populations integrated to a degree that major change is not possible unless following the destruction of an earthquake or similar event. In this case, assessments that can consider and prioritize incremental changes and rehabilitation efforts are preferred. Yet this is not a universal constraint. Participants with differing international experience pointed out that developing countries often have cities with much higher population densities, but less formal communities and infrastructure. Governments are in a position to guide intentional design in new areas of the expansion of services. However, this may also mean the removal of informal settlements that have developed at the margins of the existing city infrastructure. For these regions, assessments that allow new design as an alternative is preferred, but the incorporation of socio-environmental impacts of displaced persons into other parts of the system is also critical. More developed regions, too, should utilize tools that assess the impact of spillover into neighboring regions. The proactive resilience activity of one urban community can have important impacts on the population, economy, and demand on services in nearby communities.

The group identified data access and availability as an obstacle to conducting informative resilience assessments. Resilience assessment will be challenged by the same issues of frequency, relevance, accuracy, and existence of data points, similar to other urban planning processes. Group members expressed concern about the lack of data for 'soft infrastructure' such as institutional capacity and governance, or informal grass-roots networks as mentioned in Section 3.3, as well as about data that does not accurately characterize the systems, such as where socio-economic hierarchies or political reputation prevent it. Furthermore, the data need change depending on the objective of the assessment, and availability will have a substantial influence on what can be achieved with the assessment. While this consideration points to the appropriateness of an iterative assessment process, many participants expressed that, in their experiences, the desire of local governments is for a single assessment on which to make long-term investment decisions. Assessments that may result in changing recommendations over time would be politically infeasible. Alternatively, an iterative assessment would allow decision makers to indefinitely delay while "more information is gathered", rather than commit funding for large improvement projects. With the data that are available, questions about their relevance and relative importance will need to be addressed. Simply because some dataset exists does not mean that it is informative for the specific decision at hand; decision science methods can be utilized to guide the appropriate use of data for resilience assessments.

A central challenge in resilience assessment that was discussed was communication. An effective communication strategy will need to enlist buy-in to the concept of resilience and worthwhileness of the assessment processes. The notion of having to "convince" leaders or citizens emerged with respect to motivating action from the results of a resilience assessment. To aid decision makers in taking resilience-informed action, the assessment should include some methodology for prioritizing improvements [53]. Results without a guide to their interpretation and use is less meaningful. A group member suggested that planning is a form of storytelling and requires a persuasive narrative. All participants must agree on the validity of the process before the assessment so that there cannot be debate afterward about whether the identified resilience improvement measures are actually needed. Similarly, participants voiced concern that if an assessment is not connected to a regulatory framework that supports implementation and monitoring, it will not be used.

In all, the participants saw very similar challenges to standard planning and development activities; however, resilience has the additional challenge of being a process, not an end state. Not only is it a process, but one that pervades every aspect of a community, every department of a governing entity, and looks for solutions that incorporate structures, policies, education, relationships, and economics all at the same time, making the measurement of the outcomes and proof of success all the more difficult. A summary of the critical considerations for effective resilience assessment raised by the participants is presented in Figure 3.
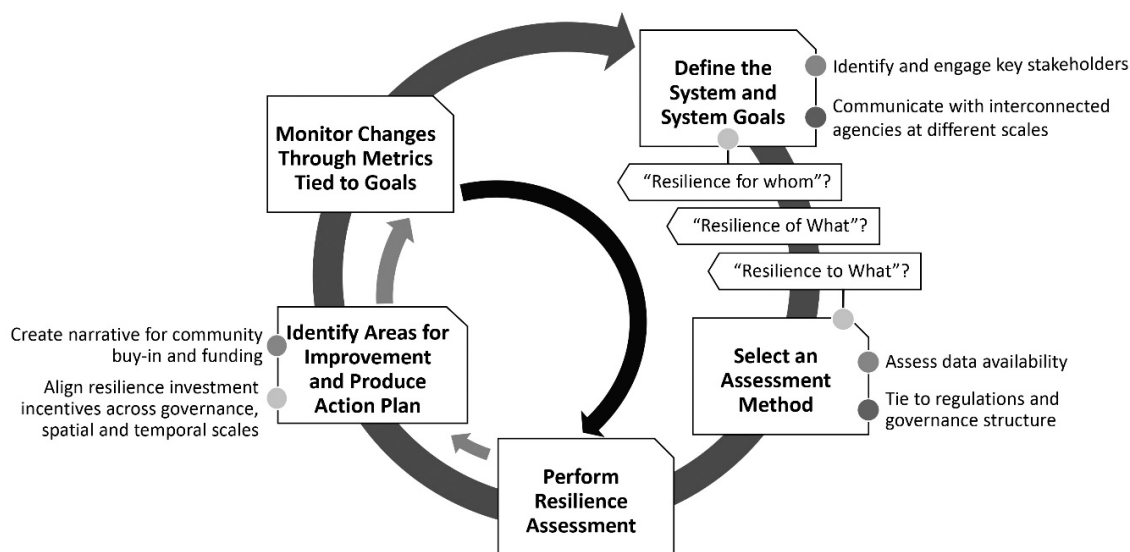
Figure 3. Critical considerations for effective resilience assessment and decision making.

