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BUILDING FOR LOCAL RESILIENCE AND THE LATENT NEXUS BETWEEN VULNERABILITY AND SUSTAINABILITY IN METROPOLITAN REGIONS

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Abstract

Providing a review of theoretical and empirical studies with a specific coverage on Europe, this paper focuses on the concept of 'metropolitan resilience' in light of public governance and regional planning, making some distinctions with the more general notion of 'urban resilience'. While discussing different approaches to 'engineering resilience' and 'evolutionary resilience' characteristic of transitioning urban systems, conceptual differences between the issues of 'specific' and 'generic' resilience in metropolitan regions were outlined, distinguishing central cities from suburban locations and larger regions surrounding urban cores. Integrating multi-disciplinary frameworks to resilience science allows formulation of shared definitions and homogeneous frameworks evaluating resilience in different socioeconomic contexts at both local and regional scale.

Keywords: Europe, metropolitan hierarchy, public governance, resilience, urban management

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1. Introduction

After decades with the 'sustainability' issue dominating both research and political arenas, the 'resilience' notion started attracting interest from positive and normative perspectives at the beginning of the new millennium (United Nations Secretary-General's High-Level Panel on Global Sustainability Report, 2012). While being sometimes restricted to strictly urban areas (e.g. inner cities or, in most cases, central cities), the concept of 'resilient cities' spread thanks, among others, to the rising interest for mitigation and adaptation to climate change (Campos et al., 2012; Coaffee, 2008; Jabareen, 2013). At the same time, policies aimed at reducing environmental risks have been progressively designed in light of the 'resilience' potential of districts and regions (Eckersley, 2018; Fankhauser et al., 2016; Hatuka et al., 2018). Urban resilience was therefore understood as a system's property stimulating (or even improving) adaptation to climate change, actively responding to ecological threats (e.g. Incerti et al., 2007; Otto-Zimmermann, 2011; Salvati and Zitti, 2005). A rising awareness to the proper management of natural risks reinforced the linkage between 'urban resilience' and the capacity to adapt to general dimensions of sustainability in a context of global change (Chelleri et al., 2015).

Despite an increasingly vast literature (e.g. Colding, 2007) delineating (and sometimes critically debating) the intrinsic relationship between resilience and urban systems from planning (Wilkinson, 2012), design (Pickett et al., 2004) and ecological perspectives (Alberti and Marzluff, 2004), a more

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intense criticism to the notion of 'urban resilience' took place recently (Porter and Davoudi, 2012). More specifically, the relationship between local resilience and socioeconomic organization (and re-organization) of cities and metropolitan regions (Balsas, 2014; Colding and Barthel, 2013; Cowell, 2013; Douglass, 2002), and the intrinsic linkage with different forms of sustainability (Ahern, 2011; Collier et al., 2013; Martin and Sunley, 2015), were discussed and often re-contextualized in a broader framework that includes (and logically reconnect) complex adaptive systems, environmental protection, spatial planning, socio-demographic issues, and economic viability of territories (Barthel and Isendahl, 2013; Müller, 2011; Williams and Vorley, 2014). Emphasis was given to social issues related to justice, equity and poverty (e.g. Baker, 2012; Rosti and Chelli, 2009; Steele and Mittal, 2012), in addition to the aforementioned visions of climate change and/or disaster recovery (Campanella, 2006; Muller, 2007; Newman et al., 2009). These contributions made clear the quest to expand the (wide) spectrum of theoretical and empirical applications of 'urban resilience' (Batabyal, 1998). Going beyond disciplinary (or thematic) visions, 'urban resilience' should be no longer interpreted as the ability to respond (only) to the impact of climate change, while considering together the evolution of metropolitan systems through long-term adaptive capacity paths (Meek and Marshall, 2018; Pelling and Manuel-Navarrete, 2011; Porter and Davoudi, 2012), that incorporate environmental issues (not exclusively related with climate change), social dynamics and economic performances in a unique interpretative framework.

