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# Spatial fragmentation as an opportunity for resilience building through urban acupuncture: Learning from Tehran and Bucharest

**Abstract** The rapid urbanization of metropolitan environments worldwide has led to increasing spatial fragmentation. Disconnected spaces have revealed spatial and social voids that reduce the adaptive capacity of a region. However, these spaces also offer latent potential for urban resilience. Accordingly, this study reveals how urban acupuncture promotes resilience in leftover spaces to reduce or embrace spatial fragmentation. This paper reviews spatial fragmentation and urban resilience from descriptive-analytical and normative perspectives. It proposes urban acupuncture to locate critical spatial structures and processes on a small scale. The study develops a conceptual framework around fragmentation and urban acupuncture. It investigates the assumptions behind the concepts of spatial fragmentation and proposes a dialectical framing of vacancy based on resilience and urban acupuncture, along with a reassessment of leftover space as a planning tool. The framework's application is demonstrated in Tehran and Bucharest. As a result, spatial fragmentation significantly influences urban resilience to prevent expansion. Urban acupuncture opens the possibility of developing optimistic scenarios by considering leftover spaces and the broader opportunities they generate for urban resilience. Depending on the urban context, this strategy can be applied through a single intervention in a specific place or a network of coordinated interventions in different locations.

**Keywords** Spatial fragmentation, Leftover space, Resilience, Urban acupuncture.

## Introduction

Spatial fragmentation has become a common issue in contemporary complex metropolitan contexts (Pírez 2002; Angel et al. 2012). Spatial fragmentation is an objective phenomenon in the evolution of urban space which is characterised by the fragmentation of urban space units, the strengthening of space segmentation, the weakening of spatial relations and the decline of the overall function of space (Peijuan et al. 2018). Spatial fragmentation is mainly caused by transportation infrastructure (Forman, Alexander 1998; Macias, Gadziński 2013) which affects almost every aspect of the landscape, including its aesthetic, ecological, historic and recreational qualities (Forman et al. 2003; Jaeger et al. 2007). Land fragmentation as a result of large-scale transportation infrastructure threatens urban integrity (Wei, Zhang 2012) as well as natural habitats (Kubacka et al. 2022).

Cities and metropolitan areas the world over are now highly fragmented, their fringes typically made up of disconnected patches of urban fabric broken up by swathes of vacant land (Angel et al. 2012). Although this process differs from region to region, rapid urbanisation has created many challenges for countries. The main growth in the cities was due to an opportunity-led development, which produced an extremely unequal urban fabric with spatial discontinuities and leftover spaces (Pessoa et al. 2019).

Cities in developing countries show a spatial pattern characterised by the variety of the physical environment or the fragmentation of urban space. From an aerial view, most Third World cities appear as a complex mosaic where the various pieces are assembled according to a logic entirely different from that of the rational and efficient industrial city model. What drives the Third World city to be, space-wise, a 'city of fragments' is still unknown. Most importantly, it is unclear whether such a physical fragmentation is in any way related to a similar economic

and social fragmentation (Balbo, Navez-Bouchanine 1995). Planning institutions have attempted to overcome spatial fragmentation problems but have faced many difficulties (Pessoa et al. 2019).

The notion of spatial fragmentation used in urban studies refers mainly to two other fields of knowledge. The first one is Landscape Ecology where spatial fragmentation is seen as more related to morphology. It is given a greater focus on the physical rupture of space. This view is present in the work of Dramstad et al. (1996), where the authors develop principles related to fragmentation of patches and corridors, against the background of a so-called matrix. Lister et al. (2015) focus more on the environmental impact of these physical interruptions, while Angel et al. (2012) develop their research on satellite images especially connected to urban sprawl. Landscape ecology studies have long been concerned with measuring fragmentation (Riiters 1995). Unfortunately, the measures proposed in the literature proved inappropriate for the comparative study of the fragmentation of urban landscapes on a global scale (Angel et al. 2012).

The second view of spatial fragmentation is based on critical Geography and takes into account the social limitations created by this physical division of the space (Pessoa 2019). Disconnected areas have exposed spatial and social voids that diminish the adaptive capacity of a region. Cities with loose spatial and social ties are enormously vulnerable to external disturbances. In an extreme scenario, a completely disconnected system is not capable of establishing minimal communication or mutual relations, and is not able to respond to potential risks (Pessoa et al. 2019). The fragmentation of urban landscapes is therefore an important concern both in terms of the efficiency of the built environment and in terms of the ecology of the open spaces in and around cities (Angel et al. 2012).

The fragmentation of urban landscapes − or the inter-penetration of the built-up areas of cities and the open spaces in and around them − is a key attribute of their spatial structure (Angel et al. 2012). Nevertheless, physical connection does not necessarily promote social connection between diverse groups or individuals. There may be other factors influencing this phenomenon apart from the simple connection of spaces. As Sabatini and Salcedo (2007) suggest, in some specific contexts, the development of gated communities and the physical barriers surrounding them can, to some extent, create a social connection between residents and non-residents of such communities. The relationship between physical connection and social connection is thus not that straightforward (Pessoa 2019).

Considerable research has been conducted to understand how urban green space (UG) changes in response to urbanisation at various scales from individual patches to landscapes (Dallimer et al. 2011; Tang et al. 2012; Zhao et al. 2013; Yang et al 2014; Benini, Asquith 2019). However, most of these studies have been conducted at a single scale and little is known from a multiple-scale perspective. The integration of approaches focusing on different scales can provide a more holistic and comprehensive view on understanding the spatial pattern of UG and its change and thereby may enhance our understanding of the social and ecological impacts of UG change (Wang et al. 2020). In this study, the concept of spatial fragmentation is aligned with the combination view of spatial fragmentation, especially related to socio-ecological resilience.

Previous research finds that larger cities are less fragmented, that higher-income cities are more fragmented, that cities with higher levels of car ownership are less fragmented, and that cities that constrain urban development are less fragmented (Angel et al. 2012). Angel, Parent and Civco (2012) recommend that making room for urban expansion in rapidly growing cities should consider their expected fragmentation levels.

An interesting example, which is discussed in more detail by Cumming (2011), concerns the parallels between social and ecological fragmentation processes. While there are important differences between ecological and social fragmentation processes, a spatial resilience framework serves to clarify some of the commonalities and general principles that underlie both cases. Just as isolated habitat fragments may lack important ecological processes relating to diversity and connectivity, socially excluded groups tend to be more vulnerable to many kinds of disturbance, often have below-average health and child survival rates and may be less resilient to physical or socioeconomic perturbations because they do not have easy access to coping mechanisms and support systems (Chaves et al. 2008).

This paper reviews the literature on spatial fragmentation and urban resilience both from descriptive-analytical and normative perspectives. It puts forward urban acupuncture as a way to locate critical spatial structures and processes that need to be addressed at a small scale. The study first develops a conceptual framework around fragmentation (from a descriptive-analytical perspective) and urban acupuncture (from a normative perspective). It investigates the assumptions behind the concepts to identify new ways of addressing spatial fragmentation and proposes a dialectical framing of vacancy (Figure 2) based on resilience and urban acupuncture, along with a reassessment of leftover space as a planning tool. The application of the framework is demonstrated in two cases: Tehran and Bucharest.

