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Editorial

Introduction: Toward a "Post-Alexandrian" Agenda

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Abstract
Christopher Alexander, who died in March 2022, was undeniably one of the most influential, if sometimes controversial, urban thinkers of the last half-century. From *Notes on the Synthesis of Form*, his first book and Harvard PhD thesis, to the landmark "A City is Not a Tree," to the classic best-sellers *A Pattern Language* and *The Timeless Way of Building*, to his more difficult and controversial magnum opus, *The Nature of Order*, Alexander has left a body of work whose breadth and depth is only now coming into view. Yet Alexander's legacy is also the subject of intense debate and critique within the planning and design fields. This introduction provides an overview of the thematic issue of *Urban Planning* titled "Assessing the Complex Contributions of Christopher Alexander." Its purpose is to provide greater clarity on where Alexander's contribution is substantial, and where there are documented gaps and remaining challenges. Most importantly, the thematic issue aims to identify fruitful avenues for further research and development, taking forward some of the more promising but undeveloped insights of this seminal 20th-century thinker.

Keywords
Christopher Alexander; harmony-seeking computations; pattern languages; pattern languages of programming; wiki

Issue
This editorial is part of the issue "Assessing the Complex Contributions of Christopher Alexander" edited by Michael W. Mehaffy (Sustasis Foundation) and Tigran Haas (KTH Royal Institute of Technology).

Although this thematic issue is titled "Assessing the Complex Contributions of Christopher Alexander," it might well have been titled "*Further Developing* the Complex Contributions of Christopher Alexander: An Introduction." Each of the authors herein takes forward some of Alexander's ideas into new topics exploring new connections, and each thereby lays out parts of a potential "post-Alexandrian" agenda for further research and development. In so doing, they give us tantalizing glimpses of much more that can be done.

Already we have seen an astonishing range of further developments of Alexander's ideas: into the realm of software and pattern languages of programming; into open-source technology, wiki, and Wikipedia (built on an innovation to share pattern languages of programming); into organization theory and Agile project management (whose founders acknowledged an explicit debt to Alexander); and into a dizzying number of other fields. It seems very likely that such innovations will continue apace.

Curiously, the one field where innovations have lagged conspicuously has been Alexander's own field of architecture and urban planning. The reasons for that are surely varied: the iconoclasm of Alexander's work, off-putting to more mainstream practitioners; the "classic" status of the books and their cult-like veneration by some, suggesting that further work would be "tampering"; the unwillingness of adherents (even Alexander himself) to see potential relationships with other investigators, and potential cross-fertilizing collaborations; the hubris of architects, whose "creation" mystique forecloses the possibility of sharable normative structures; and the rapacious nature of the modern real estate development system.

Alexander himself offered some tantalizing ideas about how to change this state of affairs. In his last

book, *The Battle for the Life and Beauty of the Earth,* he confronted the current "business-as-usual" system of urban development, which he termed "System B," and he argued that it is fundamentally incapable of creating human environments that are truly supportive of life and human flourishing, in any enduring or sustainable way. As an alternative way forward, he proposed nine "ways of working" that are more consistent with what he termed "System A"—a more adaptive, evolutionary process of growth that is more aligned with biological dynamics, and more able to produce the richly complex characteristics of human history and cultural traditions (Alexander et al., 2012). However, his recommendation was not at all to "go back" in any sense. On the contrary, he proposed to go forward, into another kind of future: one that has more fully integrated the lessons of nature and evolution into its systems.

In his magnum opus of 2003, *The Nature of Order: An Essay on the Art of Building and the Nature of the Universe,* Alexander outlined this hopeful future:

> People used to say that just as the twentieth century had been the century of physics, the twenty-first century would be the century of biology….We would gradually move into a world whose prevailing paradigm was one of complexity, and whose techniques sought the co-adapted harmony of hundreds or thousands of variables. This would, inevitably, involve new technique, new vision, new models of thought, and new models of action. I believe that such a transformation is starting to occur….Our future, as we begin to see it now, contains a vision of an entirely new kind of human process: A process, like the process of biology, which is attuned to human nature, makes more sense of human feeling and human common sense….We know that it must be possible on theoretical grounds. We know it because this is the process by which the biological world of plants and animals has already been created. Late 20th-century research on complex systems by Holland, Kaufmann, and others, showed how very complex systems with enormously rich and complex state-space have been built up, repeatedly, throughout biological history, by the process of unfolding, and by small structure-preserving processes, which go step by step, yet reach astounding results in the whole….The fundamental process and the structure-preserving unfolding process—these are things that belong to a visionary future for humankind—a future in which complex structure of the built world, its daily re-creation, its daily nurture, will be considered normal. It is this far-distant future—hardly yet contemplated—which I have been looking for the last thirty years. To be well, we must set our sight on such a future…. (Alexander, 2003, pp. 568–570)