In this regard, a new dimension of resilience – moving from the 'urban' to the 'metropolitan' spatial and operational scales – emphasizes the inherent transition from an engineering vision of 'resilient (inner) cities' to practical (and politically relevant) frameworks linking evolutionary resilience (and its emerging principles and properties) to the (evolving) geography of metropolitan regions (Ahern, 2011; Barthel and Isendahl, 2013; Chelleri, 2012; Collier et al., 2013; Salvati et al., 2012). These frameworks were grounded on the evaluation of sustainability dimensions, with a special focus on the transition towards sustainable development (Hawkins et al., 2018; Julnes, 2019; Olawumi and Chan, 2018; Zeemering, 2018), whose practical definition has been regarded as an increasingly spatially sensitive issue (Salvati and Zitti, 2009). When refining such empirical approaches, the intrinsic relationship between sustainability and systems' transition remains a key issue when assessing 'metropolitan resilience' through a multidisciplinary vision (Chelleri and Olazabal, 2012). A comprehensive investigation of the different dimensions of metropolitan resilience definitely integrates the distinctive visions of engineering resilience (Pimm, 1984) and evolutionary resilience (Holling, 1973). By this way, the investigation may evaluate together the abilities of a given system (i) to recover a state of equilibrium (a typical 'engineering' (or physical) notion), and (ii) to adapt to medium- and long-term stresses derived mainly from exogenous shocks. This transition underlies the importance of properties such as transformability and flexibility, whose evaluation is typical of approaches grounded on a socio-ecological thinking (Folke, 2006; Gunderson and Folke, 2011; Walker and Salt, 2006).

Another recent issue of intense (positive and normative) debate when discussing about the 'metropolitan resilience' concept is related with the definition of 'generic' and 'specific' resilience (Carpenter and Walker, 2001). Generic resilience is an intrinsic property of a given system *as a whole* (e.g. as a potential to activate adaptive responses and flexibility in order to self-reorganize in the face of unexpected disturbances, mostly negative and largely impactful events). Specific resilience is a variable attribute of a given system, e.g. possibly enhanced under a given external stimulus, either positive or negative. Understanding differences between generic and specific resilience is a base of 'sustainability science', which was increasingly based on the analysis and interpretation of non-linear feedback relationships between these two properties that intrinsically shape complex systems. Interestingly, the dimension of 'urban resilience' was bound to the dimension of 'engineering resilience' mostly in relation with individual resilience domains, without considering the intimate linkage between the different - interdependent - abilities of the system.

The necessary shift between the 'resilient city' paradigm and a framework capable of understanding the multidimensional notion of 'metropolitan resilience' is based on three concepts: (i) the transition from engineering to evolutionary resilience, (ii) the latent relationship between 'specific' and 'generic' resilience concepts, and (iii) the focus on even more complex socioeconomic systems, moving from the classical urban areas to include progressively larger and spatially articulated metropolitan regions.

These ambits, linking (and sometimes mixing) (strictly) urban and (strictly) rural landscapes, exalt individual peculiarities, interdependencies, and feedback relationships in complex systems (Ciommi et al., 2019; Salvati and Zitti, 2009; Smiraglia et al., 2016). By emphasizing limits and opportunities of a complex thinking framework, more recent works indicate the holistic analysis of generic resilience as a new multidisciplinary dimension of urban issues (Chelleri et al., 2012; Collier et al., 2013; Davoudi et al., 2012). Approaches typical of urban studies may delineate – better than other interpretative frameworks – the importance of future research toward a comprehensive analysis of 'metropolitan resilience' under largely differentiated socioeconomic contexts (e.g. Ciommi et al., 2018; De Rosa and Salvati, 2016; Salvati et al., 2012). 'Metropolitan resilience' should therefore become a hegemonic concept for the intrinsic linkage between research (e.g. resilience assessment) and policy (e.g. resilience preservation) at the most appropriate spatial scale for planning

intervention. At the same time, a truly effective evaluation of metropolitan resilience of interest for policy and planning should be extrinsically multi-scalar, recognizing the different meaning of 'resilience' at neighbourhood, local, regional and broader organization levels. By encouraging and sustaining a continuous dialogue between urban and rural components of the human landscape and the economic space, the 'metropolitan' scale seems to be the appropriate operational level matching a refined understanding of complex socioeconomic systems through multi-scale assessment and effective policy approaches.

Based on a comprehensive analysis of recent literature, the present commentary has multiple objectives as follows: (i) to review the concept of systems' 'resilience' in relation with 'vulnerability' (Adger, 2006), 'sustainability' (Walker and Salt, 2006), and 'transition' dimensions, moving toward a more complete approach to 'metropolitan resilience' (Grin et al., 2010); (ii) to discuss existing conceptualizations of 'generic' metropolitan resilience (Chelleri et al., 2012, Colucci, 2012; Collier et al., 2013; Resilience Alliance, 2007), outlining theoretical limits and opportunities that emerge from urban management oriented toward specific dimensions including – while being not limited to – mobility, transport, ecology, and spatial planning; and, finally, (iii) to discuss a refined (theoretical and operational) definition of 'metropolitan resilience'. This definition may emerge from a multidisciplinary vision contributing to address (and possibly solve) paradoxes still open in current literature and interpretative issues that derive from uncoordinated (e.g. 'non-holistic') approaches to resilience, going beyond linear thinking and disciplinary perspectives.

