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Morphogenesis in urban design: The path to sustainability is through a fundamental change to the way we build our world

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Abstract

Urban design is called upon to contribute to making the world more sustainable, resilient, and just. This aim is shared across urban design's many approaches and schools of thought. However, the response to the pressing contemporary problems of sustainability, resilience, and social justice routinely emphasizes the need to develop innovative tools and extend the reach of advanced technological solutions into increasingly larger domains of our lives and of the environments around us. This paper maintains that the future of urban design, particularly in the current historical transition beyond the Post-War world order, should be explored through a critical reconsideration of the root causes of the current unsustainable reality. We briefly present the disciplinary background of such an operation by recalling the concept of deep sustainability, and its various expressions in the urban design traditions, and highlighting the legacy of "radical" approaches to urban design. A particularly relevant critique of a reductionist, "mechanistic" approach to sustainability was presented by Christopher Alexander twenty years ago, in a memorable talk delivered at the Schumacher Lecture series in Bristol, UK. In his lecture, Alexander proposes the necessary departure from current building and development practices towards an "authentically sustainable" morphogenetic building process. We propose to re-examine Alexander's talk at the Schumacher Lecture as a fundamental contribution to framing a responsible pedagogy in urban design. We do so by critically summarizing its main conceptual achievements. We then highlight how Alexander's legacy, not limited to the Schumacher talk, frames the cosmological framework within which the evolutionary nature of the built environment can be recognized and elaborated. We then propose a way to elaborate on the concept of evolution in the domain of urban morphology analysis by introducing recent research in Urban MorphoMetrics and Urban Evo Devo. This forefront research explores the operationalization of Alexander's Wholeness seeking System A within an environment dominated by a mechanistic System B. We highlight its impact on urban design practice by the generation of evidence-based urban design coding. Thus, we show how the integration of urban morphology and design is a key move towards a new, evolutionary urban design pedagogy.

Keywords: Christopher Alexander, sustainability, morphology, evolution, morphometrics

1. Introduction: Urban Design Beyond Modernity?

Urban design is called upon to foster a sustainable urban future based on integrating the three "pillars" of economic development, social justice and environmental protection (World Commission on Environment and Development, 1987; Kates et al., 2005), in one unified process (Giddings et al., 2002). The mission is widely accepted across various approaches and schools of thought, an internal diversity that is particularly evident in urban design education (Yavuz Özgür & Çalışkan, 2025). However, this diversity primarily reflects differing methodologies (the "how") rather than the overarching goals (the "what"). Some view the fragmentation of urban design as a sign of vitality, while others consider it an obstacle to creating a coherent knowledge base for the discipline (Romice et al., 2022).

The disparity regarding the meaning and the value of this diversity arises from differing interpretations of sustainability amid the ongoing global transition out of the established post-war

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world order. Some scholars view this process as a challenge posited by forces that are external and antagonistic to modernity. Hence, the path to achieving sustainability would lie in more advanced technology, digitalization, and Artificial Intelligence, i.e., more modernity. This view emphasizes innovation of the instruments as a way to underpin the current social ecosystem in a new cycle of expanding opportunities, a perspective that would be positively signalled by the abundance of diversity in the urban design discipline.

Conversely, others argue that the current destabilization represents a departure from modernity itself, requiring and announcing a more profound transformation of society. This perspective calls for reevaluating the meaning of sustainability, on the basis of a reconsideration of social values, particularly the value of labour in a new economic system localized in place and proximity. They advocate a reassessment of existing social relationships in all their various forms and scales, including labour and value, class interests, and the redistributive role of education. These positions emphasize a more decentralized distribution of power to autonomous communities rooted in political traditions close to communitarianism and anarchism. In this context, the abundance of pedagogical diversity in urban design may signal an insufficient awareness of the level of the challenge, as well as the role that urban design can – and should – play in redefining its primary mission.

Along this latter line, the current tendency to focus on innovative tools and technological solutions as responses to pressing issues of sustainable urban development, climate change, for example, would only confirm a lack of critical awareness in the first place. This paper maintains that the future of urban design, particularly in the current historical transition, should be explored via a reconsideration of the root causes of the current unsustainable reality, and a reappraisal of the "radical" visions from which the ecological movement came in the first place, including in the design professions.

