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CONTEXTS

SYSTEMIC DESIGN ASSOCIATION

Systemic Spatial Design: Enhancing the potential of spatial design disciplines to navigate adaptive cycles in cities

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Abstract

Systems thinking—encompassing theories of complexity, emergence, self-organization, autopoiesis, adaptation, and complex adaptive systems—has recently informed innovative approaches to planning and design theory. Nonetheless, it has not radically influenced the disciplines related to spatial design—concerning the physical construction and transformation of the built environment—and these disciplines often struggle to address the complexity of the contexts in which they intervene. Although it is possible to identify spatial interventions that succeed in this sense, their designers do not explicitly connect their strategies to systems theories. In this respect, these interventions remain scattered good practices, but a theoretical framework that structures a systemic approach to spatial design disciplines has not yet been fully developed. For this reason, the present paper aims to accomplish three outcomes. One, to highlight the implications of systems thinking for spatial design disciplines. Two, to to start framing a new systemic approach to spatial design called "systemic spatial design." Three, to show how this approach would benefit the established disciplines related to the modification and construction of the built environment—architecture, interior, urban, and landscape design—by enhancing their potential to proactively cooperate with site-specific emergent transformations and to virtuously intervene in spontaneous cycles of urban self-regeneration and decline. In this perspective, a “multi-scale atlas” is presented here as a transdisciplinary tool for place-specific systemic inquiry. This makes it possible to (a) explore cross-scale relationships in which specific spatial configurations are immersed; (b) frame them as parts of complex socio-spatial-environmental systems, (c) identify leverage points; and (d) monitor unpredictable cross-scale effects.

Keywords: spatial design, complex adaptive systems, self-organization, multi-scale mapping, urban regeneration, adaptive cycles

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1-Towards a systemic approach to spatial design

Systems thinking, encompassing theories of complexity, emergence, self-organization, autopoiesis, adaptation, and complex adaptive systems (CAS) (Alexander, 1968; Capra, 1997; Capra & Luisi, 2014; Gunderson & Holling, 2002; Jantsch, 1980; Maturana & Varela, 1972) theory, has recently informed innovative approaches to planning and design. Nonetheless, it has not radically influenced the disciplines related to spatial design—concerning the physical construction and transformation of the built environment—which often struggle to address the complexity of the contexts in which they intervene.

With regard to design theory, systems theories brought about the emergence of systemic design (Barbero & Pereno, 2020; Jones, 2014) and transition design (Irwin, 2015), which endeavors to address "wicked" problems (Rittel and Webber, 1973)—problems which cannot be brought to a definite end as fundamentally uncertain—and shape innovative policies for place-based sustainable development.

In terms of urban studies, systems thinking led to the framing of cities as complex systems that constantly evolve over time through processes of emergence, self-organization, and through adaptive cycles of regeneration and decline (Allen & Sanglier, 1981; Batty, 2013; De Roo, 2016-2017; Dovey, 2012; Hillier, 2012; Johnson, 2001; Portugali, 1999). This conception of cities and neighbourhoods as dynamic entities in a constant state of becoming has led to a shift from planning for presumed 'static' situations towards planning in dynamic processes of change. In this respect, it has fostered the emergence of innovative forms of adaptive planning (De Roo et al., 2020) and new approaches to urban policies and regulations (De Roo & Rauws, 2016; Moroni, 2015).

Nonetheless, it has not radically affected spatial design disciplines—encompassing interior design, architecture, and urban and landscape design—which still struggle to elaborate strategies that can proactively cooperate with site-specific spontaneous emergent transformations (Porqueddu, 2018ab). Although it is possible to identify spatial interventions that succeed in this sense (see Section 3), their designers did not explicitly connect their strategies to systems theories. In this respect, these interventions remain as scattered good practices, but a theoretical framework that can structure a systemic approach to spatial design disciplines has not yet been fully developed.

For these reasons, the present paper aims to:

- Highlight the implications of systems thinking for spatial design disciplines.
- Frame a new systemic approach to spatial design called "systemic spatial design."
- Show how this approach would benefit all the established disciplines related to the modification and construction of the built environment by enhancing their potential to proactively cooperate with emergent transformations and to intervene virtuously in site-specific cycles of self-regeneration and decline.

Systems thinking is contextual thinking. While analytical approaches take something apart in order to understand it, systemic thinkers put it in the context of a larger whole. To understand things systemically means understanding the nature of their cross-scale relationships in a specific context (Capra, 1997). In this perspective, the present paper proposes a "multi-scale atlas" as a method for systemic inquiry which enables designers to explore the cross-scale relationships in which specific spatial configurations are immersed, frame them as parts of complex social-spatial systems which include human actions, and evolve in a non-linear manner through processes of self-organization and adaptive cycles.

Such a systemic understanding is here considered crucial in order to:

- Understand whether the existing spatial configuration—mapped at different scales—prevents or fosters emergent processes of self-regeneration.
- Identify the most appropriate position, type, and scale for progressive spatial interventions that can trigger/accelerate processes of self-regeneration or prevent/invert cycles of decline.
- Monitor the unpredictable cross-scale effects stimulated by these interventions over time.

In this respect, the present paper traces a strong (but non-linear) relationship between a systemic understanding of place-specific adaptive cycles and the potential of spatial designers to proactively intervene in these cycles.

The article is divided into six sections. The following section (Section 2) highlights how the emergent nature of complex urban environments questions established approaches to spatial design and generates new challenges for the disciplines related to the construction and transformation of the built environment. Section 3 specifically explores the implications of CAS and panarchy theory for spatial design. Section 4 frames spatial design as a "good perturbation" in site-specific adaptive cycles of self-regeneration and decline. Section 5 presents the multi-scale atlas. Section 6 presents systemic spatial design as a framework that can benefit the various spatial design disciplines by improving their ability to navigate—without overcontrolling—adaptive cycles in cities, and it illustrates the relevance of shaping a new systemic approach to spatial design. Section 7 offers some final remarks and suggests future lines of research.

2-Cities as complex systems: the challenges for spatial design

The recent theory of planning highlights how healthy, vibrant cities or neighbourhoods behave as complex living systems (open, non-linear, emergent, and self-organizing) which are capable of responding to unexpected changes (social, environmental, technological, and economic) by constantly adapting, evolving and renewing over time through processes of self-organization and complex adaptive cycles (Allen & Sanglier, 1981; Batty, 2013; De Roo, 2016-2017; Dovey, 2012; Hillier, 2012; Johnson, 2001; Portugali, 1999; Salingaros, 2018). The main characteristic of such complex urban systems is that their evolution cannot be predicted in advance because it arises from unexpected interactions between physical creation and social behaviour (Sennett, 2017; Alexander, 1965). Furthermore, their overall shape at the macro-scale cannot be predefined or controlled because it emerges from unforeseen (social-spatial) local interactions rather than being predetermined by an a priori intention (Jacobs, 1961; Ikeda, 2017; Moroni and Cozzolino, 2019; Porqueddu, 2018b).

The unpredictable emergent nature of such complex urban environments is incompatible with spatial design strategies, which are intended to predict and over-control the formal outcome of specific

transformations. Such strategies tend to propose a comprehensive vision of the future. They impose a new overall form— which is considered healthier and more efficient— on an existing situation that is involved in a cycle of decline. They (a) usually present themselves as finished projects where every detail is top-down over-designed from the micro-to-macro scale, and (b) show the outcome of the transformation within a predefined bounded site. In their best examples, they are animated by a sincere intention to produce a regime of urban complexity that is able to generate diversity. Nonetheless, they remain external interventions in an otherwise spontaneous and complex urban process, and thus they cannot cooperate with emergent transformations, which are bottom-up and self-organizing phenomena that unfold across scales and over time.

For example, New Urbanism (Duany et al., 2003) elaborates a new model of the metropolis rather than focusing on upgrading and updating the everyday experience across the urban fabric of American suburban sprawl, which it tends to reject and replace. New Urbanism superimposes a top-down designed city—based on abstract principles and coded urban formulae—on a reality that is identified as negative. While the aim is laudable, to address the environmental and social issues linked to urban sprawl, this approach is still based on the modern illusion that these problems can be entirely fixed by external agents, designers, and planners, who impose a new and a priori designed spatial configuration on an existing context (Porqueddu, 2018ab).