2. Resilience, vulnerability and socio-ecological transitions: broadening the debate

When evaluating strategies aimed at containing system's vulnerability with respect to environmental and socioeconomic risks, resilience has been often associated with the notion of vulnerability (e.g. Cutter, 2018; Demiroz and Haase, 2019; Fiksel, 2006; Pettit et al., 2019). By this way, the intrinsic perimeter of the 'resilience' notion may include dynamic aspects increasing the fit of a given system over time through (formal and/or informal) adaptation strategies (e.g. Chelli et al., 2009). These aspects usually go beyond (i) the traditional notion of 'reaction to disasters', (ii) scale and management of complex systems, or (iii) strictly demo-economic dimensions (Chelli et al., 2016; Ciommi et al., 2017; Gigliarano and Chelli, 2016; White, 2010). The emerging interdependencies between theoretical approaches referring jointly to local systems' vulnerability, resilience and sustainable transformation of cities, are intrinsically connected with the growing attention to urbanization patterns and processes (Lankao and Qin, 2011; Newman et al., 2009; Seitzinger et al., 2012), seen - more frequently than before - as a possible factor of environmental change (Grimm et al., 2008). The influence of metropolitan systems on the so-called planetary boundaries (Rockström et al., 2009) has been grounded on the key assumption of unsustainability of 'urban metabolism' mechanisms (Sassen, 2009). With significantly more than 50% of the world population settling in urban areas - 70% being expected in 2050 (United Nations, 2012) – and settlement dispersion advancing rapidly in both affluent and emerging economies (e.g. Colantoni et al., 2015), metropolitan growth highlights the increasing linkage between resilience, vulnerability and the uneven transition toward systems' sustainability (Rotmans and Loorbach, 2009).

Despite various applications to urban contexts worldwide (Jacobs, 2005), these concepts need a refined definition (including a more precise spatial perimeter, flexible enough to include different interpretations of the underlying processes) to delineate contact points, intrinsic feedbacks, and conflict dimensions (Ahmed et al., 2018). Vulnerability-resilience interplays are coherent with schematic definitions of sustainability, defining exposure (to a given impact dimension), sensitivity (to a specific type of impact), and resilience (to prevent – and react to – a given impact) of a local system undergoing external shocks. In turn, the 'resilience' issue has a strong semantic relationship with the outcomes of mathematical-ecological models, while vulnerability and adaptation are concepts more characteristic of disciplinary backgrounds related to geography, environmental science, and natural disasters' literature, with a broad empirical base grounded e.g. on the paradigm of climate change (Janssen, 2007).

In a context of global change (Plummer and Armitage, 2007), disciplines including socio-ecological studies and political ecology have defined (i) resilience as an integral part of adaptability (Folke, 2006) and (ii) adaptability as a component of vulnerability (Burton et al., 2002), conceptualizing vulnerability, resilience and adaptive capacity into a unique theoretical framework related to systems' complexity (Gallopín, 2006). Compared with the wider literature on risk analysis (Batabyal, 1998), metropolitan resilience was therefore seen as an outcome rather than a process. In fact, although political ecology emphasizes resilience as an evolutionary process, mainstream conceptual visions of resilience were more tightly related to basic approaches of risk mitigation, depending on the operational level of intervention (i.e. delineating the latent nexus between planning and resilience science). As a basic component of vulnerability, this debate may reaffirm resilience as a capacity to return to an equilibrium state, representing a key attribute of complex systems correlated with the reduction of risk. Adaptive capacity is thus related to specific resilience functions (Manyena, 2006). A comprehensive analysis of the intimate relationship between the two approaches (vulnerability *vs* resilience) allows a refined definition of the most relevant contact points

mentioned above (Cutter et al., 2008). A partial consensus has been reached on the need to share methodologies and practical tools identifying and assessing adaptation factors. A weak point in both frameworks relates to the lack of monitoring approaches, field protocols, sampling surveys and indicators addressing the specificity of metropolitan contexts (Lankao and Qin, 2011).