2. Designing the Living World

The origins of the hiatus between the two approaches to sustainability mentioned above can be traced to the early years of the environmental movement, often associated with Rachel Carson's The Silent Spring in 1962 (Carson, 1962). In its initial formulation, the ecological paradigm was closely aligned with broader countercultural efforts to reconfigure social and spatial relations. Awareness of systems' interdependence informed patterns of inhabitation and social organization, supporting alternative models grounded in ecological consciousness.

The work of Ernst Friedrich "Fritz" Schumacher, Sym Van Der Ryn, Ivan Illich, Murray Bookchin and Christopher Alexander, despite differences in disciplinary focus and political engagement, converged on a critique of sustainability approaches centred on technological optimization. Rather than treating sustainability as a problem of technical performance, these authors emphasized socio-cultural dynamics, economic conditions, and ecological constraints operating at the scale of local communities. Sustainability was thus framed as a socially embedded and spatially situated practice, directly implicating architectural and urban design.

Christopher Alexander's early work (Alexander, 1964, 1965; Alexander et al., 1977) articulates this position through a focus on morphogenesis, prioritizing process over product in the formation of places. He identifies non-hierarchical patterns of human inhabitation as universal principles inherent to the ecological systems and embedded in the historical evolution of settlements. Spatial form is understood as the outcome of adaptive processes unfolding over time rather than as the result of discrete design interventions.

Schumacher's Small Is Beautiful: A Study of Economics as if People Mattered (Schumacher, 1973) situates sustainability within the concept of appropriate technology. He defines such technologies as those arising from the cultural, economic, and material conditions of specific communities, in contrast to advanced technologies derived from centralized, surplus value–oriented industrial systems. Schumacher (1973) advocates a decentralized model of development aligned with human

scale and ecological sensibility, arguing that social welfare and environmental stewardship constitute two inextricably unified articulations of the same concept. This position challenges industrial paradigms that shape economic organization and the built environment, producing alienation and environmental degradation as structural outcomes.

Summarizing decades of experimental work conducted at the University of Berkeley, Sym Van Der Ryn extends this critique into architectural and urban practice (Van der Ryn & Calthorpe, 1986; Van der Ryn & Cowan, 1996; Van der Ryn & Peña, 2003). He proposes design methodologies that integrate ecological principles with community needs, emphasizing cultural and environmental context. Sym Van Der Ryn explicitly rejects "architectural knowledge as specialized technique or 'technê', particularly as architectural modernists had imagined this knowledge as an extension of rational-industrial society" (Raynsford, 2021), reframing design knowledge as contextual and relational.

By the mid-1970s, many of these ideas were increasingly absorbed and reconfigured by the industrial complex through their translation into globally standardized technological solutions. Ivan Illich articulated a sustained critique of this trajectory in a series of works published during the 1970s (Illich, 1971, 1973, 1974, 1976). Drawing on the ecological principle of bounded, interconnected systems, Ivan Illich argued that industrial production inherently leads to hyper-industrialization, wherein systems of provision become detrimental to the purposes they were intended to serve. He described this condition as "counterproductive, exposing education, healthcare, and urban planning systems that undermine learning, health, and energy, unbalanced urban functionality.

In opposition to hyper-industrialization, Illich (1973) advanced the concept of conviviality, stating: "We must come to admit that only within limits can machines take the place of slaves; beyond these limits they lead to a new kind of serfdom. Only within limits can education fit people into a man-made environment: beyond these limits lies the universal schoolhouse, hospital ward, or prison"(p. 12).

After his main work "The Ecology of Freedom" (Bookchin, 1982), Murray Bookchin addressed these same tensions in 1987 (Bookchin, 1987), criticizing mainstream environmentalism for its technocratic orientation, described as "simply trying to make a rotten society work by dressing it in green leaves and colourful flowers while ignoring the deep-seated roots of our ecological problems" (ibidem, p. 2). He instead called for an ecological movement capable of transforming market society into "a non-hierarchical cooperative society — a society that will live in harmony with nature because its members live in harmony with one another" (ibidem, 1).

Christopher Alexander's later contribution to articulate a theory of authentic ecological design culminates most clearly in his lecture Sustainability and Morphogenesis, delivered at the Schumacher Lecture Series in Bristol on October 30, 2004 (Alexander, 2004). The following section examines this work and articulates the historical imperative for design to reclaim its generative role in the evolution of living urban places.