On the one hand, complex urban systems, because of their emergent and unpredictable nature, are incompatible with overdetermined design strategies, which are entirely predefined from the top-down. On the other, they need some direction because they can also spontaneously enter a state of decline. In this respect, Jacobs (1961) foresaw how the same forces which nourish city diversity can also contribute to its self-destruction, and the recent theories of panarchy and complex adaptive systems (Gunderson & Holling, 2002; Holland, 1992, 1999; Miller & Page, 2007) have validated Jacobs's insights by demonstrating how complex systems spontaneously follow cycles of decline and self-regeneration. In this respect, the next section illustrates how these theories can inform a design approach that does not interfere with the spontaneous capacity of site-specific socio-spatial networks to adapt, evolve, and renew over time but it simultaneously intervenes to prevent its emergent decline. In this perspective, the challenge for spatial designers does not consist of replacing existing spatial configurations with new overall projects (which are over-determined from the top-down) but in stimulating and monitoring site-specific adaptive cycles in order to identify and shape the most appropriate spatial actions that can invert a spontaneous cycle of decline or trigger/accelerate a process of self-regeneration.

3-Adaptive cycles in complex systems: the implications for spatial design disciplines

The present section briefly illustrates how key concepts emerging from complex adaptive systems, adaptive cycles, and panarchy theories can be relevant to spatial design disciplines and highlights their resonance with transition theory. It then traces some connections with the pioneering work of Jane Jacobs, who observed spontaneous cycles of self-regeneration and decline in cities long before CAS and panarchy theory were conceived and subsequently applied to urban studies.

These theories show how complex systems evolve through adaptive cycles (Holling, 2001) and how it is necessary to recognize these cycles in order to prevent their decline and foster their ability to self-regenerate. These recurring cycles consist of four phases: exploitation, conservation, release, and reorganization (Holling, 2001; Gunderson and Holling, 2002; Walker and Salt, 2006). During the

exploitation phase, the system's components are weakly interconnected, and its internal state is weakly regulated. The transition to the conservation phase occurs because the system becomes more strongly interconnected and regulated. In the late conservation phase, different ways of performing the same function (redundancy) decrease in favour of performing the function in the most efficient way (efficiency). The cost of efficiency is a loss of flexibility: the system is increasingly stable but over a decreasing range of conditions. In other words, its resilience declines. If there is a small shock, the system's web breaks apart and suddenly comes undone. The release phase is brief and chaotic, but the destruction that ensues has a creative element: tightly bound capital is released, and all options are open. This quickly leads to a phase of reorganization and renewal. Novelty arises in the form of new inventions, creative ideas, and people.

As previously mentioned, cycles of decay and regeneration were observed in American cities by Jane Jacobs (1961), who highlighted that diversity was an essential condition for city vitality and resilience. Jacobs highlighted how vital cities require "an intricate and close-grained diversity of uses that give each other constant mutual support, both economically and socially" (p. 14). Nonetheless, she also foresaw the tendency for outstandingly successful diversity to destroy itself across time cycles, which she described in six famous steps:

1. In some places, a diversified mixture of uses becomes a popular and successful assemblage.
2. This success fosters ardent competition for space, and the locality develops.
3. Only a few dominant uses emerge: the winners of the competition are just a narrow segment of the many uses which together generated success.
4. Visually and functionally, the place becomes monotonous and loses its appeal.
5. The locality's suitability, even for predominant use, declines.
6. The place becomes marginal.

After Jacobs's pioneering work, adaptive cycles and panarchy theories informed studies that aimed to explore and increase resilience in social-ecological systems (Folke et al., 2010; Walker et al., 2006) and urban environments (Shutters et al., 2021)—and explore unforeseen possibilities for sustainable development. Furthermore, CAS theories were widely applied in planning theory to understand the emergence of large-scale macro-structures from the interactions between individual and collective entities (Allen, 1997; Batty, 2005; Hillier, 2012; Portugali, 1999) and shape innovative forms of adaptive planning (De Roo & Rauws, 2016).

Nonetheless, the implications of these theories for spatial design disciplines remained under-investigated. An open question is: How can spatial designers proactively cooperate with adaptive cycles in cities? How can their action contribute to triggering/accelerating processes of self-regeneration or to inverting/preventing cycles of decline?

The next sections illustrate two aspects of the aforementioned theories that are particularly relevant in addressing these questions.

Between order and chaos: Enhancing the system's adaptive capacity

An aspect of CAS theory (Holland, 1992, 1999) that is particularly relevant for spatial designers is that complex systems develop their maximum adaptive capacity when they remain "on the edges of order and chaos" (Waldrop, 1992) when they remain between two extreme points: uniformity, a position close to equilibrium which renders the system inert, and diversity, a position so far from equilibrium that the system could collapse. Between the two extremes of uniformity and diversity, efficiency and

redundancy, stability, and dynamism—a complex system is capable of adapting and self-organizing—to change by means of internal dynamics while building on layers of robustness, through which it will be able to survive. When some forces exert pressure for adjustment, a set of cohesive conditions is crucial, allowing the system to adjust and evolve while keeping it functionally together (De Roo & Yamu, 2015) (Figure 1).

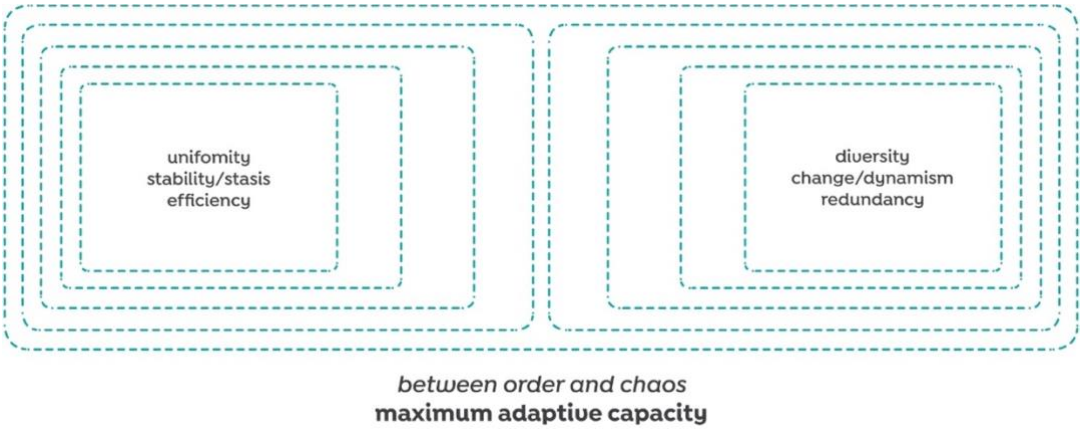


Figure 1. When a complex system flows between the extremes of uniformity and diversity, efficiency and redundancy, stability, and dynamism, it can find the right mix of confirmation and novelty, which enables it to constantly evolve, learn and renew without falling into chaos.

In CAS theory, self-organization processes, which concern the spontaneous emergence of order out of disorder (Prigogine & Stengers, 1984), have a prominent role in maintaining the system's adaptive capacity (Boonstra & Raws, 2016) and, therefore, in fostering its capacity to evolve, learn and renew without falling into chaos. In this respect, the literature on complex systems and self-organization makes a distinction between autopoietic and dissipative system behaviour (Van Meerkerk et al., 2013). Autopoietic self-organization refers to the self-maintenance and reproduction of the system (Jantsch, 1980; Luhman, 1995; Maturana & Varela, 1972) and is aimed at stabilizing it. Dissipative self-organization (Prigogine & Stengers, 1984) is boundary-breaking, leading to the evolution of systems. Dissipative self-organization refers to the increasing connection of various subsystems leading to a far-from-equilibrium situation in which small changes in the components of a system might lead to large-scale change (Morçöl, 2005).

Complex systems (physical and social) that show both types of self-organization are in a condition of 'bounded instability' (Merry, 1999) in which they can find 'the mix of confirmation and novelty' that maximizes their adaptive capacity. In a situation of equilibrium, the system is too static to be fully adaptive to new, unexpected situations. It can grow isolated and thus become irrelevant to its environment and unable to learn, evolve and renew. On the other hand, when the system is totally unstable, it is incapable of responding in a coherent way to new challenges and could easily fall into chaos and decline (Van Meerkerk et al., 2013).