4. Discussion and Conclusions

Resilience is a contested term with varying conceptualizations in different contexts and disciplines. It is increasingly used to frame research and policy debates on various issues in the context of urban studies. As the share of world urban population continues to increase, the challenges and problems that urban areas face become more severe, and adaptation-focused practices become more dominant, and resilience is expected to gain even greater traction in the future. In order to enhance the suitability of the resilience concept for guiding planning and assessment efforts, it is essential to have a better understanding of its underlying dimensions and characteristics. Adopting a co-design approach, this study provides information on diverse issues related to the conceptual underpinnings of urban resilience and its position vis-à-vis related concepts such as adaptation and sustainability. Furthermore, it discusses institutional factors that can enable/constrain resilience building, and the challenges of conducting and operationalizing urban resilience assessment. This study avoids specific discussion of specific globally-relevant practices or assessment tools and instead recommends that in order for resilience to be considered as a useful concept for guiding planning activities and for bridging disciplinary boundaries, it needs to be defined at the local level using consensus-based approaches. Negotiation-oriented conceptualization is essential for taking account of the specific conditions of the local context. Such an approach can help advance subsequent implementation of resilience plans.

In this paper, the SIM technique was employed to facilitate discussions among scholars and practitioners with expertise in different aspects of planning and urban studies, enabling them to deliberate on various topics/questions related to urban resilience. The four-step SIM process included grouping participants in four teams and assigning a question to each team, one-on-one interviews of each team member with a member from other groups, return of team members to their original table to further discuss the question in the light of interview results, and finally a plenary session to report the key ideas and receive feedback from the whole group. Discussions were primarily centered on the following four main topics: the key elements of the built environment that influence community resilience; the relationship between resilience and other concepts such as adaptation, recovery, and sustainability; the most essential institutional elements that enable/constrain building resilience; and the challenges of conducting resilience assessment. These four thematic questions were not intended to cover all aspects related to urban resilience. Instead, they can be considered as a valuable preliminary effort for further elaborating the complexity and breadth of the issue. Discussions around these four thematic questions highlighted key factors that are essential for enhancing urban resilience. In addition, major constraints to resilience planning and assessment were identified. A summary of these enabling

and constraining factors is presented in Table 2. It is worth noting that the relationship between resilience and other related concepts turned out to be the most challenging topic discussed during the SIM exercise. During the plenary session, this was the only topic that resulted in further discussions. The main point raised was that it should be acknowledged that, unlike sustainability, resilience can be either desirable or undesirable and this has implications for understanding inter-relationships between resilience, adaptation, recovery, and sustainability. This point was considered when preparing the synthesis report on this topic (presented in Section 3.1).

The discussion about the relationship between resilience and other similar concepts (Section 3.1) makes it clear that recovery and adaptation are a part and parcel of resilience as a broader concept. Recovery often refers to short-term efforts taken following the disruption. Adaptation, however, is of a longer-term nature and can be either incremental or transformational. It is emphasized that resilience and sustainability are two distinct terms and should not be confused with each other. While overlaps exist between these two, they cannot be used interchangeably [54]. In other words, a resilient community is not necessarily sustainable and vice versa [55]. Undesirable resilience can lock the system into unsustainable patterns and trajectories [55]. Nonetheless, these two concepts are mutually reinforcing. Being sustainable is an important condition which contributes to resilience. Also, being resilient is essential for maintaining long-term sustainability. This clarification is needed to avoid conveying conflicting messages in science and policy discussions. Resilience is believed to be an essential quality for achieving long-term sustainability by enhancing absorptive and adaptive capacities of urban systems. Sustainability, on the other hand, is a concept essential for not losing sight of the preferred and desirable pathways that should be followed to ensure efficient resource management and to fulfill the needs of current and future generations.