## Conceptual framework

The spatial configuration of urban green infrastructure has an important role in supporting ecological functions and in achieving social-ecological integration (Forgaci 2018). By applying Foreman's land mosaics model (1995)

from landscape ecology, Ahern proposes a classification of the spatial elements of the urban landscape into urban patches (parks, sports fields, wetlands), urban corridors (rivers, canals, drainage ways) and urban matrix (residential neighbourhoods, industrial districts, etc.). In order to support ecological functions, GI must have a networked spatial configuration (Benedict, McMahon 2006). According to Ahern, key principles from landscape ecology relevant for a functional spatial configuration of GI are connectivity, i.e. 'the degree to which the landscape facilitates or impedes the flow of energy, materials, nutrients, species and people across a landscape' (Ahern 2007:270) as opposed to fragmentation, multiscalar, also mentioned by Perini and Sabbion (2017) as the need to 'establish physical and functional connections across scales to link sites and neighbourhoods to cities and regions' and the recognition of pattern-process as a 'fundamental axiom of landscape ecology' (Forgaci 2018:80).

Cumming (2011) identified that process-related separation of any sort, including social and economic exclusion, almost always has a spatial component. In social systems this component is often ignored, but it may be fundamental to understanding the dynamics of a society or human community of interest and their interaction with natural resources. In many urban green spaces, for example, social and ecological values are positively correlated (Dooling 2009) because more affluent neighbourhoods often have taller, older trees and more recreational opportunities. Social and ecological systems exhibit some marked similarities with higher-level systemic properties such as diversity (Norberg, Coming 2008). Social exclusion can itself be viewed as an outcome of a lack of resilience to spatial fragmentation processes. It may be less likely in a more diverse community in which human interactions occur across cultural and economic boundaries. Diversity can play a role in social systems in maintaining the viability of fragments; within excluded communities (Levin 1992, 1999).

As there is no universally agreed or accepted definition of vacant sites (Pearsall et al. 2014), the general definitions of 'unutilized or underutilised parcels' (Pagano, Bowman 2000) and land 'not devoted to any functional use' (Northam 1971) are assumed here unless otherwise stated. Empty spaces left over from development can work as a double-edged sword (Naghibi et al. 2020), both fragmenting areas and providing empty space which makes it important to understand how they relate to the fragmentation of metropolises and affect the resilience of communities. Urban areas have spatial discontinuities, such as disconnected neighbourhoods, brownfield areas and leftover places. The metaphor of urban porosity can capture these discontinuities. We argue that these areas can provide capacity for flexibility, fluidity and absorptive capacity in major cities, but that they can also be a source of fragmentation, disconnection and isolation between different social groups, eroding the adaptive capacity of metropolitan systems. Porosity may thus have both positive and negative influences on the resilience of urban areas (Pessoa et al. 2019).

Spatial fragmentation refers to a negative aspect of porosity. With social disconnection, it may lead to the formation of vulnerable nodes in urban space. According to Stavrides (2007), urban porosity is the result of threshold areas and in-between (or unused leftover) spaces that loosen the borders of strict spatial and social structures (Pessoa et al. 2019). It investigates the notion of spatial discontinuity and develops the metaphor of porosity, considered one aspect of the spatial fragmentation of metropolises. On the other hand, porosity caused by fragmentation also generates opportunities for resilience; however, urban policies, such as the Brazilian federal government's Minha Casa, Minha Vida, based on market structures that reinforce fragmentation, are not able to translate this opportunity into resilience. The local context is fundamental for determining how these discontinuities will contribute to the resilience of the urban system. A close analysis of specific local conditions is necessary to an understanding of the particularities, opportunities and risks. Moreover, in addition to the necessary consideration of the local context, the porosity index can serve as a first step in assessing spatial discontinuities in metropolises.

Areas with higher porosity have more potential to trigger resilience opportunities. Moreover, in order to transform porosity into resilience, it is imperative to identify the main challenges imposed by these spatial discontinuities in each context, since they can vary from city to city. Porosity has a direct impact on resilience, since fragmented urban environments also tend to be more socially disconnected and tend to respond less efficiently to economic, social and environmental changes. Porosity can increase or undermine the capacity of a metropolis for resilience, depending on whether it constitutes a treat or a threat. In this sense, when used strategically, porosity represents an exceptional opportunity for improving resilience in the built environment (Pessoa et al. 2019).

The urban acupuncture approach opens space for the development of optimistic scenarios for the future, since it is not only based on the negative aspects of vacancy in unoccupied spaces but also on the opportunities that they generate. In urban acupuncture, local interventions are used to revitalize and rebuild a city by targeting strategic points or putting pressure on the system and activating networks. The focus of urban acupuncture is on tactical and small interventions in the structure of cities, aimed at changes in the organism (Lerner 2003; Harsema 2011), where cities are seen as living organisms that require rehabilitation (Lerner 2003).

As a consequence of urban acupuncture and socio-ecological networks, if the connections made by ecological networks are insufficient, using leftover spaces as points can facilitate energy exchange and create resilient networks. This point-based approach offers an alternative solution to solve urban problems with immediate results

through socio-ecological networks. This approach connects abandoned parts and creates flexible networks, maintains and strengthens the main corridors, and creates equilibrium in the landscape layers (Figure 1). While remaining spaces cause gaps between residential blocks in the neighborhood context, these spaces could significantly expose the network to the public and bring life to dense urban areas. Moreover, small leftover spaces can be connected to larger areas that have no function or are underutilized in order to reduce spatial fragmentation.

**Figure 1.** Targeting strategic points (in yellow) to creating new networks in maintaining and upgrading primary corridors
*Source: Unknown.*

Porosity can have both a social and a spatial impact. The 'left-over' spaces can provide space for flexibility, fluidity and absorptive capacity in large cities, enhancing spatial and social connections in the built environment. On the other hand, they can also contribute to fragmentation, disconnection and isolation between different land-use areas and different social groups, eroding the adaptive capacity of metropolitan urban systems in the case of unexpected changes or disasters. However, we also argue that the resilience of a system depends on enhancing the positive dimensions of porosity and minimising its negative dimensions. Thus, keeping in mind that porosity refers to spatial fragmentation and discontinuity, the essential question here is whether a porous system can also be resilient. In other words, to what extent do spatial discontinuity and fragmentation influence the urban landscape to adapt itself to the new situations created by external effects such as socio-ecological crises, and small-scale or large-scale changes. To start addressing this question, it is important to have a better understanding of resilience.

Urban resilience can be related to practices within landscape urbanism where the built/unbuilt continuum of the landscape provides a medium 'uniquely suited to the open-endedness, indeterminacy, and change' required to appropriately respond to the challenges of global urbanisation (Waldheim 2006:39). Urban resilience can be understood as the application of social-ecological systems thinking to the city in order to build adaptive capacity to change in urban systems. Vacant sites can become the focus of explorations into how to adapt and do things differently (Crowe, Foley 2017). Resilience is 'the capacity of a system to absorb disturbance and reorganise while undergoing change to retain the same function, structure, identity, and feedback' (Walker et al. 2004; Wardekker et al. 2010).