In this perspective, spatial designers who aim at triggering/accelerating a process of self-regeneration or preventing/inverting a process of decline face the following question:

> What are the minimum spatial interventions which could contribute to enhancing or restoring the adaptive capacity of a specific social-spatial network, thus preserving its ability to self-regenerate over time and maintain a condition of bounded instability?

It is important to emphasize that the manipulation of physical space is just one of the possible actions aimed at preserving adaptive capacity across the existing urban fabric. In cities, the enabling and constraining conditions which might nourish or threaten the adaptive capacity of a certain social-spatial network can be very heterogeneous (Carter & Moroni, 2021): they can concern the set of rules (Moroni, 2015; Moroni & Cozzolino, 2019), certain kinds of policies (De Roo & Yamu, 2015; De Roo & Rauws, 2016), the taxation system, the distribution of property or land prices (Dovey, 2012; Dovey & Symons, 2014, Moroni & Cozzolino, 2021). Often the manipulation of space is pointless if it does not go hand in hand with appropriate policies and regulations. Nonetheless, the spatial layout can be crucial in maintaining the adaptive capacity of specific social-spatial networks.

In this perspective, designers who want to influence current adaptive cycles are called to shape the most appropriate spatial actions that can restore the balance between uniformity and diversity whenever a social-spatial network risks becoming too rigid and efficient, thereby losing its diversity and redundancy (late conservation phase), or when it misses the minimum cohesive conditions that are necessary in order to avoid falling into chaos. In spatial terms, these interventions can materialize in a myriad of ways that aim to increase the cohesive conditions or reduce some physical constraints across site-specific socio-spatial networks.

In the case of the construction of a new building or neighbourhood, the role of designers who aim to maximize adaptivity consists of shaping the initial spatial conditions, which can structure a dynamic, open evolution over time without overdetermining its formal outcome. In this case, the robust initial structure (Habraken, 1972), which is designed from the top down, (1) provides room for unpredictable individual actions (which might emerge from the bottom up), (2) preserves the collective interest without overcontrolling and predefining every single intervention, and (3) provides the physical constraints that prevent the socio-spatial system from falling into chaos, without blocking individual creativity (Porqueddu, 2021).

An example of such design strategy—although the designers do not refer to these theories –concerns the incremental housing project built by Studio Elemental in Iquique (Chile) (Aravena and Jacobelli, 2012), which I have described in detail in previous articles (Porqueddu, 2018, 2020, 2021). In fact, on the one hand, Studio Elemental conceived the new buildings as basic unfinished structures that could gradually be transformed by the residents according to their individual and evolving needs. On the other, this initial structure was designed so that future expansions could occur within the initial volume, thereby limiting the possibility of chaos without the need to control every single addition. From this perspective, the project in Iquique can be considered a robust structure that is capable of containing and rationalizing informal, diverse, and unpredictable expansions without overdetermining the formal outcome of the transformation. In this case, the uniformity of the initial structure fosters the diversity of the expansions, while its stability supports its dynamism over time. Furthermore, this basic fixed structure works as a collective, cohesive layer that channels the unpredictable individual initiative of each dweller toward the collective interest.

In the case of the regeneration of an existing building or neighbourhood, the role of designers consists of altering the actual spatial structure, with the objective of increasing its adaptive capacity through minimal (and possibly progressive) spatial manipulations. For example, a design action might (a) strengthen or insert a robust spatial structure when the system lacks a cohesive layer and tends to fall

into chaos, or rather (b) reduce some physical constraints, for example, by adding new, a posteriori undetermined spaces (open structures) to an overdetermined rigid structure, thus turning it into an open, dynamic space that is capable of co-evolving with its inhabitants over time.

As I have extensively illustrated elsewhere (Porqueddu, 2021, 2022), examples of such design strategies can be offered respectively by:

- The famous Integrated Urban Plan (PUI), a complex program for the regeneration of the informal settlement of Medellin, promoted by the municipal government and coordinated by Alejandro Echeverri (Echeverri and Orsini, 2010; Davila, 2013).
- The project for the regeneration of the "Cité du Grand Parc" (a post-war modernist settlement built in the early 1960s in Bordeaux) by the architects Lacaton & Vassal with Druot and Hutin (Publica, 2017; Ayers, 2019).

In Medellin, the new structured macro-network of buildings, public spaces, and oriented fast connections (Metrocable), designed from the top-down, can be framed as the minimum robust structure that is capable of fostering the vitality and dynamism of the existing informal settlements, while reducing their tendency to fall into chaos. In this case, the new robust spatial structure that is inserted a posteriori increases the efficiency of the existing system without damaging its micro-scale redundancy, which is crucial to its vitality and resilience. The strategy proposed by Lacaton & Vassal, with Druot and Hutin, aims to alter the overdetermined rigid structure of modernist buildings by adding new indetermined extra-spaces which are designed to be easily and constantly adapted to new uses by their inhabitants in relation to their emergent needs and wishes, that are unpredictable and in a constant state of becoming.

In these cases, the design approach is based on a thorough understanding of place-specific dynamic relationships between people and their physical environment rather than on abstract principles and coded urban formulae. Furthermore, these projects are intended to incorporate time, along with its unpredictable outcomes, into the design brief. None of them claim to offer a comprehensive vision of the future or to replace large parts of the existing urban fabric with new spatial configurations entirely designed from the top down. Instead, the process becomes part of a product that is never meant to be completed. This kind of strategy is based on place-specific, incremental, catalytic interventions (Ellin, 2006; De Solà Morales, 1999; De Solà Morales et al., 2008). It endeavours to design the essential spatial conditions which enable the system to remain open, diverse, and adaptive. The strategies consist of fixing a priori—or inserting a posteriori—certain elements whose position and configuration foster processes of regeneration which emerge from existing local resources, and which require the incremental and unpredictable intervention of multiple individuals (Porqueddu, 2018b).

Adaptive cycles across scales: Influencing and monitoring cross-scale effects

The second aspect, which is also emphasized in transition theory, concerns the multi-scale nature of adaptive cycles. In this respect, panarchy theory (Gunderson and Holling, 2002) stresses how adaptive cycles and feedback loops develop across scales. A crucial point in this theory is to consider that the scale in which we are interested is connected to and affected by what is happening at the scales above and below and that the linkages across scales play a major role in determining how the system is behaving on another scale. In this respect, if we fully consider the city as a complex system, we cannot successfully interact with it by focusing on only one scale. In this sense, panarchy theory also resonates with transition theory, which explores how patterns in system innovation emerge from

the interplay between dynamics at multiple levels (MLP, multi-level perspective) (Geels, 2005; Öztekin & Gaziulusoy, 2019).

With regard to self-destruction theory, Jacobs's observations also revealed how linkages across scales are a key aspect in understanding diversity and resilience cycles in cities. Indeed, she argued that streets that experienced the self-destruction of diversity after a successful period could quickly regenerate their diversity (from release to exploitation) only if they were surrounded by other streets that were in a phase of flourishing diversity (exploitation). That is to say that, in this case, a micro-cycle can be positively affected by wider-scale processes and vice versa.

This multi-scale perspective has several implications for spatial designers who endeavour to proactively cooperate with adaptive cycles in cities. Firstly, it highlights how every time designers alter the spatial layout in a specific context. They also alter the network of socio-spatial relationships far beyond the boundaries of the project site and the time of construction. This awareness leads to a shift in the focus from the peculiar scale of the project towards the cross-scale effects that a site-specific spatial intervention triggers over time.

Secondly, since complex adaptive systems evolve in a non-linear manner through feedback loops, the outcome of these spatial interventions cannot be fully predicted. On the one hand, this awareness encourages designers to monitor the cross-scale effects triggered by their actions after the construction process so that they are ready to intervene again in the case of excessive or harmful effects. On the other hand, by understanding adaptive cycles across scales, designers can learn how to identify leverage points (Meadows, 1997) for spatial interventions, thus maximizing the effects of tiny punctual actions by using self-regulating and self-reinforcing feedback. Again, the aforementioned acupunctural spatial design strategy adopted in Medellin—and the consequent process of incremental self-regeneration across the informal settlements—can be considered a good example of this approach. In Medellin, the potential to upgrade the informal urban fabric at the micro-scale of the neighbourhood was enhanced by tracing new connections (Metrocable) with the larger scale of the city; that is to say that a widescale action was undertaken in order to retain and improve city vitality on a micro-scale. On the other hand, the coordinated assemblage of punctual micro-interventions across the intricate lanes triggered an incremental process of self-regeneration that extended far beyond the micro-scale of every specific project site and beyond the time of construction (Porqueddu, 2021).