3. Christopher Alexander and the Morphogenesis of a Living World

Building activities, in their broadest sense, form a huge part of the economy, alter the face of the earth, and are responsible for the majority of greenhouse gas emissions. Therefore, making them more environmentally sustainable has always been a major concentration of environmental thinkers, and a concern of urban and transportation planners, architects, and urban designers. However, Christopher Alexander's critique of urban planning and design, and architecture, did not stem from environmental concerns, but was a reaction to the evident failure of modernistic architecture and urban planning and design to provide a humane, physically and emotionally supportive, and beautiful built environment. His search for understanding the reasons for this prevalent failure led him to develop a theory of order, in which questions of value, coherence, life,

and beauty are understood as empirically verifiable and not based on ideology or opinion. The underlying assumption of his work is the reality and sharedness of human feeling in response to environmental conditions. While acknowledging individual and cultural idiosyncrasies, C. Alexander sees them as an overlay on more fundamental feelings and responses that are shared.

The central concept of his theory is "life", which he sees as existing throughout the physical, inanimate, and animate world. Life is not a binary property but exists to a degree in any particular region of space, depending on the level of coherence, density, and strength of entities that C. Alexander calls "centres." Centres are foci of attention and are defined recursively as made from other centres surrounding them. Thus, each centre arises in the context of a larger centre, supported by other centres of similar scale, and gives rise and is supported in turn by other smaller-scale centres, thus forming what is essentially a field of centres. Alexander discovered 15 properties that seem to exist in strong fields of centres, properties that can also be understood as the 15 different ways that centres can support each other in order to create a strong centre. He shows that strong fields of centres exist through natural phenomena, built environments, and cultural objects from throughout the world, but are rather rare in modern life, particularly in formal and industrial forms of development.

Having thus created an understanding of natural order that unites both the inanimate and animate world, as well as the natural and built environment. C. Alexander proceeds to ask how is life generated in the world. In the second book of his "magnum opus" The Nature of Order, entitled The Process for Creating Life (Alexander, 2003), he defines this process as a generative structure-preserving process. Thus, each successive structure transforms and enhances the existing structure with the aim of enhancing the unity and strength of the wholeness in which the process is evolving. This 'morphogenetic' process is shown to be at work in examples from the natural world, as well as in historical and recently built environments, where it was allowed to happen.

C. Alexander's criticism of modern planning and building practices, and his reliance on traditional buildings as inspiration and example for living process, were not a call to return to past, but an attempt to create an understanding, within scientific culture, of the limits of seeing the world as a mere machine devoid of value, and reappraise it as living wholeness of which humans are an integral part. Understanding wholeness, wherever we operate, and doing our utmost to increase its life and beauty, are therefore the rightful aim of the built environment professions, and of ordinary people as they engage in activities that shape the environment. In his last published book (Alexander et al., 2012), he describes these two systems of viewing the world as System A (concerned with the wholeness of the world) and System B (concerned with efficiency and the accumulation of money and power). Alexander saw these systems as irreconcilable, and in his lecture to the Schumacher Society (Alexander, 2004), he insisted that system A thinking is necessary for true sustainability.

However, for system A to be prevalent, the whole world of development, from its financing to its regulatory structure, the way we design and build buildings, and the administrative structures needed to maintain, upkeep and renew them has to be changed. The role of architects and urban designers has to become completely different, as they have to take on a fuller responsibility for the process of making the world, beyond merely the design of the projects, leaving others to think about how to actually build, maintain, and evolve them in practice. This also means a much more local role for urban designers, as their involvement with projects continues along the life cycle of places. Perhaps it also means a new kind of institution, or function within municipalities, which serves as a guide and institutional memory of the local urban design culture as it develops. All this also means a different education for urban designers, as they learn to see themselves as the guardians of a community's wholeness.

4. Urban Evo Devo: Operationalizing System A?

In a recent contribution (Porta et al., 2016), Porta, Rofé and Vidoli discuss the work of Christopher Alexander from the perspective of large-scale urban design. The problem is situated

within Alexander's aforementioned juxtaposition of System A and System B. Alexander's generative processes of living places proved successful at building scale yet failed to establish themselves as a new normal in Post WWII urbanization cycles. Instead, the hyper-industrial system of urban production, or "System B", demonstrated a far more advantageous standard of practice, resulting in widely successful patterns of urbanization, if utterly unsustainable.

