Research Paper

Planning the ComplexCITY:

Guiding Principles for a Systemic Qualification of Planning

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Abstract

In Brazilian cities, spatial fragmentation is reflected not only in physical but mainly in social-economic distances among different actors and has an adverse impact on the natural environment. In the absence of mechanisms and actions that can curb spatial segmentation and dispersion and ensure an equitable distribution of public equipment and spaces, as well as housing that benefits different income levels, among other problems, Brazilian cities are growing in the direction of segregation – both physical and social – leading to an increase in disparities and environmental degradation. These facts bring up the need to establish urban planning with an integrated and systemic vision that can contemplate the intricate dynamics of implications between the creation of urban spaces and social-environmental issues. Based on the Complexity Theories of Cities (CTC) – a theoretical basis that can give support to a systemic vision – this article, derived from a doctoral dissertation, presents principles that can guide planning towards rescuing the integrative capacity of the city and a more equitable and environmentally balanced reality of urban issues.

Keywords

Complexity, Socio-spatial cohesion, Fragmentation, Complex systems

1. Introduction

A fragmented, segregated and dispersed urban expansion unbalances the possibilities and the speed of interaction and access to resources and opportunities among different agents, as well as jeopardizing the balance of environmental dynamics. The segmented growth of cities is translated into the formation of urban enclaves, the spatially unequal distribution of public investments, a concentrated and elitist urban renewal, social segregation, and the growth of urbanization in a pulverized manner over environmental areas. All these circumstances not only compromise the flow, coherence, and balance of urban and natural dynamics, it also curtails complexity and conditions its emergence in a segregating and inequitable direction.

In Latin American cities, including in Brazil, spatial analyses show there is a predominance of urban growth in axial and isolated patterns – a feature of a dispersive and fragmented development. A generalized spatial expansion was observed, with growing acceleration, but with a tendency for decreasing density and fragmentation[1] underlying the increase in expansion (INOSTROZA et. al, 2013). Added to this, social inequality has grown in Brazil in the last years, reaching the worst level in at least two decades (CREDIT SUISSE RESEARCH INSTITUTE, 2021). This indicates the need to establish urban planning with an integrated and systemic view, subsidized by a substantive theoretical basis, ensuring a more equitable and sustainable social-spatial reality.

This article derives from a doctoral dissertation and adopts the Theory of Complexity, a transdisciplinary science, as support for an urban theory towards social-environmental cohesion and sustainability. It

corroborates the idea that "the degree of complexity of a network [or an urban system] is determined by the degree of cohesion and degree of interconnectedness among its elements" (BRESSER & O'TOOLE, 1998, apud MORÇÖL, 2012, p. 50). The study argues that this perspective –proposing equalization of interconnections among urban elements – can contribute to balance access to resources among agents, lead to a more sustainable form of urbanization regarding the natural environment, and promote global, equitable and collective urban organization. Elaborating principles to establish a foundation for planning approaches to achieve these systemic qualities is the purpose of this study.

2. Methodology

The methodology adopted is theoretical in nature, furthering and juxtaposing studies and exchanging concepts among different fields. The course explores complex systems properties that are transferrable to urban conditions. Its main referential theories are the Complexity Theories of Cities (CTC) and the Metaphorical School. This school argues that the importation of concepts from one technical field to another, through metaphor or translation, can trigger relevant insight for behavior in the social world (RICHARDSON, 2006). This is the strategy adopted here.

This study deals with properties inherent to complex systems that are applicable to city dynamics: self-organization, dissipative behavior, and self-organized criticality (MANSON, 2001; ALEXANDER, 2020). These properties are also the most significant for the emergence of Aggregate Complexity, the focus of this research among the different branches of the complexity theory. Interactions or relationships are the core of aggregate complexity since a complex system is defined more by its relationships than its constitutive parts (MANSON, 2001).