4-Design as a "good perturbation"

By recognizing that they cannot control emergent self-organizing orders, designers can acquire the "Butterfly" power of subtle influence (Irwin, 2004). By detecting site-specific adaptive cycles across scales, they can obtain the ability to identify the minimum top-down actions which can contribute to triggering a spontaneous process of self-regeneration that emerges from the bottom up.

In this sense, the design action can be framed as a "good perturbation": designers modify or insert the minimum physical elements which can repair or increase the system's ability to self-regulate, self-adjust, and self-organize in new and better social-spatial fits (which can neither be predicted nor predetermined). In this perspective, designers become capable of shaping minimal spatial interventions, which can guarantee that the system preserves or recovers its adaptive capacity and remains in a state of becoming.

In this regard, systems theories lead to the development of a spatial design approach that shifts the focus from the final shape of the artifacts towards the non-linear (and cross-scale) effects triggered by their insertion into site-specific adaptive cycles. In this respect, designers keep acting on physical form, although form is not the goal, rather it becomes a means to (re)activate the connections which foster/restore the capacity of a certain social-spatial networks to learn, adapt, evolve, and renew over time.

This understanding makes it possible to identify the most appropriate type and scale of (minimum) intervention that can foster or restore the system's adaptive capacity and, thus, its power to self-regenerate and self-produce the solution to emergent problems.

In this respect, such an approach to design makes it possible to increase the overall quality of the urban fabric by reducing economic costs for two main reasons. Firstly, an increased adaptive capacity entails limited costs for progressive adjustments over time (Porqueddu, 2021-2022b). Secondly, by monitoring adaptive cycles across scales (see section 5), spatial designers become able to detect leverage points (Meadows, 1997) through which they can achieve the maximum outcome through minimal progressive spatial manipulations. This also makes it possible to reduce costs, an aspect that is particularly relevant in a period characterized by extremely limited economic resources.

5-Detecting leverage points for spatial action: a multi-scale atlas

The previous sections highlighted how a design approach that aims to virtuously intervene in processes of decline and self-regeneration is based on a systemic understanding of site-specific adaptive cycles across scales. In this respect, the following section presents a multi-scale atlas as a tool that makes it possible to:

1. Frame site-specific spatial configurations as parts of complex systems that include human activities and actions.
2. Highlight how these physical spaces—at different scales—prevent or support cycles of self-regeneration or decline.
3. Identify the most appropriate position, type and scale for progressive spatial interventions that can trigger/accelerate incremental processes of self-regeneration or prevent/invert cycles of decline.
4. Monitor the unpredictable cross-scale effects triggered by these interventions over time.

The atlas was created and tested by myself as part of my PhD thesis (Porqueddu, 2012) to explore the spatial implications of a cycle of decline which was developing across a low-density Italian area—called Oltrepo' Pavese—a fine grain network of old settlements and more recent nodes, interspaced by agricultural land, situated 50 km south of Milan (in the Province of Pavia), at the intersection of two important infrastructures connecting Milan, Genoa, Turin and Bologna (Figure 2).

The Area of Observation (300 Km2) is situated at the border between the plain and the hills—agricultural and wine-growing areas—and includes eight of these municipalities (Figure 3). The major centre is a small town of approximately 40,000 inhabitants, the others being villages of 900 to 5,000 inhabitants.

The atlas was shaped in order to (a) understand whether the existing spatial configurations—at multiple scales—were fostering or preventing the emergence of city diversity (Jacobs, 1961), framed in the previous sections as a crucial variable in cycles of self-regeneration, and (b) identify leverage

points for spatial action. The atlas builds on Jacobs's phenomenological social-spatial approach, but it extends it to a multi-scale level. In fact, a multi-scale understanding becomes indispensable in the contemporary city, where the rise of mobility and communication technology has brought about a network of exchanges between discontinuous places, opening up new possibilities for interaction and exchange beyond the traditional relationship of proximity (Massey, 1994; Castells, 1996; Amin & Thrift, 2002; Boelens, 2009; Marchigiani & Bonfantini, 2022). In the domain of the contemporary metropolis, diversity emerges according to the distinct mixture of both local and wider flows intersecting at specific points in time (Massey, 1994). In this respect, the mere scale of architecture would not highlight the social-spatial dynamics beyond the boundaries of a specific site, and the wide metropolitan scale would not reveal anything about the micro-space scene of perception and human interaction.

The atlas combines a multi-layer analysis with multi-scale mapping (Lynch & Hack, 1984; McHarg, 1969; Corner, 1999) in a matrix (Figure 4), which makes it possible to explore the links between people's behaviour, activity rhythms and the physical layout that supports them at multiple scales. A key point here is that the multi-scale strips are conceived in order to shape a systemic understanding of the cross-scale relationships in which specific spatial configurations are immersed.

The maps are organized into five thematic strips, investigating respectively:

The daily concentrations of people in specific places according to different time cycles, event geographies and commuter flows. This layer is important because diversity emerges from a distinct mixture of heterogeneous people crossing in space (Massey, 1994; Jacobs, 1961).

The fast-slow network of connections that support heterogeneous flows of people and goods (the street network, including pavements, parking lots—size, shape, and spatial distribution—and the transport system) (Figure 6).

The types of boundaries and public-private interfaces. This layer shows how the layout and types of physical and administrative boundaries encourage or discourage unforeseen interaction between heterogeneous activities and between public and private spaces. This layer is important because complex self-organizing systems require open unfixed interactions between heterogeneous components (Dovey & Wood, 2015).

The distribution, concentration and types of activities and businesses (local and supra-local) across the urban fabric. The mix of heterogeneous activities and uses is considered one of the main generators of diversity (Jacobs, 1961; Sennett, 2017).

The building footprint and density. This layer shows the concentration and mix of building types combined with data on density in terms of Floor Area Ratio (FAR). This layer is relevant because density in terms of Floor Area Ratio and compact urban form is still central in the discussion on city diversity.

Every layer is investigated on a wide range of scales (Figures 4–6) within the framework of:

- *15 m and 15,000 m2*. This scale shows how space is perceived and how it supports face-to-face interaction between people. This is the scale of architecture and interior design.
- *1.5 km2*. This scale shows whether the spatial layout—at the scale of a village or neighbourhood—supports the movement (fast-slow) of people and their interaction across

different activities and spaces. This is the typical scale of landscape design, urban design and planning.

- *300 km2*. This scale shows the main infrastructures in relation to the existing urban fabric, natural environments and administrative boundaries, and it highlights the flows between different settlements. This is the typical scale of planning.
- *15,000 km2*. This scale situates the studied area(s) within the wider scale. It is typical of regional planning and geography.

The multi-scale thematic stripes make it possible to spatially visualize and interrelate the data collected (Figure 5):

- through interviews and informal face-to-face interactions (with inhabitants, municipal administrators, and local experts);
- through behavioural-photographic surveys (direct experience of the mapped areas including travelling at different speeds—driving, walking, cycling and the public transport experience—and engaging with people while observing their behaviour across space);
- through statistic data analysis; and
- through multi-scale mapping.

In this respect, the thematic stripes intersect heterogeneous data (both quantitative and qualitative) collected through statistical analysis (ISTAT– the Italian National Institute of Statistics), as well as through the direct experience of places. The stripes enable designers and other experts to analyse specific contexts both as detached external observers (from above) and as participants in site-specific "urban ballets" (Jacobs, 1961) (Figure 5). In this respect, the atlas is based on the idea that while advances in digital data visualization methods (Batty, 2013, Hensel et al., 2022, Ortiz et al., 2021) are crucial in informing the work of transdisciplinary teams of experts that analyse complex urban problems as external detached observers, all the actions concerning the direct physical transformation of space, at all scales, should also be informed by intuitions that can only emerge from the direct—sensorial, physical, social, emotional—experience of places, which cannot be entirely replaced by any sophisticated software.