A resilient system is able to survive, adapt and transform itself (Ludwig et al. 1997), and although it may be changed or influenced by a disaster, it is able to reform itself (Tasan-Kok et al. 2013). In this sense, porosity can impact resilience in several ways. Urban resilience can be understood as the application of social-ecological systems thinking to the city and therefore a mechanism for thinking differently about the city. Change is the only constant in social-ecological systems (Walker, Salt 2006) and urban resilience thinking aims to help build adaptive capacity in urban systems in order to facilitate and manage change whilst maintaining basic functions (Ahern 2011).

This paper explores the mapping of vacant sites as an example of urban resilience in practice using two approaches: engaging vacant sites in metropolitan cities, contextualizing them within urban acupuncture thinking and the contemporary discourse on urban resilience. Figure 3 summarises how the concepts used in this paper are related to each other.

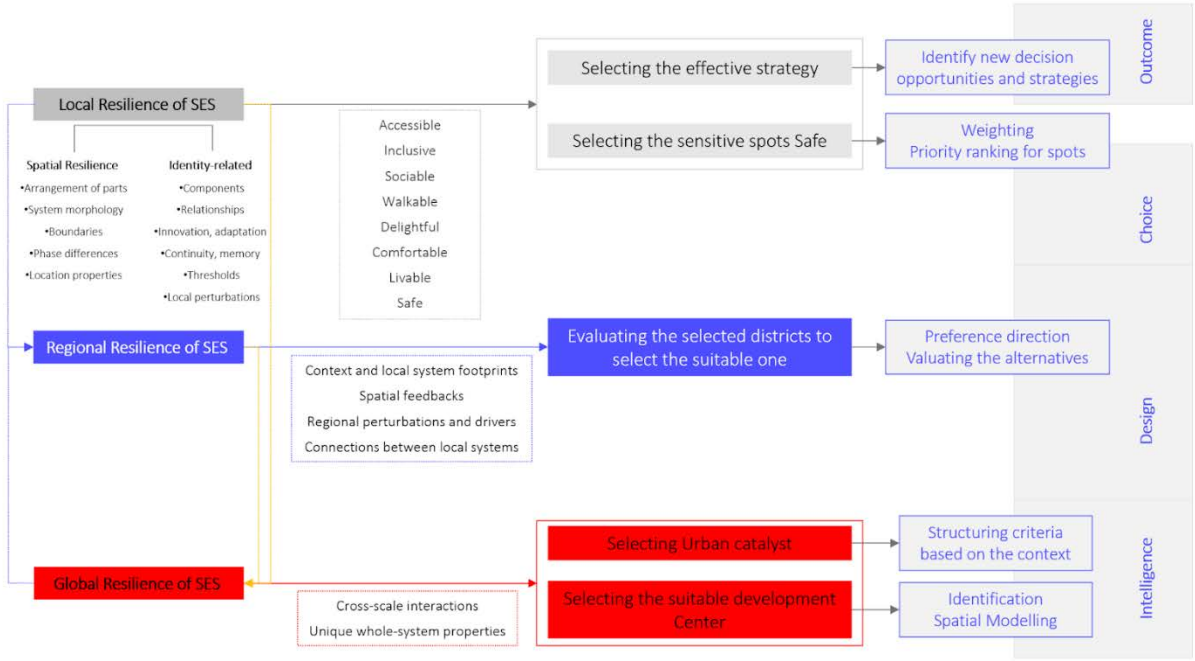


**Figure 2.** A Spatial Decision Support System for urban acupuncture intervention:
A Transformative Resilience Perspective for leftover spaces
*Source: Authors' own work on the basis of:Cumming 2011; Nassar 2021; Cerreta et al. 2021.*

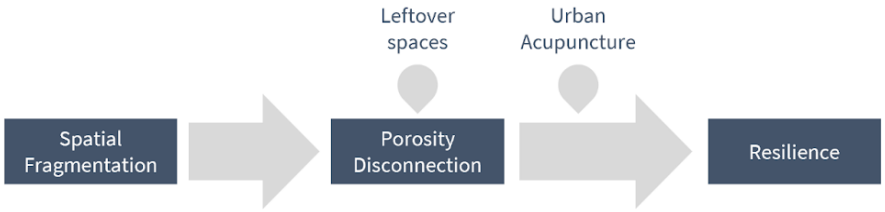


**Figure 3.** Conceptual Framework
*Source: Authors' own work.*

## Methodology

The main point of the present study is to reveal how urban acupuncture can promote resilience in leftover spaces to either reduce or embrace spatial fragmentation. By reviewing literature and projects, and by focusing on two cases, this paper outlines descriptive-analytical and normative aspects to highlight context-specific factors and to indicate general characteristics. The descriptive scenario explores possible futures, whereas the normative scenario describes preferred futures (van Notten et al. 2003). Normative scenarios focus on the current situation (Börjeson et al. 2006). The term 'normative landscape scenarios' is also used by Nassauer and Corry (2004) to refer to the plausible future development of landscapes. In addition, 'normative scenario methods' describe 'paths to desired outcomes or visions' (Rounsevell et al. 2012). Based on the description of case studies, this paper examines how urban acupuncture is a way to locate critical spatial structures and processes that need to be addressed at a small scale.

## Case studies

One of the approaches that supports deeper and more detailed investigations is through case studies that investigate a phenomenon within its context (Rowley 2002). In this paper, the application of the framework is demonstrated in two cases: Tehran and Bucharest (Figure 4). These two cases were selected to illustrate the diversity of local conditions that can lead to different forms of spatial fragmentation, leftover spaces and porosity, and prompt acupunctural interventions. The authors' familiarity and experience with the cases was also considered in the selection.