This, then, is Alexander's agenda: to realign our systems to produce more adaptive, more coherent, more whole environmental structures. But the reconfiguring of our planning, design, financial, legal, and other myriad systems that together determine what is built and where—what we might call our "operating system for growth"—will surely be an immense task. It will require large numbers of people working on a wide range of problems, doing research and development, implementation, experimentation, adaptation, and transformation—exactly the kind of process that Alexander described. And that is the process described in part by the authors of this volume.

In his commentary, "Christopher Alexander as an Architectural Thinker," Almantas Samalavičius (2023, p. 153) takes up the question of why Alexander has not been more carefully assessed within the mainstream of contemporary architectural discourse "despite his original, important, and lasting contributions to the field." "Alexander consciously distanced himself from his peers and the mainstream doxa," Samalavičius notes, "enabl[ing] him to bypass the influence of architectural modernism, pursue his goals without falling prey to this architectural ideology, and develop his own (oppositional and meaningful) ways of seeing architecture and the built environment" (Samalavičius, 2023, p. 155). But his legacy might be better sustained, Samalavičius (2023, p. 155) concludes, by further developing some of his most promising ideas and concepts, and "patiently drafting and implementing new educational programs (e.g., Building Beauty) rather than debunking criticism."

Ruihua Chen et al. (2023) assess the state of pattern language practice in their article "Navigating Approaches to the Use of Pattern Language Theory in Practice." They find that application of pattern language theory "differs across four components: artefact, activity, roles and tools, informed by practitioners' diverging values and needs" (Chen et al., 2023, p. 156). They report on the development of a set of conceptual tools that aim to support applications of pattern language theory, employing an "activity kit" that has been applied in a Dutch housing renovation project to support homeowners in communication and decision-making, with promising results.

In his commentary, "Community and Privacy in a Hyper-Connected World," Roderick J. Lawrence (2023) takes up Alexander's first co-authored book from 1963, with his colleague and mentor Serge Chermayeff, *Community and Privacy: Toward a New Architecture of Humanism*. Lawrence finds it to be newly relevant for today's hyper-connected, globally networked age. He notes that we have failed to recognize the significance of healthy boundaries between public and private realms, an essential (if somewhat paradoxical) ingredient in their capacity to provide the vital connectivity between public and private. This is especially urgent now in the wake of the Covid-19 pandemic, Lawrence (2023, p. 169) argues, when we need to re-formulate "the spatial organization of domestic architecture that can support and sustain choices about private and public life in a world of global networks, intrusions of social media, and

increasing video surveillance that challenge our autonomy and privacy.''

In the spirit of connecting and reconciling Alexander's work with others', Ngoc Hong Nguyen et al. (2023) take on Leslie Martin's insights on grid patterns, not as relentless top-down structures but as generative frameworks for organic growth. Their article, "A Grid Is Not a Tree: Toward a Reconciliation of Alexander's and Martin's Views of City Form," uses Abu Dhabi as a case study. They find that "overlap, order, and adaptability can coexist in gridded street network," and "a fine-grain scale of the grid plays a critical role in supporting the quality of urban space" (Nguyen et al., 2023, p. 172).

In his commentary, "The Structure That Structures Us," Jaap Dawson (2023) reflects on the emotional and transcendental qualities of Alexander's work, with an intriguing focus on the link between Alexander and psychologist C. G. Jung. Dawson points out that Jung explored the meaning of mandalas as reflections of the psyche or soul, and he sees a similar pursuit for Alexander: as Alexander himself put it, toward "works which have consciously, and deliberately been created as offerings to God, as pictures of the universe, or of something that lies behind the universe . . . as pictures of the human soul" (Alexander in Dawson, 2023, p. 186). Dawson (2023, p. 187) concludes that "we need more than a checklist of an ideal design….We need to reconnect with the structure that structures us. And then we can build a world that embodies that living structure."

Ridvan Kahraman (2023) assesses the challenge of moving beyond geometrical states into structuring processes in Alexander's theories, extending the analysis of centers and wholeness further into the realm of events. In the article, "Centers in the Event Domain: A Retake on the Wholeness of Urban Spaces," Kahraman focuses on the qualities of public spaces in particular, using a case study from Stuttgart, Germany. His research concludes that "utilizing Alexander's theories from an event-first rather than a geometry-first perspective is an approach especially well-suited for public spaces" (Kahraman, 2023, p. 188).