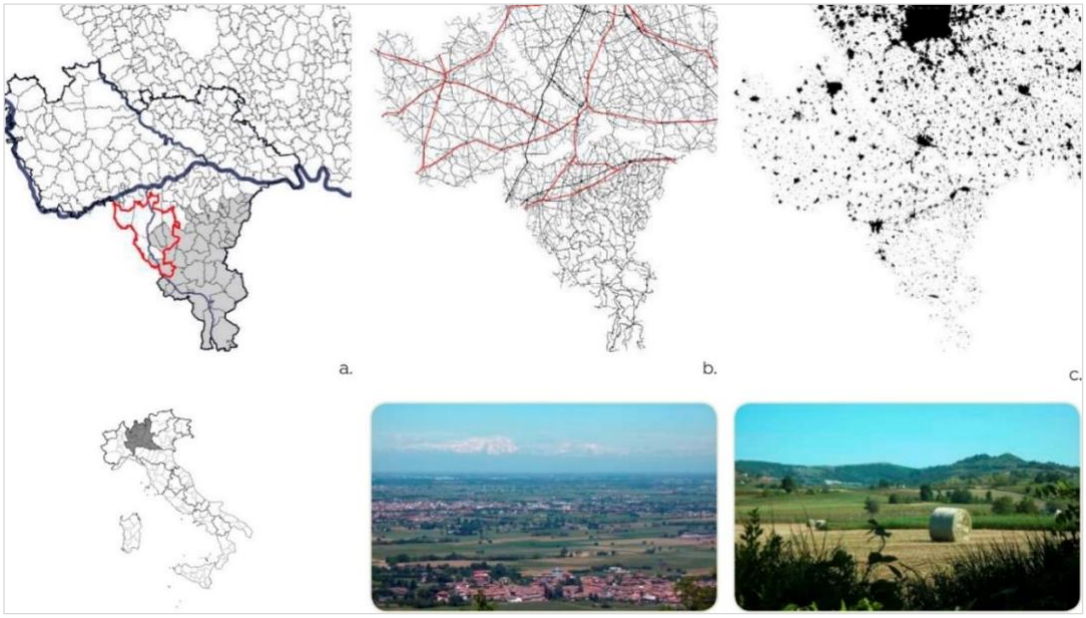
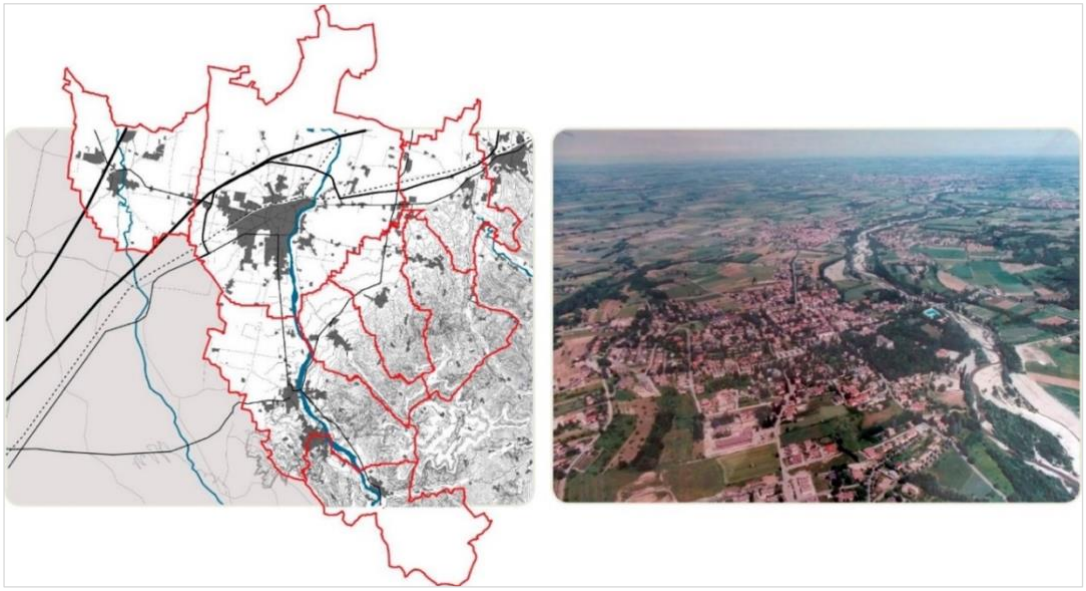


Figure 2. The Province of Pavia. (a) Administrative boundaries; (b) Network of connections; (c) Built-up areas. (Porqueddu, 2015, 2018a).



a. **b.**

Figure 3. (a) Observation perimeter (300 Km frame): Eight municipalities; (b) Aerial photo. (Porqueddu, 2015, 2018a).

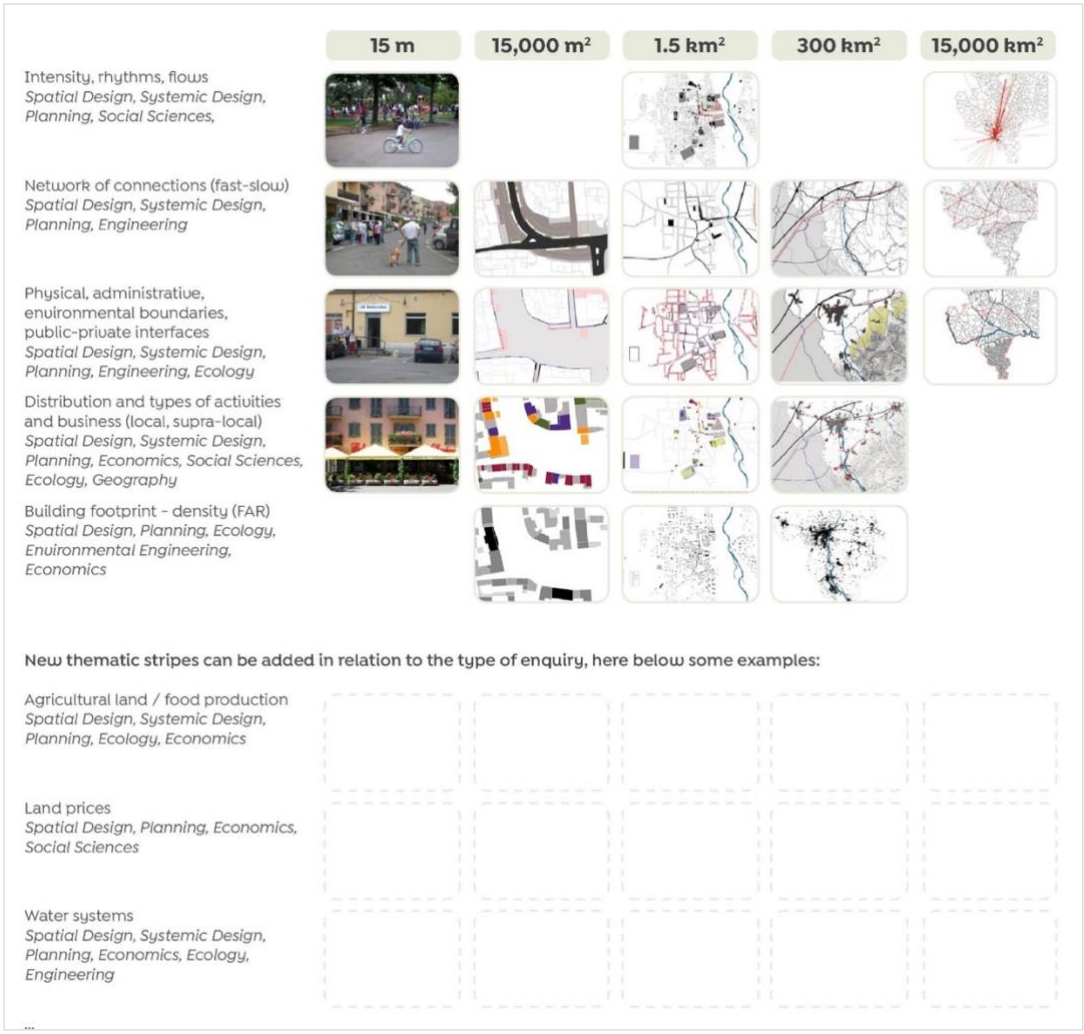


Figure 4. The multi-scale atlas: thematic stripes, disciplines currently or potentially connected to these specific themes, and potential implementation through new stripes related to evolving types of enquiries.