Assuming that the ultimate goal of both approaches is reduction of a given system's vulnerability by increasing resilience (Miller et al., 2010; Turner, 2010), a promising (transitional) approach rooted in the study of 'Socio-Technical Systems' (STS), contributes to operationalize these frameworks (Grin et al., 2010). Since innovation plays a key role in determining system's evolution at different spatial and temporal scales (Smith and Voß, 2010), this approach introduced methodologies and practical tools to manage, promote or guide system's transitions from an equilibrium state to a new one (Loorbach, 2007), delineating planning options on the ground or, at least, evidencing alternative solutions to a mainstream developmental path. Being driven by technical innovations (Kates and Parris, 2003), the approach positioned in-between theory and application, having a contact point with sustainability in the management of transitions. In these regards, this assumption is in line with the evidence that socio-ecological resilience has more recently considered the transformations of specific parts of a given system to justify its reorganization (Derissen et al., 2011; Folke, 2006).

Still far from providing methodological evidence to delineate transformations in socio-ecological systems, metropolitan realities provide examples of transformability intimately connected with the local context (Mumford, 1968). For instance, the notion of resilience has been considered in a representative social movement (i.e. transition town) linked to urban transformations worldwide (Hopkins, 2010). Defined as the ability to revert from unsustainable trajectories such as dependence on oil and global production chains, this movement relied on self-sufficiency as the essence of metropolitan resilience. By promoting a real transition towards a sustainable system assuring self-sufficiency (e.g. in energy, food, water), this movement developed on a relatively small community and is now widespread throughout the world (Hopkins, 2008). While promoting a broad debate (Smith, 2011), the movement maintained a strong commitment to the native 'social' root, resulting to be different from the experiences oriented toward the STSs vision (see above), where transitions are seen and managed by expert panels depending on the sector in which the innovation is managed (and developed) at the level of the whole society (Loorbach, 2007; Smith and Stirling, 2010; Van der Brugge et al., 2005). The conceptual integration of the various transition models is a recent challenge to operationalize the concept of resilience and adaptive capacity at a 'truly metropolitan' scale, considering together sustainability, vulnerability and resilience of contemporary cities' growth.

3. The notion of "metropolitan resilience"

A recent challenge in the 'resilience science' was the shift from a vision dominated by specific resilience of a given system to a more complex perspective embracing multiple dimensions referring to general resilience (Chelleri et al., 2015). This vision reflected the transitional thinking from 'urban' to 'metropolitan' resilience, delineating the intrinsic characteristics of a given system that make it more flexible and adaptable, being able to face challenges at different operational, temporal and spatial scales (Chelleri et al., 2012). Scale factors are a relevant issue in any approach grounded on such thinking. The complex dependence between different systems at various operational scales is far from being measured, estimated, or predicted. The concept of 'panarchy', although emphasizing the management of resilience as a factor of redistribution and reconfiguration of opportunities, capacity, and power between different systems and scales (Lauer et al., 2013), does not provide a methodological framework facing with cross-scale interactions. In these regards, Holling's model provides a possible response to this challenge, envisaging the metaphorical idealization of system's development through sequential waves of growth, specialization, collapse, and reorganization for a new growth path (Gunderson and Holling, 2002). Suggesting that resilience decreases with increasing system specialization (Ulanowicz et al., 2009), this thinking outlines the intrinsic changes in the level of resilience typical of metropolitan regions, thanks to a vast network of settlements and systems that support local functions and structures. Such evidence definitely emphasizes the (complex) dimension of 'resilience in the city', being intimately distinctive from the more traditional (and linear) expressions recalling the so-called 'resilience of cities' (Ernstson et al., 2010).

The interplay of spatial and temporal dimensions was not always evident in generalized theoretical frameworks, such as those proposed by the Resilience Alliance (Chelleri et al., 2012; Collier et al., 2013; Resilience Alliance, 2007). While the Resilience Alliance illustrates the general issues underlying urban governance, Chelleri et al. (2012) represent the complexity of urban resilience delineating conflicts between the existing approaches in the different disciplines that constitute an integrated approach to analysis of complex systems. Such contributions highlight the intrinsic limits of sectoral and disciplinary definitions, recalling us that ecosystems' resilience - evolving over longer time intervals and radically oriented toward conservation approaches - has to coexist with socioeconomic system's resilience (rapidly transforming toward another equilibrium state).