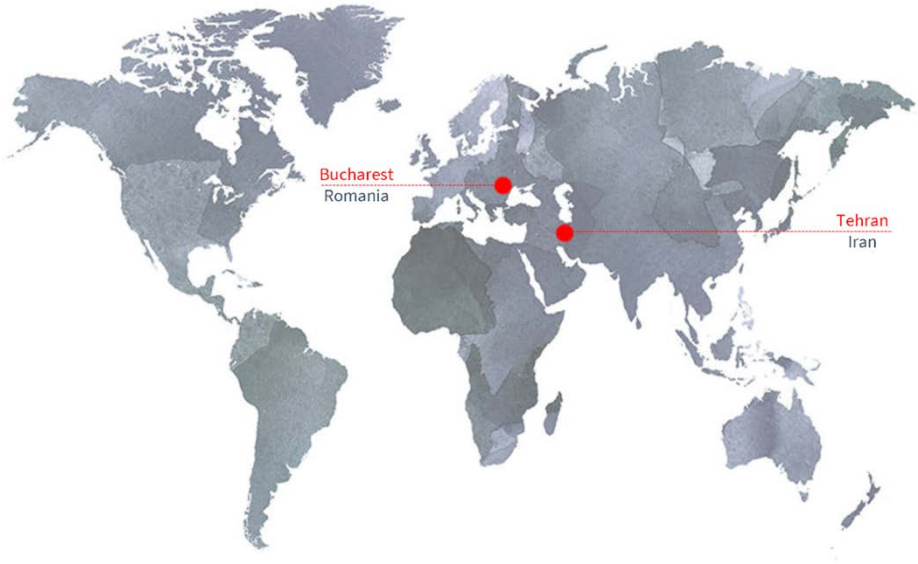


**Figure 4.** These studies are located in Bucharest (Romania), and Tehran (Iran)
*Source: Authors' own work.*

## Tehran

Tehran has 8.7 million people who live in a 15-million metropolitan area. The city's rapid growth has frequently been unequal, causing many voids in the urban fabric. Land plots are occasionally left undeveloped due to a lack of resources, the absence of owners, or the site's unique development challenges, such as problematic terrain or form. As the city of strangers has had to accommodate a steady flow of immigrants throughout the country and overseas, its cultural identity has been challenged. It is possible to discover social exclusion in cultural domains. Tehran was categorized as a high-density city in 2011, with an average density of 128 P/ha. However, this city never enjoyed any of the claimed positive effects of high density. Also, heavy traffic and air pollution turned into a crisis for Tehran's inhabitants (Ghadami et al. 2020).

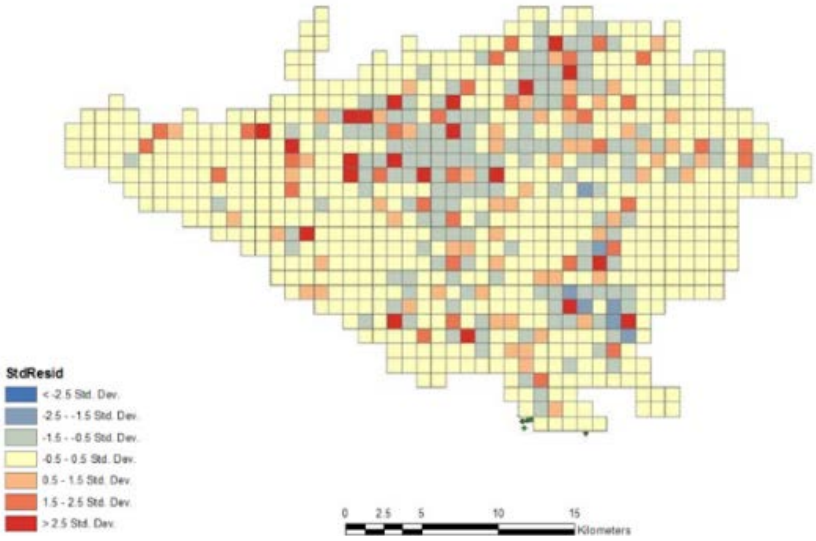


**Figure 5.** The lack of spatial correlation in the proposed pattern of population distribution in the Master Plan Tehran in 2007
*Source: FAR regulations of the Master Plan.*

Historically, Iranian cities have been known to integrate and unify green structures in their structures and patterns. While Tehran is a spatially fragmented metropolis (Figure 5). Additionally, it lacks physical unity and spatial heterogeneity between the north and south of the city is the main characteristic of its urban structure (Tavakoliniya, Shali 2015). At the macro level, distributing green spaces involves maintaining and establishing connections between natural and built areas and combining smaller patches of green (Khansefid 2008). Despite Tehran's

abundance of green patches, the urban landscape lacks a natural infrastructure due to the lack of meaningful relationships in the form of a systematic structure. Tehran's inefficient green network is largely caused by partial and one-dimensional consideration of natural infrastructure management, the discontinuity of the components, and the disconnection from other urban infrastructures (Saboonchi et al. 2018) (Figure 6). The natural and built patches in Tehran include the vacant lands on hills, yards, green corridors such as river valleys, green paths and marginal spaces along the streets and highways among the other potentials in Tehran that can facilitate the creation of integrated spatial infrastructures.

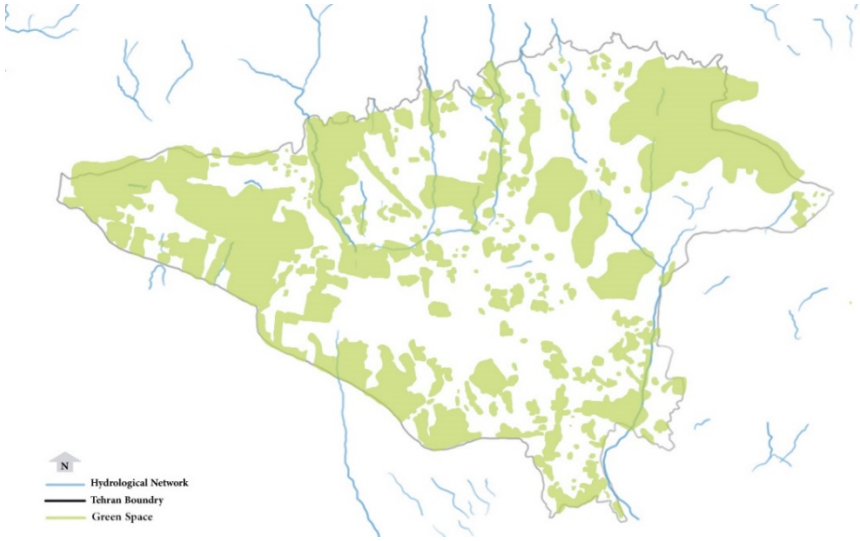


**Figure 6.** Green open space is the main ecological component and the hydrical network of the city
*Source: Authors' own work.*

A practical spatial scale can be achieved through ecological networks. Depending on their purpose, ecological networks may be single-purpose (Jongman 1995) or multipurpose, but their name implies that coherence is determined by ecological processes (Aminzadeh, Khansefid 2009). In the light of multifunctionality, social values and recreational opportunities contribute to the integrity and interconnectedness of ecological networks (Jongman, Pungetti 2004) and result in a more resilient city.

According to Aminzadeh and Khansefid (2009), built and natural ecological features in Tehran's metropolitan area do not appear to interact complementarily. As a result of urban growth, natural corridors are often destroyed or obstructed in the city context. In this regard, Tehran as a case helps to identify the potentials and limitations of networks as a solution to spatial fragmentation in metropolitan areas. The first step will be to locate green plots on a smaller scale to connect fragments.

Ecological structures in the landscape directly affect their elements and functions, and a city's performance is influenced by the size, type, shape, orientation, settings and distribution of its elements. Also, the spatial distribution of nodes, intersections, and corridor hierarchies affects the structure and, consequently, the city's performance (Figure 7). In light of the spatial fragmentation in Tehran, the urban acupuncture strategy proposes overlapping urban networks with distinctive characteristics.

**Figure 7.** The structure of Tehran is determined by the analysis of N-S and W-E green layers
*Source: Authors' own work.*

The main constraints in the field of Tehran environment are land-use change, urban development invasion of the remaining parts of nature, destruction, obstruction of natural corridors of river valleys, and gradual separation of urban fabric and green areas which result in Ignorance of urban ecological networks. To accomplish a comprehensive socio-ecological network of the city, leftover spaces could be identified to connect the green spots and strengthen networks.