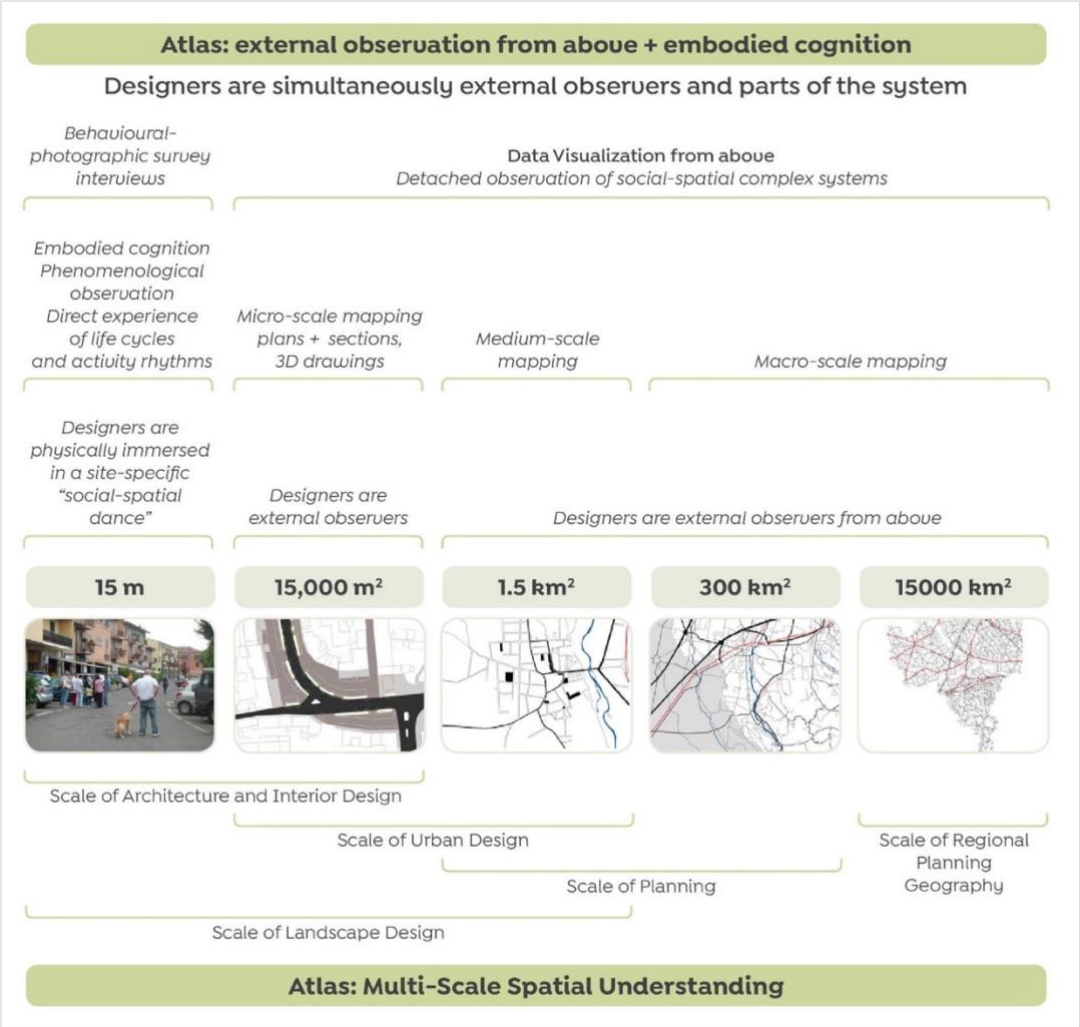


Figure 5. Multi-scale development of each thematic stripe.

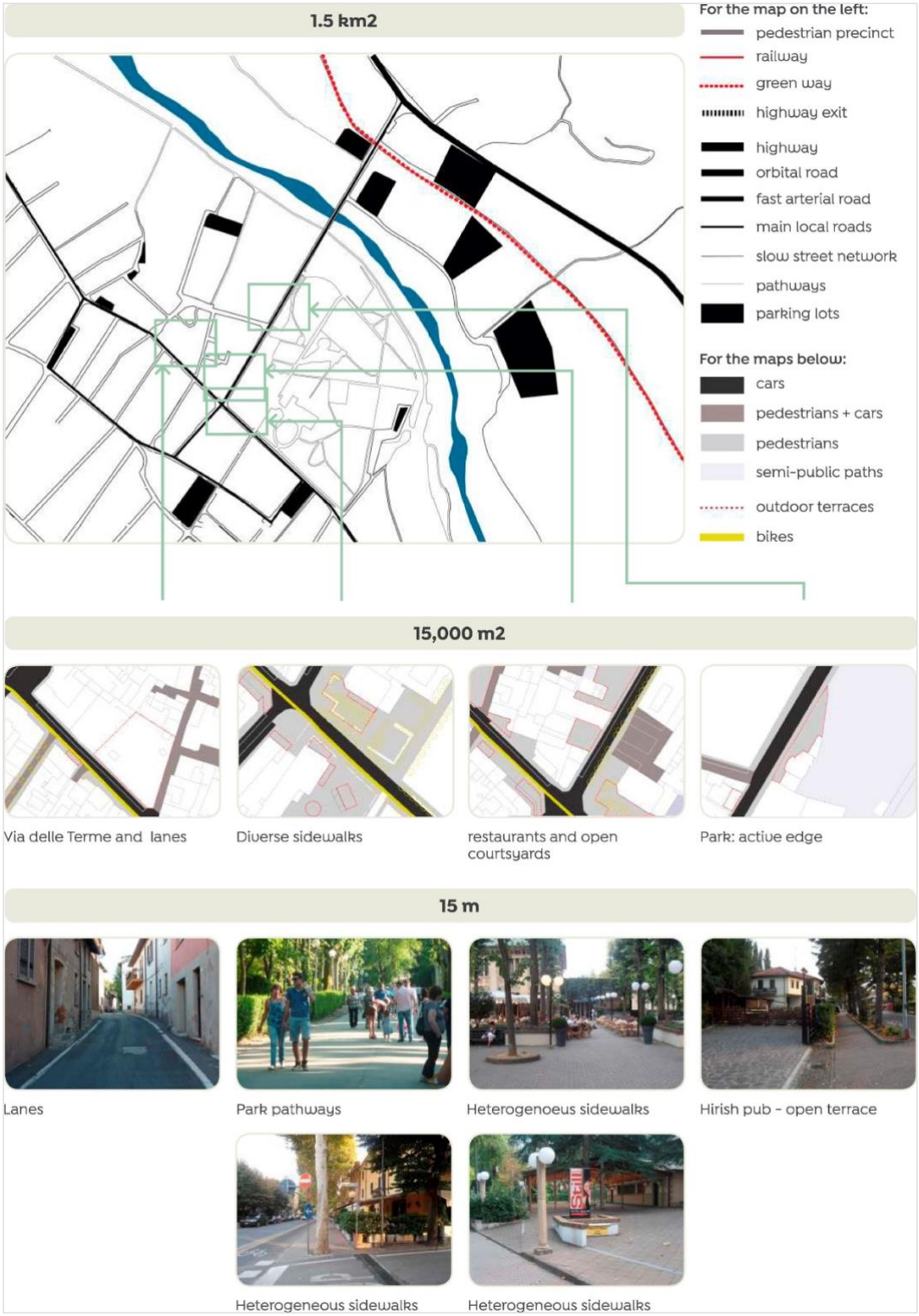


Figure 6. An example of a fully developed thematic stripe (network of connections) (Porqueddu, 2015, 2018a).

The act of moving across the urban fabric, the sensorial perception of other people's movement, of their interaction with specific spaces, the immersion into smells, noises, voices, symbols, and signs of specific places, the face-to-face conversation with inhabitants, are here considered crucial in understanding and interacting with cycles of self-regeneration and decline in cities. In fact, here, the built environment is not conceived as an abstract spatial composition existing in free geometric space but rather as the existential field of our tactile consciousness. As Mallgrave (2013) argues, we are sensorimotor beings embedded in our environments and intersubjective relations; our nervous system, our body and the environment are interwoven and highly structured dynamic systems (Thompson & Varela, 2001).