In "A World of a Thousand Independent Regions: Confronting the Ever-Increasing Refugee Problem," Hans Joachim Neis and Pamanee Chaiwat (2023) take up Alexander's work in the contemporary context of climate change, nuclear danger, pandemics, overpopulation, and refugee crises. Their primary subject is the first pattern from *A Pattern Language: Towns, Buildings, Construction*, titled "Independent Regions." They note that although this pattern may seem to be focused on regional autonomy, it is actually focused on the wholeness of each constituency of a healthy and peaceful global society. Using the microcosm of a refugee settlement, they propose a "refugee pattern language," which includes a minimum complement of the elements of governance and informality to promote cohesion and resilience. By contrast, global systems are overdependent on "ever larger countries with hegemonial or world domination ambitions" resulting in global instability and destructive outcomes, including refugee crises (Neis & Chaiwat, 2023, p. 209). By contrast, "this proposal tries to proceed in the opposite way by emphasizing the scale of human living within an entity that people can understand and govern well by themselves" (Neis & Chaiwat, 2023, p. 209). The authors conclude that "the relevance and vision of this concept and pattern are probably most visible and needed in the current turmoil of a transforming world" (Neis & Chaiwat, 2023, p. 201).

A related application of Alexander's work to more contemporary global challenges is explored in "The Pattern Language Approach as a Bridge Connecting Formal and Informal Urban Planning Practices in Africa," by Priscilla Namwanje et al. (2023). Using a case study of a wetlands management pattern language in Kampala, Uganda, the authors explore the value of pattern language methodology utilizing both informal patterns (derived from and with the residents of informal settlements) and formal patterns (derived from more technical and institutional sources). In so doing, they seek to transcend the colonial legacy of a "dual city," with "formal and informal communities using resources and spaces differently, leading to spatial segregation and non-implementation of urban plans" (Namwanje et al., 2023, p. 212). The authors conclude that "using the pattern language approach as a tool to understand informal practices and their possible incorporation into a planning process that captures the needs of citizens, this research offers relevant insights into achieving sustainable and inclusive urban environments" (Namwanje et al., 2023, p. 212).

Tarina Levin et al. (2023) take up Alexander's difficult and somewhat controversial concept of "living structure" within human environments, anchoring it more firmly within the existing literature in their article "Social Sustainability and Alexander's Living Structure Through a New Kind of City Science." In particular, the emerging "science of cities" does contain many parallels to Alexander's work, notably the understanding of complex adaptive systems, including biological systems and their dynamics. A more philosophical parallel is in the understanding of life as an emergent phenomenon latent in the physical world, an insight close to Alexander's own ideas about the capacities of spatial regions to support—or perhaps manifest, in a primordial sense—life. The issue is one of health of cities, people, and planet.

One of us (Mehaffy, 2023) also contributed an article on further development of Alexandrian ideas, notably by combining Alexander's work on pattern languages, geometry, and generative processes. The article, "Patterns of Growth: Operationalizing Alexander's 'Web Way of Thinking,'" presents a number of new projects in pattern languages, wikis, and related areas, with case studies from a number of ongoing and expanding international consulting projects. The article finds evidence that such a synthesis offers very promising practical methods for actual implementation at the project level.

Finally, Alice Rauber and Romulo Krafta (2023) take forward one of Alexander's last and most advanced research efforts: a collaboration with colleagues at the University of York to develop "harmony-seeking computations." As Alexander described the effort:

> We are trying to build a computer model of wholeness in a given thing, so that one can then see if the computer can be instructed to find the latent centers in a given configuration….Even if we succeed in a rudimentary form, it will be very important….I think for an odd reason. And that is that if we can find algorithms which do that, it's not that that process will then be computerized, but more, it will be possible to tell people what the search for the latent centers really is. (Sustasis Collaborative, 1:08:25)

Rauber and Krafta's (2023, p. 246) article, titled "A Quanti-Qualitative Approach to Alexander's Harmony-Seeking Computations," describes "a way to tackle complexity" by developing a harmony-seeking model of urban design. The model identifies subsets of spatial, functional, and cognitive elements, each of which consists of characteristic sub-subsets (public spaces, built forms, mobility systems, interactions, and information units, including Lynch's paths, nodes, edges, districts, and landmarks). These are represented within graphs, which are then optimized using network analysis techniques. Although the authors find that "more empirical works are needed to verify the correlation between graph-based measures and real phenomena," they find promise in what they conclude is "a reasonable way to operationalize the HS [harmony-seeking] process in a design context since it allows the depiction of various global patterns related to different aspects of urban design" (Rauber & Krafta, 2023, pp. 256, 254).