The strengthening of socio-ecological networks in Tehran faces limitations. In order to achieve a resilient city, Tehran's social-ecological networks can be improved by using the concept of ecological networks in several dimensions. To enhance socio-ecological development in Tehran, leftover spaces can be used to create flexible networks that will support other layers of the urban landscape (Figure 8). Identifying and reusing vacant urban lands is an integrated vision that will solve urban problems. Therefore, urban acupuncture as a new approach is promising due to space constraints and potential.

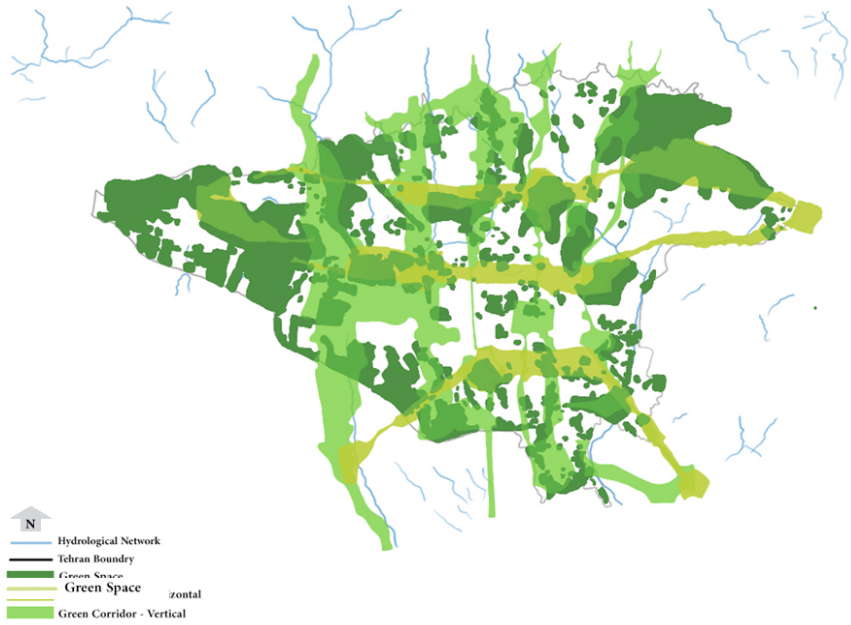


**Figure 8.** The map of ecological and hydrological networks in the natural matrix of Tehran
*Source: Authors' own work.*

### Bucharest

Spatial fragmentation and porosity in the city of Bucharest can be seen in at least three major particularities of its urban fabric: the loose spatial configuration of the urban fabric developed on a network of 'maidans', the radical implant of the Civic Centre, and the process of piecemeal transformations in the absence of coordinated and strategic urban plans. These three elements of Bucharest's urban morphology are very context-specific and are all related to either the creation or transformation of urban vacant land in the Romanian capital.

### Maidane

Despite its size of around 2 million inhabitants and density of 8500 inhab/sqkm, Bucharest has been often described as a large village. This may be explained from social, cultural, economic points of view, but it may be argued that one of the key conditions that led to this specificity is morphological. Bucharest's urban form was preceded by diffuse rural structures, just like most of the settlements in the South of Romania. The city grew around a constellation of villages that had been intensified and merged due to their strategic commercial and topographic position. Later on, the fact that during the Ottoman occupation the city was prohibited to build fortifications, it maintained its polynuclear character much longer. These nuclei, built around parishes and neighborhood units called 'mahalale' (Harhoiu 1997), can still be found in today's compact urban structure. This formal rural morphology is characterized by an organic street network with amorphous and loose intersections called 'maidane' (Figure 9). Formerly accommodating the main public space functions of the city, those intersections are today occupied by car traffic, traffic islands, parking spaces or brownfields that are often inaccessible leftover spaces.

**Figure 9.** The network of 'maidane' underlying the urban fabric of Bucharest (left) and an example of a former maidan mostly occupied by traffic, parking space and undeveloped land (right)
*Source: left – Harhoiu 1997; right – photo by Mihai Petre.*

On the other hand, the phenomenon of urban expansion, even if it has decelerated in the last years in many Eastern European cities, is undoubtedly happening in an uncontrolled way, threatening the relationship of the city with the rural settlements and the open land surrounding it. The periphery, an urbanization pattern different from the former rural structure but also from the inner city, becomes an increasingly important form of urbanization. Just like ecotones in ecology or the in-between cities described by Sieverts (2003) at a territorial scale, the area of urban-rural transition becomes an important topic of enquiry for understanding how contemporary urbanization deals with changes. This is especially important in the Eastern European context, in which, on one hand, post-communist transition led to a very uncontrolled form of urbanization, and, on the other hand, studies dealing with this phenomenon are still scarce or inconclusive.