3. Main Concepts

With the purpose of establishing an understanding of the systemic and circular logic involved in urban dynamics and phenomena, this research adopts, exchanges, transfers or conceives of concepts from possible insights through metaphorical translations. In association with the concept of system, the city is understood as "an immense set of cells (the elements) unequally distributed on a territory […] and connected to each other in a selective fashion" (KRAFTA& SILVA, 2020). As to the urban elements that comprise a city, this study classifies them as buildings, open spaces, agents and uses. The first two (buildings and open spaces) are tangible elements that change more slowly, while agents and uses represent intangible elements that are mobile and whose behaviors change more easily. There are unequivocal relations among all these types of elements.

A set of these types of elements with many interactions or connections among each other corresponds to a module (SALINGAROS, 2005) or field of attraction (ALLEN, 1997). Hence, a "module" is any group of nodes (units or elements) with many internal connections (SALINGAROS, 2005). Within a module, arrangements of activities (or elements) have a greater exchange of information than with other modules (COURTOIS, 1985; PARNAS, CLEMENTS & WEISS, 1985). A system can be partially decomposed into a set of semiautonomous complex modules with equally complex interfaces, allowing a connection among them (SALINGAROS, 2005). Strong internal forces keep a module together, while weaker forces keep different modules in their places within the system (COURTOIS, 1985).

A module is configured by a basin of attraction, i.e., a trajectory within the system's global organization to which the elements subjected to a specific order parameter are attracted (HAKEN & PORTUGALI, 2017). The "order parameter" refers to the collective mode (or collective variable) that dominates the system's macroscopic behavior when it is near critical circumstances, i.e., near instability, and can describe the pattern of evolution (KELSO & HAKEN, 1997).

The actions of individuals (the agents) correspond to these collective or predominant patterns of behavior. These patterns emerge from interactions (of attraction or repulsion) among urban elements. They may arise from the choices of agents (their preferences or needs) and from the interaction among elements, or through relations of social-economic or economic complementarity of scale (PALMA, 2011). From this perspective, different mechanisms - associated with different channels, levels of emergency or the synergy among agents - are responsible for the formation of types of urban patterns, classified here as Synergic or Asynergic, and that may or may not correspond to Normative Patterns.

A Synergic Pattern emerges from the predominant cognitive or social demands and choices resulting from the synergy, cooperation, or complementarity among the agent's choices, from relations of economic complementarity or convergent interactions at a collective scale and represents bottom-up processes. A synergic urban pattern is the result of the convergence between the movement, occupation, or location of a group of agents or elements and favors the system's self-organization.

An Asynergic Pattern emerges from asynergic or competing actions and represents a top-down process. It is defined by exclusivist decisions: techniques disconnected from collective demands added to isolated political (linked to the financing of election campaigns, f.ex.) or economic interests, or linked to scale economy processes. An asynergic urban pattern results from the needs of the movement, occupation, or location of one element, entity, agent, or a reduced group of agents and, when it clashes with emerging collective demands, it may be unfavorable to the system's self-organization.

A Normative Pattern is determined by legal mechanisms or rules of social conduct. It may correspond both to synergic and to asynergic patterns. Relations of economic complementarity or scale economy may also be regulated by normative patterns linked to fiscal or tax mechanisms, however, these are not the focus here.

4. Translating properties to urban reality

Hence, urban patterns may be imposed by or emerge from interactions between urban elements – triggered by forces of attraction, connection, or disconnection – and can configure, maintain, or misconfigure modules. When a set of elements can remain in interaction within the same module or field of attraction and resist being pushed into another field, and thus to another behavioral pattern, we say it is resilient (ALLEN, 1997). In this stationary state, even if unstable and open to flows of material and energy (dissipation), the system is not unsettled by events but self-organizes. Therefore, a rupture (or a few slight ruptures) in interactions is followed by instabilities or oscillations (the fluctuations) in the dynamics that tend to re-balance since they allow the system to self-organize, generally, through the emergence of new urban patterns.