The second question (Section 3.2) addresses built environment factors that are essential for building resilience. It is emphasized that the built environment should be considered as a social construct shaped by both physical and socio-economic factors. Enhancing resistance and robustness through updating and enforcing building/construction codes; improving accessibility to infrastructure, resources, and services; decentralizing critical infrastructure; increasing density in least risk prone locations; and optimizing street design and connectivity are among the most important strategies that can provide benefits in terms of a number of resilience qualities (qualities which need further investigation, about their consistency when applied to urban systems, since they are usually taken from other fields) such as robustness, diversity, redundancy, flexibility, efficiency, and adaptability.

Urban risks and coping mechanisms are largely influenced by local circumstances, regional resources and geography, and national policies. The complexity of cities and their ecosystems calls for decision making across several layers of government. The discussion about institutional elements (Section 3.3) can be boiled down to several key issues: first, without having effective governance and institutional mechanisms it would be difficult, if not impossible, to take advantage of resilience as a bridging concept suitable for coordinating planning efforts between multiple sectors and across geographical and temporal scales. Appropriate institutional mechanisms are needed to facilitate desirable interactions between a wide variety of socio-economic, ecological, and political forces over time and across space. Second, resilience planning should be context sensitive and capacity-building activities should be undertaken to ensure participation of a wide range of local stakeholders and key actors throughout different stages of the planning process. Such an approach improves accountability and transparency of the process and enhances the chances of implementation. Third, concrete, coherent, and diverse financial arrangements are required for sustaining resilience planning efforts. Finally, development (and regular update) and implementation of regulatory, anticipatory, and monitoring frameworks are essential to ensure meeting targets and avoid being overwhelmed by future uncertainties.

Table 2. Enabling and constraining factors for urban resilience attributes.

Attribute	Enabling Factors for/Linkages with Resilience	Constraints/Considerations
Relation to adaptation, recovery, and sustainability	Close linkages with concepts of recovery, disaster risk reduction, and adaptation Achieving resilience (as a high order goal) can be facilitated through continuous and incremental adaptation efforts Synergies of ecosystem preservation with resilience and sustainability Recovery stage can serve as an opportunity to enhance resilience	Tensions in expert communities around the three concepts High emphasis on climate adaptation and resilience may undermine the importance of sustainability How to better articulate conflicts of priorities between different approaches? Adaptation does not necessarily ensure long term sustainability Sustainability measures do not necessarily prepare for future shocks
Built Environment	Integrating resilience principles in urban form and building codes Accessibility of urban infrastructures and services (physical and social) Decentralized and distributed infrastructures Street networks that facilitate smooth movement of people and vehicles	Built environment should be viewed in relation to social processes and legislative and institutional frameworks Possible conflicts between economic growth plans and environmental and social resilience of communities
Institutional/Regulatory context	Coordination between and within governments; and between government and non-government actors Clear understanding of roles and responsibilities at different levels Transparency, accountability, and participation in public budgets Strong and effective bottom-up institutions, actors, and networks Strong local leadership Risk anticipation and scenario-making capacities	Inherent trade-offs between local and more immediate measures versus long-term measures for resilience building Maintaining continuity of urban resilience policies and implementation on the local policy agenda given the short-term nature of political cycles Weak regulations and enforcement
Resilience Assessment	Effective communication strategy to gain buy-in for resilience planning/assessment The form of resilience assessment will inform the options for operationalizing and implementing assessments that can consider and prioritize incremental changes and rehabilitation efforts Proactive resilience activity of one urban community can have important impacts on the population, economy, and demand on services in nearby communities Assessment should include some methodology for prioritizing improvements	Identification and consensus of all relevant stakeholders Framing and communication of the assessment Resilience assessment tools that are both generalized and at the same time adaptable for context-specific applications Defining scales and system boundaries (spatial and temporal) Gaining political buy-in