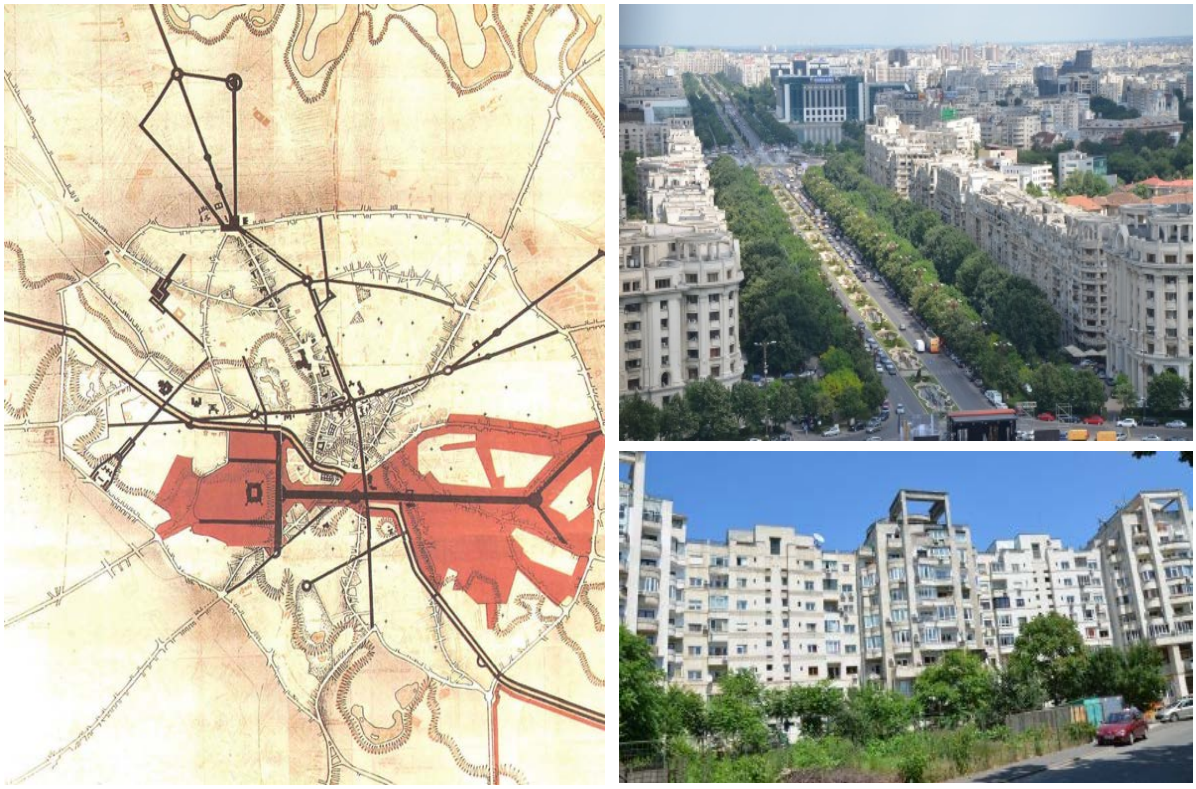

**Figure 10.** The Civic Centre built in the 1980s replacing 400ha of former urban fabric in Bucharest (Harhoiu 1997) (left, in red) and images of the front (top right) and back (bottom right) of the newly cut Boulevard of Union
*Source: N. Pangere, Civic Center: Ceaușescu's Bucharest, online https://nomadicniko.com/2012/06/15/bucharest-civic-center/ (access: 20.08.2022).*

### Civic Centre

The Civic Centre of Bucharest, implemented in the 1980s under the rule of Ceaușescu, was a radical large-scale intervention that replaced 400 hectares of former urban fabric with a boulevard bordered by high-rise apartment blocks and institutional buildings and the Palace of the Parliament (Figure 10). As the intervention was mostly meant to create a space for representation on the front side, focusing on the Palace of the Parliament, the back side of the Civic Centre ris an amorphous space resulting from the intersection of the former urban fabric and the boundaries of the new intervention. The barriers created by this transformation have led to an unprecedented fragmentation of the urban fabric and interstitial spaces, many of which are left vacant until today.

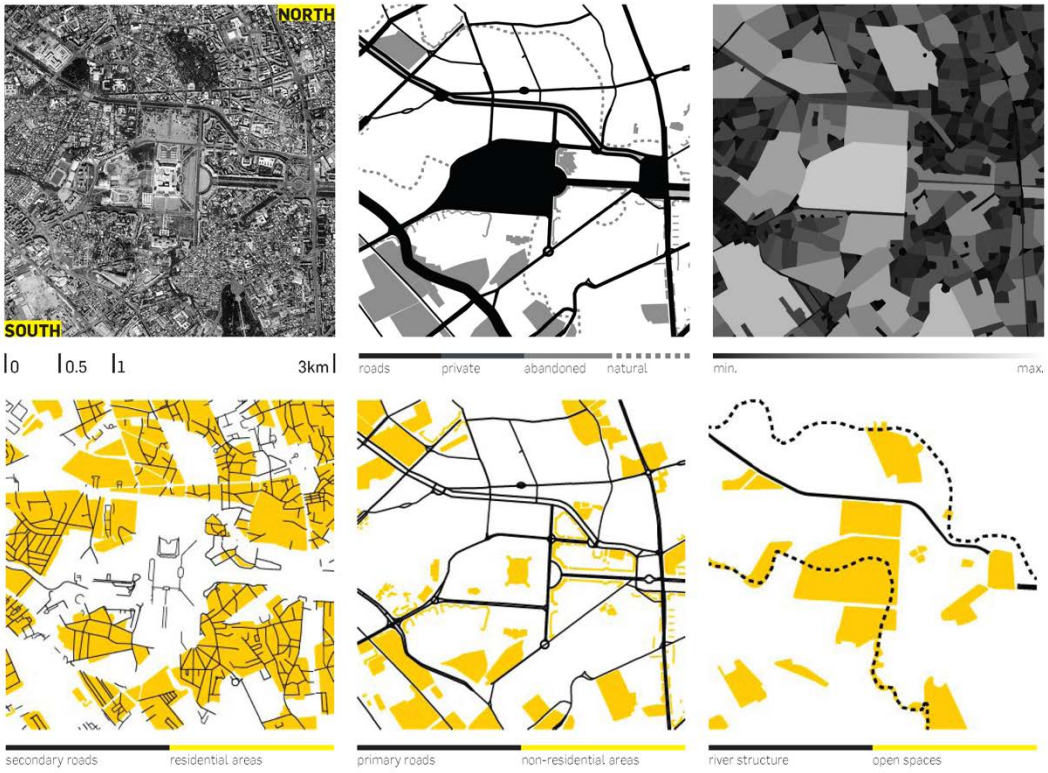


**Figure 11.** Spatial fragmentation of Bucharest's urban fabric around the historical centre and Civic Centre. From top left to bottom right: satellite view, main infrastructure barriers (black) and functional barriers (grey); scale of urban islands; distribution of residential functions; non-residential functions; main open spaces
*Source: Forgaci 2013.*

The porosity of the urban fabric in the city of Bucharest is thus characterised by open spaces resulting from either the organic development or from barriers created by more recent large-scale transformations. In addition to those small-scale leftover spaces, natural structures such as the River Dâmbovița crossing the centre of the city cluster most of the large urban green spaces and parks. Together with the smaller vacant lands, these large green spaces present a potential network of open spaces with both social and ecological functions that can scale up opportunities of social-ecological resilience to the scale of the city.

### Piecemeal transformations

Recent spatial developments of Bucharest can be characterised as local, bottom-up, private-interest-driven interventions, without clear planning frameworks and regulations. These interventions cannot be called acupunctural as they are usually not strategic in nature and usually do not have objectives beyond the boundaries of the intervention area. However, the phenomenon of piecemeal transformation and the abundance of leftover spaces creates the conditions for acupunctural interventions. The increasing interest for green and blue infrastructure and nature-based solutions as well as the growing civic engagement can further promote such strategies. In a case-driven analysis, a typical motivating question is, 'What can we learn from comparing these cases?'. The analytical challenge becomes finding a way to accommodate multiple types of data under one umbrella (Cumming 2011).

In Tehran, meydan (Square) was the center for cultural, economic and official exchanges, similar to maidane in Bucharest which accommodates the main use of public space. On a grand scale, meydan was used as the courtyard of the Iranian city. Central courtyards in between masses of solid volumes reflect the critical role of emptiness in Iranian architecture. The only elements allowed in emptiness are the vital natural elements: green and water. Thus, the Iranian plaza was conceived as a city courtyard, emphasizing its boundaries while the center is always empty (Afsharnaderi 2007).

The meydan in Tehran has been incorporated into the urban fabric, connected by lines and regular streets, unlike the organic street network and loose intersections in Bucharest. Over time, meydan changed from being socio-cultural behavioral patterns to traffic patterns, the same as maidane in Bucharest; those intersections are occupied by cars, traffic islands, parking spaces and brownfields which are often inaccessible leftover spaces. As Lefebvre's works celebrate the urban grid and the streets, squares and parks of the city, the enhancement of small urban spaces like meydan (Tehran) and maidane (Bucharest) in urban structure play a critical role in cities.