Empirical results of earlier studies (e.g. Collier et al., 2013) investigating the intimate transition of

urban systems to resilience and sustainability have illustrated city resilience in relation to the different dimensions of metropolitan change, proposing (and, in some ways, accompanying) an effective transition towards sustainability. Reflecting on the importance of the 'metropolitan' dimension, practical schemes developed in such contexts have been oriented towards the integration between transition and resilience, by interpreting transition as an operationalization of resilience to achieve sustainability. While finding rarely an operational scale of intervention, graphical representations were provided to define key elements composing resilience in metropolitan systems. For instance, barriers such as infrastructural systems, exposure to certain environmental risk factors, or the characteristics of a given social system - such as institutions, practices, regulations and flexibility – were recognized to cause permeability between hierarchical levels. However, a less intense focus has been deserved to enlarge the approach to larger study regions, moving from the classical notion of 'city resilience' to a more integrated and spatially comprehensive 'metropolitan resilience' concept.

Conceptual frameworks more frequently focused on conflicts and synergies between the different components and factors of local resilience (Ernstson et al., 2010). Open challenges in the construction of this framework were identification of scale factors that allow characterization of specific resilience dimensions at different scales (local, urban, metropolitan, regional, national). These relationships (and influences) at different scales constitute a basic problem in the operationalization of metropolitan resilience, undermining the latent relations with the broader dimension of sustainability. For instance, a locally resilient system with diversified and flexible infrastructures, societies and economies because of resources and capabilities (i.e. functional diversity) does not guarantee that its impact on other local systems is sustainable and fair enough (Quaranta et al., 2019). In other words, the consequences of a policy aimed at promoting different types of local resilience in metropolitan areas can have side effects on the spatial redistribution of vulnerability to external shocks.

4. Assessing metropolitan resilience

Theoretical models and empirical approaches implementing measures, metrics, indicators and composite indices assessing metropolitan resilience have been developed mainly over the last two decades (Resilience Alliance, 2007; Otto-Zimmermann, 2011). A specific limit in such approaches was that such measures refer to actions centered on one (or a couple of) specific sectors/dimensions, preventing the adoption of a robust theoretical framework evaluating synergies and the inter-sectoral effects of scale. In the following, measures of metropolitan resilience investigating the inter-scale complexity of local systems and its composing dimensions were reviewed and critically discussed. Collier et al. (2013) provided guidelines for measurement of metropolitan resilience at the local community scale, within a sustainable development perspective. Paradigmatic dimensions include (i) the integration of information and communication technologies in urban metabolism, (ii) a stronger linkage between green infrastructures and planning, (iii) a new operational approach to planning through collaborative responses, (iv) adaptation and mitigation strategies to climate change in regional planning, (v) containment of urban sprawl and, finally, (vi) promotion of short-chain economic approaches.

Despite being non-conclusive and likely partial, these practical issues stimulate a more general reflection dealing with the transition from 'specific' to 'generic' resilience, evidencing the importance of a transition from general approaches of engineering resilience (e.g. assessing the inherent capacity of preserving dynamic balance conditions) to a socio-evolutionary concept of resilience (assuming e.g. transformability as a basic characteristic of resilient local systems). The first issue may lead to a paradox: defining resilience 'potential' of metropolitan systems reconnects with the problematic definition of cities, urban areas, and broader regions. These concepts are clearly separated and need distinctive definitions and operational practices, difficult to be realized in differentiated socioeconomic contexts all over the world. Although the transition from ecological to engineering resilience is complex to define and assess, modelling may simulate a non-linear, adaptive system, identifying which features and capabilities influence its functioning.

Metropolitan regions were clearly adaptive and complex systems that present profoundly divergent characteristic and dynamics in relation to geographical, physical and cultural factors. While for generic resilience of a given ecosystem, it is possible to establish which characteristics increase the chances of survival of the same system without collapse, in the case of a metropolitan region, to determine capacities and tipping points is evidently more problematic (Ahmed et al., 2018). In partial antithesis with this perspective, Balsas (2017) argued that "stages of maturity, compact urban development patterns, regulatory and administrative planning traditions, and socio-economic and cultural systems influence territorial coherence". According to this author, "anticipatory regional planning has the capacity to adapt to changing conditions in order to maintain and develop more sustainable and resilient territories". In this perspective, "public spending oversight and programmatic firewalls allow corrections to be made before problems escalate out-of-control".