Nevertheless, in some circumstances, the elements lose their capacity for permanence within the field of attraction, invalidating the module's dynamic stability. This can occur when states or forces of attraction are greater than the stationary states due to Urban Patterns of Attraction that drive elements from other modules in their direction. This can also occur due to the presence of Disruptive Patterns that prevent or break up relations, or when facing a new dynamic – when the emergence of new patterns (which could ensure the maintenance of interactions or the system's resilience) are hindered. The social, economic, cultural, and political context influences not only the form in which interactions are established, which patterns emerge or are imposed, but also what causes the ruptures and which ruptures lead to critical conditions. These adverse conditions or urban disturbances are here classified as dispersion, concentration, or disconnection. Excessive concentration or dispersion of the same type of element throughout the system in detriment of other types, or, even, the disconnection (discontinuity or abrupt transition) among any elements, prevents relations among each other, produces social-spatial fragmentation (critical ruptures) and reduces the system's cohesion.

The rupture of relations between buildings and uses can represent the impossibility of the building adopting other uses over time due to its typological condition. Residential buildings on pilotis, representative of Modernist Architecture found commonly in Brazil, reflect this situation, since their architectural configuration demands significant changes so that the ground floor can take on commercial uses, for example. It may also mean the use will demand a specific typological condition for installation, such as a hospital, a stadium, or a theater. Other uses may be more adaptable to several building types, such as residential use, small businesses, or services and, therefore, are more easily distributed throughout the territory.

The rupture in the relations between agents and buildings may occur through the concentration of exclusivist gated communities, urban enclaves, impermeable facades, or the predominance of private or elitist equipment in detriment of public installations. It may also mean the absence of the building's visual wealth or a building complex's typological monotony that does not evoke sensory stimuli and emotional connections between agent and building.

The rupture in the relations between buildings and public spaces means there is an inactive interface between the two. Some examples of this is the scant physical or visual permeability of the constructed interface, blind facades, or inadequate landscaping of transitional spaces (entrance areas). It may mean excessive constructed density in detriment of open spaces in the surrounding area, or an abrupt transition between high constructed densities and productive areas or those of environmental protection.

The rupture in the relations between agents and public spaces represents inaccessibility due to distance, (the result of poor space distribution of throughout the territory) or even the controlled or compromised accessibility of the agent caused by the financial or social intervention of a private entity over public space. It may also mean the public space is unable to attract agents due to poor quality, degradation, or absence of equipment.

The rupture in the relations between agents and uses represents the agent's inaccessibility to different uses due to poor distribution (dispersion and distance related to mobility conditions), monofunctionality, and the agent's economic conditions that prevent access, often occurring because the State cannot provide any access to the different uses, such as housing and essential services. It may mean there is poor distribution or the absence of health, leisure, and social public equipment in the area and moreover a deficient public transportation system. Poor distribution may be associated to urban dispersion, expanding the distance and access of agents to different uses.

The rupture in the relations between public spaces and uses is tied to the monofuncionality of public spaces, i.e., the inflexibility of the space to assume different uses due to normative impossibilities or the absence of infrastructure. Versatile and adaptive public spaces can embrace different prospects for businesses in leisure, relaxation, food, and sports activity.

The rupture in the relations between elements of the same type can represent, among buildings, morphological discontinuity due to the divergence of a new edification in relation to the buildings previously constructed, or, even, large-scale repetition of buildings of the same age or building pattern, disrespecting scale hierarchies, incremental growth, and making the landscape elitist and uniform. In relation to public spaces, it may represent the absence of connections between the spaces that foster an interconnected network or ecosystemic mesh. Or it may mean there is an abrupt transition between accessible public spaces and protected areas. Among uses, it may represent economic incompatibility or competition that prevents the co-presence and co-survival among uses, and also, monofunctionality that eliminates relations of economic complementarity. And, finally, among agents, it may represent social exclusion, segregation, or self-segregation; a populational density above or below adequate limits

(excessive concentration or dispersion and isolation) and even conflicts regarding divergences over urban, economic, or political conditions.