In Bucharest, rural structures spread in an uncontrolled way, threatening the relationship between the city and open land surroundings. Also, in Tehran's informal settlements, spatial inequalities have intensified and the urban structure has been fragmented. These phenomena cause social, economic and cultural losses. Furthermore, landscape fragmentation is one of the consequences of increased socio-economic pressures facing Bucharest and Tehran.

In Tehran, studies have been conducted on finding intervention spots for connecting ecological and social networks. However, leftover spaces have not been included in Tehran's classification of non-constructible parcels and occupancy types. Thus, to better understand the nature of these non-constructible parcels, it is necessary to identify a few urban parameters.

Tehran's porosity has been characterized by top-down and large-scale interventions, with no clear urban landscape regulations. Therefore, and similarly to Bucharest, these interventions cannot be called acupunctural since they are usually not strategic and usually have no goals beyond the intervention area. In light of the abundance of leftover spaces and current piecemeal transformation, this study proposes a broader view of urban acupuncture in Bucharest and Tehran for nature-based solutions and civic engagement. Along with the small leftover spaces, natural structures (e.g., the seven river valleys in Tehran, such as the river Dâmbovița in Bucharest) could also cluster most of the large urban green spaces. Thus, In both Bucharest and Tehran, combined with the smaller vacant lands, these large green spaces can strengthen urban social-ecological resilience by providing both social and ecological functions.

## Conclusions

This paper argued for a re-problematization of urban leftover spaces resulting from spatial fragmentation as essential components of urban porosity and spaces of potential for resilience-building. Considering the fragmented and diffuse nature of urban porosity, acupunctural interventions were highlighted as strategic and scalable interventions meant to exploit the resilience-building potential of leftover spaces. The two cases, Tehran and Bucharest, demonstrated the variety of context-specific factors that can constitute porosity as well as the importance of a multi-scalar understanding thereof. On the normative dimension, the Teheran case shows the importance of green infrastructure in locating and scaling up acupunctural interventions in a city where leftover spaces are in abundance. The Bucharest case shows that fragmentation caused by large interventions, either organically and incrementally (the network of 'maidane') or radically (the Civic Centre), create spaces of potential encounter and fracture, respectively, that contribute to the porosity of the city and potentially increase the city's adaptive capacity through acupunctural interventions. A good understanding of the types of porosities can lead to the definition of typologies allowing for scaled-up interventions.

### References

Afsharnaderi K., (2007), *The gardens of paradise*, Tehran: Kelk.

Ahern J., (2011), *From Fail-Safe to Safe-to-Fail: Sustainability and Resilience in the New Urban World*, 'Landscape and Urban Planning', vol. 100, no. 4, pp. 341–343.

Aminzadeh B., Khansefid M., (2010), *A case study of urban ecological networks and a sustainable city: Tehran's metropolitan area*, 'Urban Ecosystems', vol. 13, no. 1, pp. 23–36.

Angel S., Parent J., Civco D.L., (2012), *The fragmentation of urban landscapes: Global evidence of a key attribute of the spatial structure of cities, 1990-2000* 'Environment and Urbanization', vol. 24, no. 1, pp. 249–283.

Balbo M., Navez-Bouchanine F., (1995), *Urban fragmentation as a research hypothesis: Rabat-Salé case study*, 'Habitat International', vol. 19, no. 4, pp. 571–582.

Benedict M.A., McMahon E.T., (2006), *Green Infrastructure: Linking Landscapes and Communities*, Island Press, Washington.

Benini L., Asquith M., (2020), *Understanding Sustainability Challenges. In The European Environment-State and Outlook*, Publications Office of the European Union: Luxembourg, p. 346.

Börjeson L., Höjer M., Dreborg K., Ekvall T., Finnveden G., (2006), *Scenario types and techniques: Towards a user's guide*, 'Futures', vol. 38, no. 7, pp. 723–739.

Cerreta M., Panaro S., Poli G., (2021), *A spatial decision support system for multifunctional landscape assessment: A transformative resilience perspective for vulnerable inland areas*, 'Sustainability', vol. 13, no. 5, pp. 1–23.

Chaves L.F, Cohen J.M, Pascual M., Wilson M.L., (2008), *Social exclusion modifies climate and deforestation impacts on a vector-borne disease*, 'Plos Neglected Tropical Diseases', no. 2.

Crowe P.R, Foley K., (2017), *Exploring urban resilience in practice: a century of vacant sites mapping in Dublin, Edinburgh and Philadelphia*, 'Journal of Urban Design', vol. 22, no. 2, pp. 208–228.

Cumming Graeme S., (2011), *Spatial resilience in social-ecological systems*, Dordrecht: Springer.

Dallimer M., Tang Z., Bibby P.R., Brindley P., Gaston K.J., Davies Z.G., (2011), *Temporal changes in greenspace in a highly urbanized region*, 'Biol Lett', vol. 7, no. 5, pp. 763–766.

Dooling S., (2009), *Ecological gentrification: A Research Agenda Exploring Justice in the City*, 'International Journal of Urban and Regional Research', vol. 33, pp. 621–639.

Dramstad W., Olson J., Forman R., (1996), *Landscape ecology principles in landscape architecture and land use planning*, Island Press, Washington.

Forgaci C., (2013), *Bucharest: Between North and South*, Delft University of Technology.

Forgaci C., (2018), *Integrated Urban River Corridors Spatial design for social-ecological resilience in Bucharest and beyond*, Delft University of Technology.

Forman R.T.T.D., Sperling J.A, Bissonette A.P, Clevenger C.D, Cut V.H, Dale L., Fahrig R., France C.R., Goldman K., Heanue J.A., Jones F.J., Swanson T., Turrentine T.C., (2003), *Road Ecology. Science and Solutions*, Island Press, Washington D.C.

Forman R.T.T, Alexander L.E., (1998), *Roads and their major ecological effects*, 'Annu. Rev. Ecol. Syst.', vol. 29, pp. 207–231.

Ghadami M., Dittmann A., Safarrad T., (2020), *Lack of spatial approach in urban density policies: The case of the master plan of Tehran*, 'Sustainability', vol. 12, no. 18, pp. 1–20.

Harhoiu D., (1997), *București, un oraș între Orient și Occident/Bucharest, a city between Orient and Occident*, Simetria.

Harsema H., (2011), *Acupuncture*, 'Scape: The International Magazine For Landscape Architecture And Urbanism', no. 1, pp. 15–17.

Jaeger J.A.G., Schwarz-von Raumer H.G., Esswien H., Müller M., Schmidt-Lüttman M., (2007), *Time series of landscape fragmentation caused by transportation infrastructure and urban development: A case study from Baden-Württemberg, Germany*, 'Ecology and Society', vol. 12, no. 1.

Jongman R., Pungetti G., (2004), *Ecological networks and greenways concept, design, implementation*, Cambridge University Press, UK.

Jongman R.H.G., (1995), *Nature conservation planning in Europe: developing ecological networks*, 'Landsc Urban Plan', vol. 32, pp. 163–183.