These and other works demonstrate that Alexander's complex contributions are indeed being taken forward by a growing number of collaborators in a growing number of fields, with renewed energy in the disciplines of the built environment. Indeed, the remarkable work already completed suggests an exciting frontier—or multiple frontiers—await.

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Conflict of Interests

The authors declare no conflict of interests.

References

Alexander, C. (2003). *The nature of order: An essay on the art of building and the nature of the universe* (Vol. 2). Center for Environmental Structure.

Alexander, C., Neis, H., & Alexander, M. M. (2012). *The battle for the life and beauty of the Earth: A struggle between two world-systems*. Oxford University Press.

Chen, R., Bos-de Vos, M., Mulder, I., & van Eldik, Z. (2023). Navigating approaches to the use of pattern language theory in practice. *Urban Planning*, *8*(3), 156–168.

Dawson, J. (2023). The structure that structures us. *Urban Planning*, *8*(3), 185–187.

Kahraman, R. (2023). Centers in the event domain: A retake on the wholeness of urban spaces. *Urban Planning*, *8*(3), 188–200.

Lawrence, R. J. (2023). Community and privacy in a hyper-connected world. *Urban Planning*, *8*(3), 169–171.

Levin, T., Sjöberg, S., Jiang, B., & Barthel, S. (2023). Social sustainability and Alexander's living structure through a new kind of city science. *Urban Planning*, *8*(3), 224–234.

Mehaffy, M. W. (2023). Patterns of growth: Operationalizing Alexander's "web way of thinking". *Urban Planning*, *8*(3), 235–245.

Namwanje, P., Muñoz Sanz, V., & Rocco, R. (2023). The pattern language approach as a bridge connecting formal and informal urban planning practices in Africa. *Urban Planning*, *8*(3), 212–223.

Neis, H. J., & Chaiwat, P. (2023). A world of a thousand independent regions: Confronting the ever-increasing refugee problem. *Urban Planning*, *8*(3), 201–211.

Nguyen, N. H., Alawadi, K., & Al Hinai, S. (2023). A grid is not a tree: Toward a reconciliation of Alexander's and Martin's views of city form. *Urban Planning*, *8*(3), 172–184.

Rauber, A., & Krafta, R. (2023). A quanti-qualitative approach to Alexander's harmony-seeking computations. *Urban Planning*, *8*(3), 246–258.

Samalavičius, A. (2023). Christopher Alexander as an architectural thinker. *Urban Planning*, *8*(3), 153–155.

Sustasis Collaborative. (2021, December 21). *Christopher Alexander: Life in buildings (full)* [Video]. YouTube. https://www.youtube.com/watch?v=oKO3vYjZbcs&t=331s

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Commentary

Christopher Alexander As An Architectural Thinker

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Abstract
In this commentary the author discusses why Christopher Alexander remains on the margins of contemporary architectural discourse despite his original, important, and lasting contributions to the field. Being a somewhat controversial figure in architecture and architectural theory, Alexander has occupied the status of a seminal albeit not always adequately understood and interpreted author. The rejection and misinterpretation of his ideas are due to multiple reasons, including his refusal to act and write as a standard scholar and his lack of interest in appealing to his professional community. While his attitude perhaps explains the neglect of his intellectual legacy, it does not justify it. A reconsideration of his legacy could benefit from rethinking his intellectual identity. This commentary suggests that Alexander should be approached as an original architectural thinker rather than a standard architectural academic. Thus, he could be comparable to other renowned figures of the modern era, including such influential yet often misunderstood social thinkers as Ivan Illich or Jacques Ellul.

Keywords
architectural discourse; architecture; Christopher Alexander; modernism; patterns

Issue
This commentary is part of the issue "Assessing the Complex Contributions of Christopher Alexander" edited by Michael W. Mehaffy (Sustasis Foundation) and Tigran Haas (KTH Royal Institute of Technology).