5. Insights and concepts elaborated

Therefore, the system's resilience (or the dynamic balance of interactions) is connected to a huge variety of associations or links that can ensure ample possibilities of interaction among elements over time. This is related to the fact that "additional options help the system rebound from the loss or disruption of one or more pathways or nodes". (GOERNER et al., 2009, p.77). Urban resilience is also a result of the potential of each element to connect to others, and strong connections can maximize the system's density. Density is a measure of "group cohesion" or degree of connection among actors that are part of a network (WASSERMAN & FAUST, 1994). Cohesion, systemic integration, or degree of complexity of a network, called Systematicity (MORÇÖL, 2012), is determined by the degree of interconnection among its elements which, according to what is defended here, is the product of the balance in the distribution of different types of elements and of the potential for specific connectivity each element has.

Hence, the dynamics of complex systems and, consequently, of cities, is the result of forces that distribute or move the elements, associated to system structuring and the variety of elements – an attribute here called DistributioniCITY[2] - and forces that keep elements in interaction in their local connections and are associated to each element's individual capacity to connect to one another by means of their adaptability and the variety established – an attribute here called ConnectiCITY[3]. DistributioniCITY would be ensured by Systemic Distributive urban patterns, while ConnectiCITY would be ensured by Connective Modular urban patterns. Both are circularly influenced since the variety established by DistributioniCITY can foster ConnectiCITY at a local level.

From this perspective, urban systems would be a dynamic combination of structure and systemic flows, associated with efficiency; and diversity and connections, associated with resilience. Harmony between efficiency and resilience in a system could be achieved through diversity and connectivity configurations (GOERNER et al, 2009), which are crucial for interaction balance and constancy.

However, studies by Ulanowicz et al. (2009) suggest that the maintenance of systemic balance is located slightly in the direction of resilience, or that it plays a slightly greater role in its maintenance than efficiency (GOERNER et al, 2009). From this perspective, the connectivity, diversity, and adaptability of elements would be more relevant for systematicity than structuring, which is associated with the rigidity of the system. In relation to urban systems, studies suggest there is an emphasis proportion of one third for structuring to two thirds for diversity. Nevertheless, this proportion still requires more research (WESTERHOF, 2014; COLLEGE VAN RIJKSADVISEURS, 2019).

In regard to this theory, structuring is observed to be more linked to tangible elements (buildings and open spaces), mainly large-sized ones, that are more fixed, change more slowly and are harder to replace and thus, according to the logic indicated, should exist in smaller number. On the other hand, smaller buildings as well as open spaces, when in larger quantity, expand alternatives of interaction or links and are more easily replaceable, converging with the diversity of elements associated with the system's self-organization and resilience and thus are more relevant in ensuring cohesion and sustainability[4]. From this perspective, a large variety of property types, or tangible elements (buildings and public spaces), would ensure the co-presence of a myriad of different preferences, interests and plans (WEBSTER & LAI, 2003; ANDERSSON & MORONI, 2014). Hence, the connections between tangible and intangible elements (agents and their uses) would be made easier, propelling interactions, expanding possibilities for new synergic patterns to emerge (in face of fluctuations) and enhancing urban resilience.

6. Mechanisms for the Systemic Qualification of Urban Planning

As to the mechanisms in the sphere of urban planning that could foster these conditions, i.e., mitigate structuring and ensure the system's resilience, based on Moroni (2015), adopting relational rules is suggested, associated with Distributive Systemic urban patterns (ensuring DistributioniCITY) and Connective Modular (ensuring ConnectiCITY). Relational rules do not restrict element localization, i.e., they are not linked to maps or zoning, but define relations among elements, allowing them to distribute or flow throughout the system, interacting among themselves more easily.

This is a nomocratic ordination system, which is general, abstract, and relational, corresponding to the rules and codes that promote common, collective, and essential values (MORONI, 2015). These rules do not aim to model the city, but filter negative effects. Hence, they can ensure specific life conditions while acting upon protecting vulnerabilities. Relational rules converge with the emergence of synergic patterns since they allow interactions and thus self-organization. However, in face of the flexibility they give rise to, the vulnerabilities of each type of element (buildings, agents, uses and public spaces) would need to be protected by public entities, ensuring their survival and inclusion in urban dynamics.