In this perspective, the atlas can also become a cross-disciplinary tool that makes it possible to intersect data collected through investigations from different disciplines connected to the construction and transformation of the built environment (Figures 4–5). In fact, geographers and planners collect data about people and their emergent activities, but they often show these data through widescale maps or bird's eye visualizations, which do not illustrate the physical sensorial urban environments (on a micro scale) where these activities and businesses take place. Architects often focus on the human scale of perception and interaction, but they rarely observe the behaviour of people across different scales through statistical data analysis. Social scientists and anthropologists observe human behaviour and informal practices, but they rarely map them (and mapping is the only tool that can draw connections between space, behaviours and flows, and emergent mixes of uses and activities). Landscape designers (Corner, 1999, 2006; Waldheim, 2006) are masters in using multi-scale mapping. This is because they work with living materials, and they need to understand ecosystems (which are emergent systems) and life cycles, but they mainly focus on natural elements, and they rarely use mapping as a tool to investigate emergent cultural, economic, and social dynamics. In this respect, the atlas is designed to cut across all these disciplines to spatially visualize and intersect heterogeneous types of data.

Although this is not the place for an extensive description of this specific case study, which was illustrated in previous articles (Porqueddu, 2015-2018a-2022a), I will briefly outline some of the findings which emerged from this investigation and which I consider relevant to the issue addressed in this paper.

Across this specific urban network, the atlas highlighted the presence of emergent supra-local attractions (such as hotels, spas, sport centres, new workshops, shopping outlets, shopping centres, important showrooms, and famous restaurants or clubs) that catalyse metropolitan flows of people within the municipal boundaries of the small settlements. This is particularly relevant because, in this area, a vibrant local street life can be nourished just by wider flows, developing on a metropolitan scale. Indeed, here a single settlement is neither dense nor big enough to generate diversity within its boundaries. Nonetheless, the atlas also underlines how the current spatial layout (at multiple scales), in most cases, tends to discourage emergent synergies between local activities and new supra-local attractions.

Figure 7 shows the typical situation where the intricate urban fabric of the old nuclei—which has the potential to foster unforeseen synergies between heterogeneous activities and between public and private space—is disconnected from the network of fast arterial roads and new supra-local attractions. In this type of spatial layout, people travelling on a regional scale can directly reach the supra-local attractions without walking through the old settlement, which remains cut off from these wider flows. Street life in the old settlement, therefore, tends to disappear, and people have the impression that the whole area is declining, even when there are several new activities and businesses. In this case, the new supra-local attractions decrease rather than foster the emergence of local activities and street life even when they are placed at a walkable distance from the old nuclei. In just a few villages (Figure 8), the new supra-local attractions are well integrated into the fast and slow network of connections and interwoven with local businesses and activities, thus fostering street life vitality and city diversity across the existing urban fabric of the village.

In this perspective, the atlas highlights how a spatial design strategy which aims to invert this cycle of decline should shape a coordinated assemblage of minimal interventions aiming to integrate the historical urban fabric of the small settlements into the regional metropolitan network without the need to re-design large parts of the system.

These interventions could focus on the following:

Revising the network of streets and parking lots to better integrate the slow micro-street network of the historical settlements into the regional macro-network of fast arterial roads.

Shaping a series of actions (both spatial and normative), which can invert this trend and render the inner part of the settlement appealing for new activities and businesses. These actions should not interfere with the spontaneous tendency of supra-local attractions to spread across this area, but at the same time, they would transform their negative effects into new potential synergies with existing local activities. By fostering the concentration of the new supra-local attractions across the existing urban fabric, this strategy could also contribute to reducing soil consumption and protecting the beauty of the local landscape and the agricultural land. In spatial terms, it consists of promoting and experimenting with innovative spatial solutions, materials and technologies, which make it possible to increase the adaptability of the historical urban fabric to emergent activities and uses (above all, the adaptability of the ground floors of existing buildings), and provide existing and new buildings with responsive, reversible public-private interfaces and accesses that can easily be adapted to unpredictable individual-collective needs (definitive boundaries are one of the main obstacles to emergent synergies between different activities and between private and public spaces (Dovey & Wood, 2015). In this regard, the ability of designers is crucial in order to elaborate options which can increase the adaptive capacity of the historical urban fabric by preserving and increasing its valuable aesthetic quality.



Figure 7. Local-metropolitan disconnection (Porqueddu 2015, 2018a)

A key point here is that the types and scales of these interventions are very different, and they belong to various spatial design disciplines. Point one mainly concerns the action of public administration and the disciplines of urban or landscape design, which entail a widescale overview and long-term interventions. In particular, it concerns the administration's ability to establish a framework (both spatial and normative) which can guarantee that the unforeseen individual interventions—mentioned in point two—foster city diversity without the need to over-control the development of every single project. Point two includes the incremental temporary spatial adjustments enacted by multiple inhabitants and emerging from their wish to adapt the existing urban fabric to new activities and uses. These tiny interventions are linked to the knowledge developed in other spatial design disciplines related to micro-scale short-term transformations, such as architecture, interior and product design. In this respect, the atlas shows how a synergy between heterogeneous design disciplines operating at different scales—interior design, architecture, urban and landscape design—would create the spatial conditions which could possibly invert an emergent cycle of decline and foster the transition of this network of villages and small towns into a low-density distributed rural metropolis which could combine the diversity and vitality normally associated with a city with the potential given by the natural environment in which they are immersed.



Figure 8. Local-metropolitan interaction (Porqueddu 2015, 2018a)

Since this kind of strategy aims to influence—without overdetermining—the position and types of projects promoted by heterogeneous individuals, it might also generate unexpected and undesirable effects. In this respect, the atlas is designed to be continuously updated, thereby enabling local administrators, planners, and designers to constantly monitor the cross-scale effects triggered by their decisions and projects so that they can be ready to revise their strategy if new, unexpected cycles of decay emerge (Figure 9).

Even though in this specific study, the atlas had a limited application connected to a specific enquiry, it was structured to be constantly implemented through data collected within other fields of expertise—such as systemic design, economics, the social sciences, ecology, biology, the life sciences, anthropology and environmental engineering—that are not directly linked to spatial design disciplines: the thematic stripes can be incremented or varied in relation to other types of enquiry (Figure 4). In this sense, the atlas could also be of use to experts from other disciplines who are less familiar with mapping by enabling them to visualize the spatial implications of specific problems related to their field of expertise and by highlighting whether these problems are related to the urban fabric.