As one of the most transformative systems because of the capacity for self- and re-organization (Campanella, 2006), metropolitan regions can be considered less resilient due to the historical and continuous transformations that have seen collapsing and restoring socioeconomic and spatial organizations (Mumford, 1968). The necessity to consider the transformation of the sub-parts of a system under the

umbrella of resilience as a capacity to reorganize the entire system derives from this statement (Folke, 2006). Assuming properties of transformation/adaptation as a proxy of resilience, metropolitan regions are systems able to transform - evolving on a global scale - and the conceptualization of 'generic urban resilience' can be defined as the capacity to recover, adapt and transform at the same time, even if at different scales, and according to different hierarchies and life cycles. To make this definition operational, some critical reflections are therefore essential, as discussed below.

Applying the traditional principles of resilience (including the dimensions of connectedness, redundancy, and latitude) to complex socioeconomic systems is a particularly hard task (Wardekker et al., 2010), when delineating what dimensions contribute the most to metropolitan resilience (Walker et al., 2004). These principles derive from ecosystem ecology, assuming that living populations can be reorganized (e.g. in specific attributes and/or structures) while being given in their functions and roles. In these regards, tipping points, thresholds and limits to system's reorganization maintain system's balance or evidence different development paths (Holling, 1973). However, metropolitan systems display exceptional transformability and adaptation (e.g. resident population can change the main function within the system in a short time period). An interpretative framework grounded on tipping points does not seem to be performative unless it specifically refers to ecological thresholds (e.g. availability of natural resources essential to human life) or the environmental functioning of some metabolic flows (e.g. regeneration capacity).

A refined understanding of metropolitan resilience therefore requires formulation of a framework grounded on new principles such as attraction basins, socioeconomic networks, as well as thresholds and elements promoting resilience. Such frameworks should consider together human conditions (e.g. individuals' skills), economic performances (e.g. transformability), and ecological dynamics (e.g. the relationship between cities' functioning and environmental dynamics that provide fundamental ecosystem services) intimately characterizing the metabolism of metropolitan regions. From this perspective, recent findings underline how the role of innovation (Smith and Voß, 2010), the structure of networks in resource management (Ernstson et al., 2010), as well as social behaviors and environmental interdependencies, generate synergies between global commodity chains and global cities' networks (Sassen, 2002). All these factors are key elements defining the basic principles that influence metropolitan resilience, and thus the evolution of global urban hierarchies. This theoretical step recalls a basic planning dimension based on the intrinsic linkage between (settlement) form and (socioeconomic) functions shaping local dynamics (e.g. Neuman, 2005, 2009).

When using simplified schemes according to the time scale of different resilience approaches, actions oriented at recovery, adaptation or transformation may reflect differentiated metropolitan dynamics; their characterization is essential to delineate actions consolidating resilience towards sustainable paths. Transitions to a new socioeconomic regime are trajectories full of barriers built by economic interests at the base of the current regime, strongly tied to centripetal forces aimed at maintaining the *status quo* (De Jesus and Mendonça, 2018; Fernandez and Rodrik, 1991; Gehlbach and Malesky, 2010; Kirchherr et al., 2018; Roland, 2002; Singh and Giacosa, 2019; Wihlborg et al., 2019). This dynamic equilibrium can be reflected on the planned interventions for infrastructure maintenance, e.g. approaches aimed at the maintenance of obsolete systems rather than at the redefinition of new structures. In the case of water or energy policies, preferences for maintaining centralized, public and oligopolistic management, contrast with decentralization forces, with the consequent redistribution of responsibilities and different access to (and regulation of) natural resources (Rakauskiene and Strunz, 2016). The varying permeability of institutions also suggests how conservative systems will leave no room for innovation, change, and public participation. When evaluating policies strengthening metropolitan resilience, the constituting elements should be reframed according to the relationship between such dimensions and conservation, adaptation or transition approaches (Johannessen and Wamsler, 2017). This framework finally stimulates the creation of transitional spaces towards sustainability (Quaranta et al., 2019).

Equity and social justice underlie metropolitan transformations and the specific management of cities. A possible consequence of the resilience paradigm from a typically social perspective, is the intrinsic reorganization of power impacting forms and structures, while leaving the same network of power and competences unchanged. For instance, creation of smart settlements and neighborhoods is an example of a latent transition to a new city model (Dezi et al., 2018) that is sustainable (e.g. efficiency in managing resources) and resilient (modularity and smartness, e.g. using remote controls), although socially divisive, because of price barriers (e.g. Salvati et al., 2019). Developing settlements accessible only to specific population segments represent, on the one side, a pivotal experiment for design and implementation of new technologies and, on the other side, a missed opportunity to solve (or mitigate) issues of class segregation and local-scale inequalities (e.g. Di Feliciantonio et al., 2018).