Kharat Zebardast E., (2001), *A survey of functional linkages of spontaneous settlements on the Tehran metropolitan fringe*, 'Honar-ha-ye-ziba', no. 8, pp. 65–73.

Kubacka M., Żywica P., Vila Subirós J., Bródka S., Macias A., (2022), *How do the surrounding areas of national parks work in the context of landscape fragmentation? A case study of 159 protected areas selected in 11 EU countries*, 'Land Use Policy', vol. 113.

Lerner J., (2003), *Urban Acupuncture*, Rio de Janeiro, Record.

Levin S.A., (1992), *The problem of pattern and scale in ecology*, 'Ecology', vol. 73, no. 6, pp. 1943–1967.

Levin S.A., (1999), *Fragile dominion: complexity and the commons*, Perseus Books, Reading.

Lister N.M., (2007), *Sustainable large parks: ecological design or designer ecology?* [in:] G. Hargreaves, J. Czerniak (eds.) *Large parks*, Architectural Press, New York, pp. 35–54.

Lokman K., (2017), *Vacancy as a laboratory: design criteria for reimagining social- ecological systems on vacant urban lands*, 'Landsc. Res.', vol. 42, pp. 728–746.

Macias A., Gadziński J., (2013), *Assessment of road transport environmental impact as illustrated by a metropolitan area*, 'Pol. J. Environ. Stud.', vol. 22, no. 6, pp. 1749–1758.

Naghibi M., Faizi M., Ekhlassi A., (2020), *Undefined lands: A review of their role as an underexplored resource of landscape*, 'Landscape Architecture and Art', vol. 16, pp. 60-69.

Nassar U.A.E., (2021), *Urban Acupuncture in Large Cities: Filtering Framework to Select Sensitive Urban Spots in Riyadh for Effective Urban Renewal*, 'Journal of Contemporary Urban Affairs', vol. 5, no. 1, pp. 1–18.

Nassauer J.I., Corry R.C., (2004), *Using normative scenarios in landscape ecology*, 'Landscape Ecology', vol. 19, no. 4, pp. 343–356.

Norberg J., Cumming G.S., (2008), *Complexity theory for a sustainable future*, Columbia University Press, New York, pp. 312.

Northam R.M., (1971), *Vacant urban land in the American city*, 'Land Economics', vol. 47, pp. 345–355.

Pagano M., Bowman A., (2000), *Vacant land in cities: An urban resource*, The Brookings Institute: Center on Urban and Metropolitan Policy.

Pearsall H., Lucas S., Lenhardt J., (2014), *The contested nature of vacant land in Philadelphia and approaches for resolving competing objectives for redevelopment*, 'Cities', vol. 40, pp. 163–174.

Peijuan Z., Qingyun H., Xiang Z., Shuqiang C., Xiaoshuang W., (2018), *Research on urban space fragmentation*, 'Geographical research', vol. 37, no. 3, pp. 480–494.

Perini K., Sabbion P., (2017), Urban Sustainability and River Restoration, Wiley.

Pessoa I.T.M., (2019), *Spatial fragmentation and self-organisation: A negative relationship in Brazilian metropolises*, 'Urbe', no. 11, pp. 1–15.

Pessoa T.M., Version D., Pessoa T.M., (2019), *From fragmentation to resilience*, online https://doi.org/10.7480/abe.2019.4 (access: 19.12.2023).

Pírez P., (2002), *Buenos Aires: Fragmentation and privatization of the metropolitan city*, 'Environment and Urbanization', vol. 14, no. 1, pp. 145–158.

Riitters K.H., O'Neill R.V., Hunsaker C.T., Wickham J.D., Yankee D.H., Timmins S.P., Jones K.B., (1995), *A factor analysis of landscape pattern and structure metrics*, 'Landscape ecology', no. 10, pp. 23-39.

Rounsevell M.D.A, Pedroli B., Erb K., Gramberger M., Busck A.G., Haberl H., et al. (2012), *Challenges for land system science*, 'Land Use Policy', vol. 29, no. 4, pp. 899–910.

Sabatini F., Salcedo R., (2007), *Gated communities and the poor in Santiago, Chile: functional and symbolic integration in a context of aggressive capitalist colonization of lower-class areas*, 'Housing Policy Debate', vol. 18, no. 3, pp. 577-606.

Saboonchi P., Abarghouyi H., Motedayen H., (2018), *Green Landscape Networks;The role of articulation in the integrity of green space in landscapes of contemporary cities of Iran*, 'Bagh-e Nazar', vol. 15, no. 62, pp. 5–16.

Shahid J.T., Faculty B., (2015), *Analysis of Spatial Fragmentation in Tehran Metropolis Using ANP*, 'Analytic Network Process', vol. 40.

Sieverts T., (2003), *Cities Without Cities: An Interpretation of the Zwischenstadt*, Routledge.

Stavrides S., (2007), *Heteropias and the experience of porous urban space* [in:] K.A. Franck, Q. Stevens (eds.) *Loose Space: Possibility and Diversity in Urban Life*, Routledge, Abingdon, pp. 174–192.

Taşan-Kok T., Stead D., Peiwen L., (2013), *Conceptual Overview of Resilience: History and Context* [in:] A. Eraydin, M.T. Tasan-Kok (eds.) *Resilience thinking in urban planning*, Springer, Dordrecht, pp. 39-51.

van Notten P.W.F., Rotmans J., van Asselt M.B.A, Rothman D.S., (2003), *An updated scenario typology*, 'Futures', vol. 35, no. 5, pp. 423–443.

Waldheim C., (2006), *The Landscape Urbanism Reader*, New York, Princeton Architectural Press.

Walker B., Holling C.S., Carpenter S.R., Kinzig A., (2004), *Resilience, Adaptability and transformability in Social–Ecological systems*, 'Ecology and Society', vol. 9, no. 2, pp. 5-13.

Walker B., Salt D., (2006), *Resilience thinking: Sustaining ecosystems and people in a changing world*, Washington, DC: Island Press.

Wang J., Zhou W., Wang J., Yu W., (2020), *Spatial distribution of urban greenspace in response to urban development from a multi-scale perspective*, 'Environmental Research Letters', vol. 15, no. 6.

Wardekker J.A., de Jong A., Knoop J.M., van der Sluijs J.P., (2010), *Operationalising a resilience approach to adapting an urban delta to uncertain climate changes*, 'Technol. Forecast. Soc. Change', vol. 77, no. 6, p. 987e998.

Wei Y., Zhang Z., (2012), *Assessing the fragmentation of construction land in urban areas: An index method and case study in Shunde, China*, 'Land Use Policy', vol. 29, no. 2, pp. 417–428.

Yang J., Huang C., Zhang Z., Wang L., (2014), *The temporal trend of urban green coverage in major Chinese cities between 1990 and 2010*, 'Urban Forestry and Urban Greening', vol. 13, no. 1, pp. 19–27.

Zhao J., Chen S., Jiang B., Ren Y., Wang H., Vause J., Yu H., (2013), *Temporal trend of green space coverage in China and its relationship with urbanization over the last two decades*, 'Science of the Total Environment', vol. 442, pp. 455–465.