To reach specific aims through operationalization, we defend the use of teleocratic instruments (plans, programs, projects), mainly by means of organizations. In this case, previously defined investments and actions can be monitored and adjusted with the aim of corresponding to essential relational rules (ALEXANDER et. al, 2012).

7. Principles for the Systemic Qualification of Urban Planning

Consequently, despite their complexity, interactions among urban elements are not a random configuration, but a dynamic order of phenomena that, though uncontrollable, can correspond to specific principles.

7.1. The Object: The system and its elements

Principle 1: A city is composed of four main types of elements: open spaces (public, productive and protected), buildings, uses and agents. The first two are tangible elements that change at a slower pace. Uses are connected to choices made by agents - both of these are intangible elements that change and move more easily. There are unequivocal relations among all the types of elements. The intensity of the rupture of these relations is proportional to the intensity of spatial fragmentation. The proposal of complex urban development is to foster these relations.

7.2. The Attributes: SystematiCITY: DistributioniCITY and ConnectiCITY

Principle 2: Each type of element is distributed throughout the territory in a more dispersed or concentrated manner, and more homogenously or heterogeneously in regard to its variations. Good DistributioniCITY, i.e., a good balance in the distribution and variety of the patterns of the same element throughout the city, contributes to the emergence of relations. Good distribution along with greater variety entails greater proximity of one element (or its variations) to all others and hence fosters relations among them. The variety of elements involves buildings of different ages and sizes, different uses; public spaces with different sizes and functions, and agents (individual) of different classes or sizes (in the case of legal entities).

Principle 3: Each element contains a potential for connection with other elements, influencing the intensity of relations among themselves: their ConnectiCITY. A building can have a variety of degrees of connection with public spaces; a use can have greater or smaller potential of insertion in buildings, or attract a greater or smaller number of agents. A building may also assume one or many uses, it may

assume a few or many agents. In sum, an agent may have access to many or a few uses, buildings or public spaces, and may or may not have a large number of relations with other agents. The connectiCITY of the element should be ensured over time, which demands it have a great potential for adaptability to new connections.

Principle 4: Social-spatial cohesion is influenced by the conditions in distribution and variety of the different types of elements throughout the territory and by the individual potential for connection of each element to other elements, i.e., their SystematiCITY. Systematicity, or systemic integration, can promote the co-presence of a myriad of different preferences, interests and plans and attend to human needs more equitably. Complex development is based on relations of equalization in the distribution and coexistence of a variety of types of local connections among elements over time, promoting systematic re-self-organization in urban dynamics.

7.3. Disturbances: Dispersion, concentration, and disconnection

Principle 5: Ruptures in the relation among elements generate urban disturbances that impact the balance of dynamics and compromise the agents' quality of life. A rupture, or slight ruptures, corresponds to a fluctuation that can be corrected with the emergence of new patterns (self-organization) or corrective measures, such as urbanistic norms or local physical adjustments. A large rupture, or many ruptures, leads to critical circumstances, consistent alterations in dynamics, and may result in break downs, demanding large scale urban interventions.

Principle 6: Disturbances can be arranged in three categories: dispersion, concentration, and disconnection. Excessive concentration or dispersion of the same type of element, or the disconnection (an abrupt discontinuity or transition) among any given elements, hindering relations among them, creates social-spatial fragmentation and a decrease in cohesion.

7.4. The Objectives: Cohesion, Self-organization, and Protection

Principle 7: The main objective of Urban Planning is the study and implementation of solutions that contribute to social-spatial cohesion and sustainability to restrain urban disturbances that result in a reduction in quality of life and environmental degradation. Two complementary principles are derived from this objective:

Principle 8: Complex urban political systems are not controlled by public planners or authorities. However, through governmental action (via norms or physical-spatial interventions), urban planning can expand the capacity for self-organization of urban dynamics. Thus, increasing the possibilities, effectiveness, equity, or balance of interactions among the different types of elements promotes the emergence of self-organization and reduces that of disturbances. Nevertheless, this process should protect vulnerabilities, according to principle 10.