While being a possible operationalization of sustainability (United Nations Secretary-General's High-Level Panel on Global Sustainability Report, 2012), conceptualization of metropolitan resilience can be seen as a sort of trap, preserving traditional hierarchies of power at the base of (a presumed 'sustainable') land management (Salvati and Zitti, 2009). While resilience *per se* does not represent a

positive principle for regulation of resources' use, the notion should be preferentially related with some features of the system related with social justice. This emerging issue underlines the importance of 'resilience tradeoffs' (Lauer et al., 2013), i.e. transcalar implications that a resilient system can indirectly generate.

A relevant topic related to resilience tradeoffs, social justice and metropolitan growth is reflected in the complex relationship between urban and rural areas, in turn resulting in the global dynamics of urbanization. As previously mentioned, the growing concern for urban sustainability comes from a more generalized awareness that metropolitan regions have become an important hot-spot of global environmental change (Grimm et al., 2008), and a restless hub for socioeconomic transformations, not necessarily negative for the environment (e.g. Katz and Bradley, 2013). This concern finds answers in specific approaches aimed at improving the sustainability of urban metabolism, while it seems to ignore a worrying implication of this transformation, i.e. the abandonment of productive land owned, especially in developing countries, by large companies that are ensuring control of future food production (Sassen, 2001). Based on this example, a paradox of metropolitan resilience linked to global sustainability (Seitzinger and Svedin, 2012) is that a resilient policy from a complex system perspective, requires a complete understanding of both urban metabolism and the local-global mechanisms and interrelations activated by such mechanisms. In this sense, metropolitan resilience should act as the appropriate dimension to recompose both on-site and off-site conflicts between urban and rural territories. A practical thinking may contributes in this way, e.g. delineating, up to the global scale, the impacts and implications of production and distribution chains of goods consumed in metropolitan regions.

If resilience also implies a rebalancing of responsibility in the management of resources, global urbanization translates into a new paradox, given that resilience strategies would promote recovery of the widespread responsibility and control of productive land at different spatial scales. Questioning the link between urban and rural resilience is part of the most recent debate in resilience science, discussing three critical points: (i) the local-global relationship between urban and rural areas that may activate responses capable of understanding the complex relationship between agriculture, cities and food security; (ii) local-regional dynamics, typical of peri-urban areas classified as particularly vulnerable and needing solutions inspired to principles of general resilience of metropolitan systems and, finally. (iii) the achievement of socioeconomic conditions for urban-rural resilience implies paths that should involve common and integrated responses to exogenous shocks, implementing resilience and promoting a truly sustainable development of cities and the surrounding territories. In all these cases, metropolitan regions still provide the necessary spatial base to speculative analysis, discussion and operational implementation of policies.

5. Discussions

Future research on metropolitan resilience are increasingly required to incorporate a critical revision of principles and criteria (e.g. network structures, institutions, innovation), paying attention to specific dimensions of change (e.g. conservation *vs* transformation) and the critical evaluation of (direct or indirect) trade-offs related with social components (e.g. justice-equity combination) and natural components (e.g. ecosystem services and agricultural production). Exemplifications of the concept of metropolitan resilience are primarily associated with management of natural and climatic risks (e.g. strategies containing urban vulnerability linked to geomorphological factors and to the safety of infrastructures and services and, more generally, of the built environment), or implementation of technology (e.g. smart cities) maximizing the efficiency of urban metabolism. The principles of resilience that underlie these applications are (i) risk reduction (responding to the linear logic of 'greater resilience-lower vulnerability'), (ii) rapidity of response to external shocks (e.g. thanks to remote control of metabolic functions based on principles of engineering resilience) and (iii) self-sufficiency.

System's complexity has led to simplified resilience strategies in urban environments, being oriented toward a linear analysis of system's vulnerability. However, the recent vision for smart cities reproduces a self-sufficiency that does not take into consideration relationships, influences, trade-offs between operational scales neither at social level (equity, social justice) nor ecological level (characteristic of urban-rural relationships, and thus the intrinsic linkage between cities and ecosystem services) (Mier et al., 1993). In addition to disciplinary visions typical of engineering resilience, these applications were mainly driven by a top-down approach, building resilience from the top. If resilience is considered in terms of reorganization capabilities (Bingham, 2006; Bovaird, 2005; Ielite et al., 2015), stakeholders such as citizens, organizations, formal and informal institutions, social networks, and economic dynamics (De Nisco et al., 2008) - should play a fundamental role in resilience preparedness (Carrol, 1991; Donaldson and Preston, 1995; Freeman, 2010; Freeman and Reed, 1983).