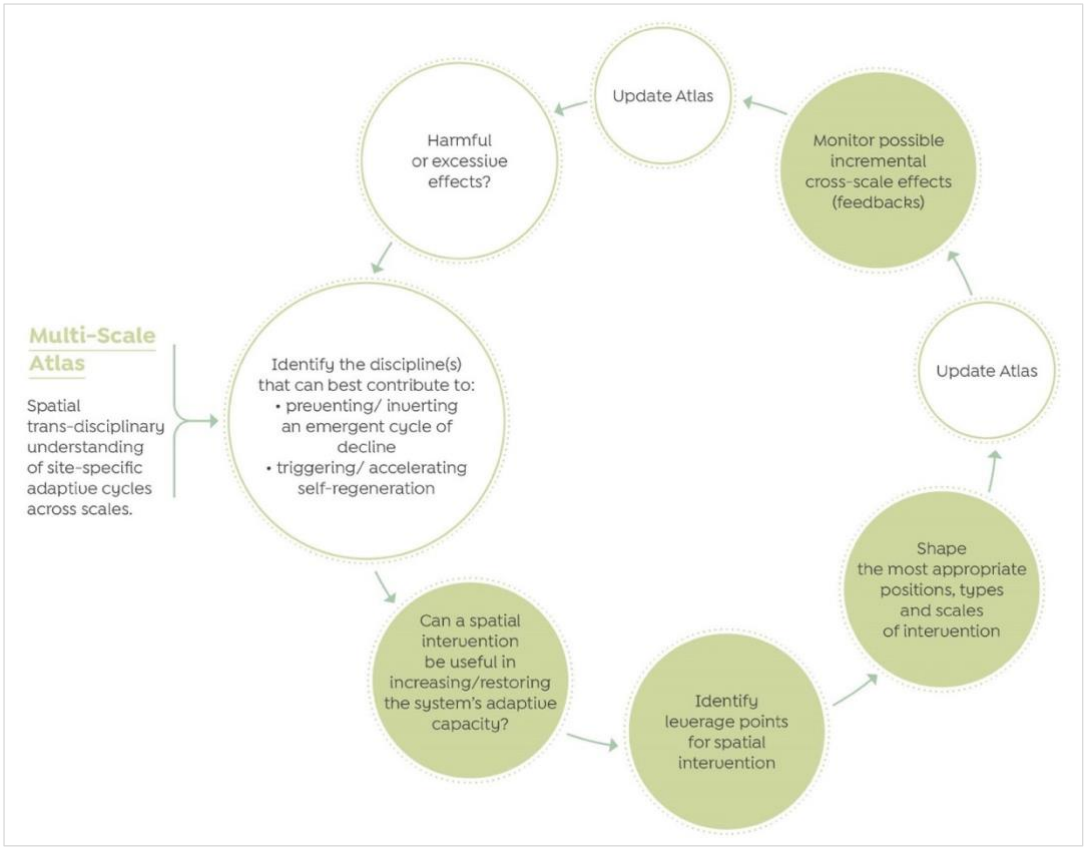


Figure 9. The systemic spatial design process.

Design as a good perturbation. The multi-scale atlas (spatial trans-disciplinary understanding of site-specific Adaptive Urban Cycles of self-regeneration and decline) is part of the design process.

In this perspective, the atlas can also become a fertile ground for developing unforeseen synergies between different experts, stakeholders, and users, which could lead to experiments in co-disciplinary strategies of urban regeneration. In this regard, the multi-layer maps make it possible to spatially visualize and intersect data concerning both environmental and social-economic adaptive cycles, thus framing the built environment as a component of a wider ecosystem that includes non-human organisms (Allen et al., 2003; Rees, 2012; Spirn, 1984). This aspect would be particularly relevant in developing site-specific trans-disciplinary strategies aimed at turning unsustainable urban areas into "self-sustaining assemblages of living species existing in complementary relationships with each other and their physical environment" (Rees, 2012). In this respect, the atlas can also show whether a spatial design intervention is required, whether a co-disciplinary strategy is needed, or whether other disciplines would be more appropriate in terms of intervening in order to invert a site-specific cycle of decline (Figure 9).

6-"Systemic spatial design," a framework for innovation in spatial design disciplines

The present paper highlights how a systemic approach to spatial design—which I propose as "systemic spatial design"—encompasses all the disciplines related to the construction or modification of the built environment—interior design, architecture, urban, and landscape design. This is because it focuses on influencing site-specific adaptive cycles of decline and self-regeneration rather than on the final shape of specific artefacts, buildings, or neighbourhoods. In order to trigger a process of self-regeneration, systemic spatial design could work at the micro-scale of interior design, at the scale of architecture or at the macro scale of urban design, or simultaneously at different scales in different discontinuous—but interconnected—sites. The focus shifts from the specific scale and type of spatial interventions towards the site-specific cross-scale effects produced by these interventions over time.

While the physical construction of space in cities is mostly associated with the disciplines of urban and landscape design—which entail a widescale overview and long-term interventions—the present paper highlights how adaptive cities and neighbourhoods, to a large extent, organically evolve and self-regenerate over time thanks to a series of incremental temporary and tiny spatial adjustments emerging from the spontaneous initiative of multiple individuals (Allen & Sanglier, 1981; Batty, 2013; De Roo & Rauws, 2016; De Roo, 2017; Hillier, 2012; Johnson, 2001; Portugali, 1999; Jacobs, 1961; Moroni & Cozzolino, 2019; Cozzolino, 2019). Such interventions are linked to the knowledge developed in other spatial design disciplines related to micro-scale temporary transformations, such as architecture, interior and product design, which, however, rarely address problems related to urban adaptive cycles—of streets and neighbourhoods—that unfold beyond the scale of their usual action. On the one hand, the specific body of knowledge of each of these disciplines—interior design, architecture, landscape, and urban design—enriches the range of solutions available for interventions on specific scales. On the other hand, the fragmentation of their action decreases the potential of these disciplines to proactively interact with spontaneous adaptive cycles of self-regeneration and decline that develop across scales and over time.

In this respect, systemic spatial design is here proposed as a framework which aims to trace and experiment emergent synergies between the various spatial disciplines, thus improving their ability to navigate—without overcontrolling—adaptive cycles across scales in the contexts in which they intervene. Since in adaptive cities and neighbourhoods, the stable systems do not have to block the flow of the dynamic ones, and the dynamic ones do not have to tear up the slow ones with their

constant change (Brand, 1995; Habraken, 1998), an open challenge for systemic spatial design is that of coordinating the action—at multiple scales—of different design disciplines in such a way that:

- **The widescale and long-term** spatial interventions typical of the urban design discipline—and set by local government bodies—can shape frameworks that are able to foster rather than prevent progressive short-term micro adaptations that increase the ability of specific urban environments to constantly evolve and self-regenerate over time.
- **The short-term micro-adjustments,** which are typical of architecture and interior design—and are promoted by multiple individuals—can trigger/accelerate incremental processes of self-regeneration or prevent/invert cycles of decline, thus producing positive long-term effects that extend far beyond the scale and time of each single micro-adjustment (Porqueddu, 2022c).

This does not mean that the formal quality of every single spatial manipulation becomes secondary. As highlighted by the projects in Medellin, Iquique and Bordeaux, this quality remains a fundamental characteristic in cycles of urban self-regeneration (Porqueddu, 2021-2022b). In this sense, systemic spatial design does not question the established practices of spatial design disciplines. On the contrary, it aims to shape a framework that increases their potential to cooperate proactively and virtuously with site-specific adaptive cycles of self-regeneration and decline.

Furthermore, since systemic spatial design seeks to detect leverage points that make it possible to maximize the effect of punctual interventions via feedback, it leads to the maximum outcome through minimal progressive interventions. In this perspective, by decreasing the number and size of the interventions and by playing as much as possible with existing local resources, a systemic approach makes it possible to allocate a greater amount of money to each single project without increasing the overall costs. In other words, the maximum quality (i.e., spatial, tactile, visual, technological, and environmental) can be obtained with a limited amount of money, as happens, for example, in the aforementioned projects. This also leads to an empowerment of the traditional disciplines of spatial design in terms of the overall quality of single artefacts and their potential to maintain their adaptive capacity over time.

Finally, systemic spatial design aims to increase the capacity of the urban fabric—in a site-specific context—to adapt over time to unpredictable changes rather than adapting it to a peculiar and contingent situation. In this respect, it enables designers to influence emergent transformations without predetermining their formal outcome, thus increasing their ability to deal with uncertainty and enhance the potential of our built environments to respond to and progress with unpredictable changes (Galimberti,2021, 2022; De Roo et al., 2020).

7-Final remarks

This paper presents systemic spatial design as a framework which aims to outline — and experiment with — emergent synergies between the established disciplines related to the modification and construction of the built environment—interior design, architecture, urban and landscape design—thus enhancing their ability to proactively cooperate with emergent transformations and to virtuously intervene in site-specific cycles of decline and self-regeneration.

In this respect, the multi-scale atlas here presented highlights how an understanding of site-specific adaptive cycles across scales is crucial to shaping a systemic strategy which can channel the specific action of the various design disciplines so that they can best contribute to navigating—without overcontrolling—adaptive cycles in the context in which they intervene.

While this paper mainly focuses on social-spatial dynamics, there are many other aspects—economic, environmental, geographic, administrative, political, and normative—which play a crucial role in urban cycles of decline and regeneration, and which are extremely relevant in exploring the potential synergetic action of the different spatial design disciplines.

In this regard, further transdisciplinary research investigating the complex relationship between these heterogeneous aspects could have a crucial role in constructing a systemic spatial design framework and in unlocking unforeseen potential for urban regeneration and sustainable development across our existing and emergent urban systems.

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