Principle 9: Given that there are different forms of relationship, every type of element has different levels of vulnerability that must be protected by public entities: open spaces may require Integral or Sustainable Use Protection, Protection of Rural and Productive Areas and also Protection of Indigenous Lands; buildings may demand Protection of the Collective Memory and Historical and Cultural Heritage; agents may demand protection due to different levels of vulnerability; and specific uses demand subsidy and protection due to their essentiality. These vulnerabilities are the central elements of public administrative action and cannot be flexibilized.

7.5. The Means: Participation and Relational Rules

Principle 10: In order to adopt complex development and reach its main objectives, urban planning can use three principal means. Regarding its procedural characteristic, it can involve agent participation in the

planning process, creating policies that converge with synergic patterns and the emergence of self-organization through the absorption of bottom-up processes. As for its substantive character, the protection of vulnerabilities can be ensured through universal nomocratic normative instruments – laws, rules, or relational patterns. To achieve defined aims through operationalization, teleocratic tools (plans, programs, projects) should be used, subordinated to relational rules to ensure the equalization of interactions among the different types of elements at the macroterritorial scale.

Principle 11: Complex development is the result of non-linear and circular relations among the elements in the system. A small action can cause a large effect and interactions are interwoven and retroactive. It is impossible to control or prevent how they will be established and what their impact will be over time, but one can observe that they move in specific patterns. These patterns are also dynamic and change over time, according to the social, economic, and cultural context. Nevertheless, the attributes of the patterns can be ensured, which demands they are able to adapt. The potential for adaptability is crucial for Systematicity since it allows elements to be more susceptible to relationships. Therefore, attributes should be relational, i.e., establish relations among urban elements, allowing the potential for the system's self-organization.

Principle 12: Besides the correspondence to attributes, physical-spatial interventions and projects are subject to the temporal context and the response of agents, i.e., changes in patterns. Hence, the scale of the intervention should be proportional to implementation time. Large urban projects should materialize in phases, allowing the elements to adjust to changes in contextual circumstances or new patterns that can emerge.

Principle 13: Relations among elements should be equalized towards SystematiCITY through ConnectiCITY and DistributioniCITY. They correspond to relational rules and synergic patterns – Distributive Systemic Patterns and Connective Modular Patterns. Distributive Systemic Patterns balance the spatial distribution of elements and of their variety in the system, while Connective Modular Patterns act as local rules that connect the elements through relations of strict proximity.

Principle 14: Relational rules are susceptible to the social, economic, cultural, and political context. Therefore, their creation should be based on principles that are defined collectively and not on actions that are contingencies or strategies. They do not aim to model the city, but to filter the negative effects to protect vulnerabilities while giving way to self-organization.

8. Final Considerations

The principles devised involve the equalization of relations among urban elements and the protection of essential issues to contribute to social-spatial cohesion. They corroborate a relative normativity to urban planning as a theoretical-substantive body that gives support to operationalization and ensures systemic urban qualities through a dynamic and participative process.

To expand the research developed so far, we intend to further the investigation and proposition of urbanistic devices that ensure the presence of the attributes DistributioniCITY and ConnectiCITY, focusing mainly on the socially unequal consolidated urban environments that lack the action of Urban Planning in terms of structural solutions with a public and collective sense.

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[1] This study understands fragmentation as a process of configuring spatial and/or morphological discontinuities that divides the city into socially homogenous areas.

[2] DistributioniCITY is categorized in three types: Spatial (the equitable distribution of different-sized buildings and public spaces throughout the system), Functional (the equitable distribution of different uses throughout the system) and DistributioniCITY of Agents (the equitable distribution of (individual) agents from different classes or sizes (in the case of legal entities).

[3] ConnectiCITY is a specific feature of each agent, use, building and public space to connect to another type of element (agents, use, building or public space).

[4] Convergence with the Law of ZIPF, a Scale Law.