Dealing with future uncertainties is perhaps one of the most challenging parts of any resilience planning process. Future changes are hard to predict and a certain amount of error is always present in models developed for predicting future changes and trends [56]. There is now a growing recognition among planners that the "predict and prevent" approach to planning fails to appropriately accommodate modern complexities and persistent uncertainties [57]. It is suggested that regular and iterative assessment and the development of different future scenarios (that analyze future changes within short, medium, and long-term time horizons) can facilitate brainstorming on the complexities of urban system dynamics and, to some extent, prepare communities to deal with future uncertainties [4,58,59]. Such assessments and scenario-making processes may be resource intensive as they require regular updates of changing thresholds and baseline conditions [4,58]. Although regular assessment and scenario making can be somewhat effective, a shift from the "fail-safe" approach to the "safe-to-fail" approach requires acknowledging inadequacy and incompleteness of scientific knowledge for dealing with future changes and uncertainties. Creating "safe-to-fail" cities requires planning and design processes that consider attributes such as redundancy, diversity, connectivity, modularity, and multifunctionality [15,56,60]. Uncertainty can also promote innovation and self-organization [61]. This can be achieved through developing institutional and social capacities to seize uncertain disruptions as opportunities for encouraging experimentation, learning by doing, and reflection [60]. Cohesive societies with high levels of trust and social capital have a higher capacity to deal with irregularities and uncertainties involved in disaster risk management [62].

The paper argues that challenges for resilience planning and resilience assessment are very similar to those faced by conventional planning and development activities (Section 3.4). A recurring issue in all discussions is the necessity of maximizing co-benefits and minimizing trade-offs between goals and objectives pursued by different social, economic, ecological, and institutional forces that influence resilience planning over time and across space. It is emphasized that defining system boundaries is a major challenge that needs to be carefully considered early in the design process. Without clarifying the system boundary issues, it may not be possible to take account of all factors that need to be integrated into resilience planning and assessment. A major challenge is related to the mismatch between short-term political cycles (elected positions) and the long-term and dynamic nature of socio-ecological systems. Resilience planning often implies setting long-term visions and targets, but defining and updating planning visions through engaging a wide variety of stakeholders can be considered as a strategy to address this issue. Other noteworthy challenges are related to data availability, costs of developing context-specific plans and assessment tools, political buy-in, and the identification of relevant stakeholders. Interestingly, the capacity to collect and interpret information and generate collective knowledge is critical; it has also been identified as a process which can even delay action and commitment by waiting for the best available information. Knowledge co-production and management processes can be costly and time-consuming; on the other hand, they are also highly beneficial in order to generate consensual decisions that can better meet needs and expectations and are socially and economically balanced. All in all, decision making must account for uncertainties and define acceptable levels of risk, with sufficient flexibility, so that processes of monitoring and assessment can be iterative and meaningful. Further research into processes of co-production and reflexivity in decision making is needed to better understand their effectiveness for addressing resilience challenges.

The SIM technique used in this study proved to be effective for facilitating discussions between a reasonable number of participants with diverse expertise and geographical contexts. A major benefit of using this technique is that it allows all participants to individually voice their opinions and ensures that sessions are not dominated by only a few active people (common in focus groups or larger workshops). Another benefit is that it allows for the collection of a significant amount of information and for the synthesis of it within a reasonable timeframe. Furthermore, as an iterative and co-design technique, it facilitates refining ideas and developing consensus among participants. Crucially, the SIM process supports rapid coalescing of key points important both for each topic area and across topic areas. Therefore, it is suggested that the SIM technique could be further utilized in the future for

both intra-disciplinary discussions on resilience issues as the field evolves and for collaboration across disciplines, as was demonstrated and illustrated through this exercise.

Overall, it can be stated that resilience is a multi-faceted concept and its definition and underlying dimensions can vary in different contexts and across different temporal and spatial levels of analysis. This study shed some light on the physical, social, and institutional dimensions of urban resilience. It is emphasized that factors and attributes contributing to resilience in terms of these dimensions are intertwined and that building resilience requires adopting an integrated approach that takes account of different attributes and synergies and conflicts between them. While being a distinctive concept, resilience has clear links with other related concepts such as recovery, adaptation, and sustainability. Although some tensions exist between them, more synergies were uncovered and it is recommended that these synergies should be maximized during the evolution and long-term process of resilience building within the broader sustainability planning community.

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