In line with the assumptions of the 'new public governance' (Osborne, 2010; Torfing and Triantafillou, 2013; Walsh and Hallegatte, 2019), these limits underline the fundamental importance of redefining and critically orienting metropolitan resilience toward (i) a wider horizon of application of specific-to-general resilience and (ii) broader transformations (e.g. specific-to-evolutionary resilience), instead of perpetrating visions related to engineering resilience. Assuming the operational definition of specific resilience as the fundamental

issue of ecological resilience (Carpenter and Walker, 2001), two issues should be specifically considered in metropolitan regions: (i) the dynamic equilibrium between the different recovery-adaptation-transition strategies, in order to promote long-term sustainability (not falling into the application of engineering and specific resilience) and (ii) impact and cross-scale consequences of various measures and applications of the resilience notion.

Finally, a third question arises, i.e. why we should face with systems' resilience. The notion of resilience has been and is still criticized despite appearing more and more widespread in the political arena at all levels of governance (Albers and Deppisch, 2012; Markusen, 2003; Porter and Davoudi, 2012; Redman and Kinzig, 2003; Tobin, 1999). Having explored the current limits and the need for more integrated research at different observation scales, another question arises, i.e. what resilience science adds to sustainable development and theories of socio-environmental transition. The answer is intrinsically bonded to the exhaustive exploration of two fundamental principles of resilience, i.e. self-sufficiency and flexibility (e.g. Chelleri et al., 2015; Delfanti et al., 2016; Salvati et al., 2016). The translation into practice of these fundamental concepts can proceed through decentralization and redistribution of functions (e.g. preferences for widespread energy production, decentralized water management, non-centralized food production), with responsibilities divided into small urban metabolism managers, exalting the importance of multi-scale and cross-scale definitions of metropolitan resilience.

If resilience implies flexibility reflecting adaptive response to change, this notion definitely represents the antithesis of extreme specialization, a concept particularly developed in the mainstream economic analysis of metropolitan systems. While niches of production and specialization work in a global network under dynamic and changing markets, their survival lies in the vast network thanks to the fact that their specialized functions play a fundamental role for the macro-organisms (e.g. the global market and the production and consumption chains). Ability to adapt to different production chains makes a niche (more) resilient.

Metropolitan networks are standardized structures in global market mechanisms, with the consequent risk for the individual components of such networks to become more dependent on the functioning of macro-systems, and possibly less resilient, because of the intimate dynamics of international networks, which are beyond the control of governments and planning at all the appropriate intervention scales (Carlucci et al., 2018; Kazemzadeh-Zow et al., 2017; Muñoz, 2003). In these regards, the claim of Quigley et al. (2018) for a new 'socio-ecological resilience' agenda facing with the specific problems of urban design, planning and governance is particularly appropriate when addressing such issues.

6. Conclusions

Assuming resilience as an expression of a large set of assets that provide flexibility, the most coherent approach to metropolitan resilience requires a complete redefinition of the capacity of societies, and the built environment in general, to be flexible enough to change. For this reason, articulating future research on metropolitan resilience through the lens of the dimensions mentioned above can proceed in the light of criteria of self-sufficiency and decentralization. As a political tool, resilience preparedness implies a greater bottom-up participation, defining priorities between infrastructural control (e.g. ensuring short-term system's functioning) and resilience transition over longer time horizons. This transition is facilitated by encouraging stakeholders of public institutions, social movements, and informal networks to participate to resilience building. This will capture the increasing demand of newly built-up urban and peri-urban structures, and secure the transition from traditional planning systems to a coherently adaptive management of metropolitan regions.

The fundamental step in this transition is the shift from predominantly technical and technological experiences to an integrated approach that focuses on social integration and environmental implications. From an epistemological point of view, reconnecting metropolitan resilience with regional planning and traditional scientific backgrounds (e.g. in ecology or environmental sciences) means a more tight linkage between theory and practice, which is exactly what is considered a relevant weakness in the mainstream literature on urban resilience.

In these regards, specific approaches to socioeconomic analysis and to investigation of form-functions relationships in cities - coherent and fully integrated in a resilience discourse - are necessary to inform a permanent monitoring of vulnerability and sustainability of local development processes in expanding metropolitan regions.

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