From an urban morphology standpoint, Alexander's morphogenetic process can be interpreted as one way to access the "spontaneous consciousness" described by Caniggia and Maffei (Caniggia & Maffei, 2001). Here, "spontaneous consciousness" manifests as the outcome of largely non-theorized, tradition-based know-how, or a form of "collective wisdom" evolved across generations of imitation practices and embedded in historically and culturally specific urban fabrics. While Alexander's approach seeks to access this repository of collective wisdom by recreating its primary source—namely, the body-mind material of living individuals engaged in construction—the urban morphologist can only observe the urban fabrics in which such patterns are embedded. Rather than relying on personal feelings accessed through in-depth individual conversations and shared on-site construction experiences, the urban morphologist proceeds through the mapping of regularities observable in existing "morphological regions". The underlying material is the same, but the methods of description and capture differ.

Recent developments in urban morphology analysis offer new options that may be relevant to this exploration. Crucially, the innovation lies primarily in the instruments of the discipline, namely a formal language that System B is capable of understanding and processing. This new wave of studies has emerged over the past few years under the label of "urban morphometrics", cutting across computer science, geospatial analysis, and urban geography, and demonstrating the capacity to characterize very large geographical extents while maintaining richness and comprehensiveness of information (Oliveira & Porta, 2025). This combination of large spatial extent, granular informational scale, and comprehensive descriptors enables an unprecedented geography of "ordinary" urban fabrics, described through their embedded morphological patterns on a building-by-building basis across regions, nations, and continents. This opens the way to a sequence of questions: can we a) extract the collective wisdom embedded in existing ordinary urban places that have demonstrated adaptive living properties; b) translate that information into a language that System B can process; and c) embed that wisdom and language into large-scale design codes operating at System B's order of practice? At present, not only are the conceptual understanding and foundational knowledge available to pursue this agenda, but also the necessary technology, that is, the means to access the operating system of System B. Can we, in short, "outsmart" System B by reconfiguring it from within?

An additional, non-secondary aspect of the emergence of urban morphometrics is that, as frequently observed in the history of science, innovation in instruments may generate innovation in the science itself. From its earliest conceptual formulations, urban morphometrics has been driven by a broader vision: the development of a scalable numerical taxonomy of urban form, enabling the foundations of a new science of urban form evolution (Porta et al., 2011; Dibble et al., 2016, 2019). Within this framework, the inference of relationships of descent (phylogeny) among urban form types that exhibit observable and measurable relationships of similarity (phenetics) becomes possible. Urban morphometrics may thus play a role analogous to that of natural history, descriptive biology, and comparative anatomy in the emergence of evolutionary biology, which first enabled systematic description of phenetic similarity among living organisms (Fleischmann et al., 2022). An initial attempt in this direction is currently underway at the Konrad Lorenz Institute for Evolution and Cognition Research in Vienna (AT). Converged under the project "Urban Evo Devo", evolutionary developmental biologists ("evo devo") and urban morphologists from various European countries and China are engaged in the foundational transfer of knowledge between the two domains. The scientific aim of the project is to demonstrate the evolutionary nature of urban form mathematically, by processing the largest urban morphometric repository existing

(Fleischmann et al., 2025a; Fleischmann et al., 2025b). Strategically, the aim is to instruct a radical paradigm shift in the way the nature of urban form is generally perceived, by using a language, that of quantitative science, that System B can decode and process accordingly. Once the evolutionary nature of the form of cities is culturally absorbed as an undisputable truism, the adaptive process of urban morphogenesis can only follow as its inevitable operating system. Urban Design education and research are at the forefront of this strategic change.

5. Conclusion

This viewpoint calls for reassessing sustainability in urban design pedagogy, returning to its 1960s–70s countercultural origins that framed sustainability as the integrated pursuit of economic prosperity and social justice within environmental limits. Contemporary curricula largely adopt a technological paradigm that neglects social and political contexts. This critique echoes Christopher Alexander's 2004 Schumacher Lecture, defining sustainability as "the wholeness of the land, the extent to which we see our land (rural, urban, or wilderness) as sacred, and the extent to which we treat our interaction with the land as a sacrament" (Alexander, 2004, p. 5).

Urban morphometrics enables the development of a science of urban form evolution validated at a large scale, which can be processed by current System B. In turn, the affirmation of urban form as an evolutionary system would generate a paradigm shift in urban design education, making the morphogenetic process identified by Christopher Alexander an inevitable reality.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Ethics Committee Approval

Ethics committee permission is not required.

Resume

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