1. Introduction

The impact and influence of Christopher Alexander on architecture and architectural theory, as well as on other fields (including computer science and software engineering), is undeniable. Most of his books have been and continue to be widely read, discussed, debated, and criticized. Though his *A Pattern Language* is often mentioned as a perennial best-seller in the field of architecture and urbanism (Dawes & Ostwald, 2017), Alexander remains a lonely, somewhat isolated, and contested yet towering figure. A lot of his critics are inclined to dismiss him or belittle his contributions to architecture and urbanism, suggesting that his writings lost their importance long ago, though most agree that he was influential in the 1980s and 1990s. For example, Peter Eisenman, his opponent in the renowned Harvard debate in 1982, remarked that Alexander "fell off the radar screen" (Alexander & Eisenman, 2004). There is no lack of similar opinions. The reviewer of a new edition of Roger Scruton's *Aesthetics of Architecture* took the opportunity to emphasize that authors with whom the English philosopher shared his view of architecture are no longer key figures in architectural discourse:

> Alexander and Krier briefly occupied a position of influence in the 1980s and 1990s—the heydeys of postmodernism—but their intellectual impact has largely withered away due to the renewed prominence of modernism and modernity, in all their complexities, as the main point of reference. (Heynen, 2017, p. 208)

Some recent studies have presented a detailed account and classification of critical responses to Alexander's concept of patterns that provide a broader picture of his critical reception (Dawes & Ostwald, 2017). Unsurprisingly, quite a number of these responses question his approach and methods. Occasionally, even some of his former students and collaborators doubt the validity of his concepts

and dispute their applicability in architectural practice (Angel & Salingaros, 2022).

Nevertheless, the problem remains. How should Alexander's legacy be interpreted in the present context now that architectural modernism and industrial design have largely won their war on tradition and its discourse has not only become dominant in the West but also been sucessfully imposed on non-Western cultures as everywhere modernism was embraced by the architectural profession and the building industry? Did he lose his life-long battle or the war? Can his contested legacy be meaningfully adopted to the needs of the present and future? Was he a scholar or a thinker?

2. Patterns and Beyond

Nikos Salingaros recently discussed the reasons for Alexander's failure to convince the architectural community that his concepts provided the key to many problems of architectural and urban design practice. Salingaros insists that the discipline of architecture (including practitioners and academia) is largely to be blamed for rejecting Alexander's ideas, which remain synchronous with most recent scientific discoveries, neuroscience being one of the fields to support his untimely concepts of patterns and phenomena that he called quality without a name (Salingaros, 2021). Shlomo Angel, on the contrary, sees the roots of the problem not so much within the architectural community and/or its habits of thinking and acting but in Alexander's flawed strategy of communication. According to Angel, "Alexander was not able to influence the practice of architecture significantly because he did not 'recognize' the architects. He never acknowledged that architects have a role in creating the built environment. He wanted to talk directly to 'users'" (Angel & Salingaros, 2022, p. 388). Even Per Galle (2020, p. 347), who is sympathetic to Alexander's ideas, acknowledges that his writings "sometimes verge on the edge of eccentricity."

All this seems puzzling, bearing in mind that Alexander was not just some eccentric author putting together strange and incomprehensible ideas but a sensible, hard-headed practitioner who implemented many architectural projects on several continents and spent decades teaching in academia. Alexander, as an architectural designer and author, was concerned with practical as well as metaphysical questions (Alexander, 2001–2005) and "advocated a logical, objective approach to design" (Steenson, 2009, p. 22). Besides, his work with his clients is described as "collaborative" (Galle, 2020, p. 346).

On the other hand, his impact on architectural theory is indisputable. A recent look at Google Scholar confirms that Alexander has accumulated an impressive amount of no less than 39,735 citations (last accessed on February 3rd, 2023). In this respect, he far surpasses any other contemporary architectural theorist, including those currently in fashion.

3. Challenging the Sacred Cow

Alexander was highly critical of the developments in architectural modernism, especially the cultural, social, and aesthetic consequences of this omnipotent cultural and aesthetic ideology. As modernism (and a multitude of its avatars) largely remains a sacred cow in the community of architects, Alexander's ideas are generally rebuffed without convincing arguments being provided. In this sense, it seems like he crossed the limits of discourse acceptable to most members of the architectural profession.

Nevertheless, his critical view of modernism, his attitude towards his professional community, and the controversial reception of his writings among members of the architectural discipline evoke parallels with other important intellectual figures of the last century. The philosophers and social critics Ivan Illich and Jacques Ellul seem to match Alexander both in their critical inquiries into modernity and its technologies as well as in their controversial reception by their professional communities. Being educated as a philosopher, Illich chose to speak to other communities and society at large, while Ellul crossed the boundaries of sociology and entered the realm of philosophy to unwrap the role of technology in modern society. Consequently, Illich is described by a friend and intellectual biographer as a "contradictory" figure—a "modern man who wanted to be 'a reminder of the past'" yet who remained a thinker of high integrity (Cayley, 2021, p. 467). Both Illich and Ellul set out to dismantle the "certainties" of modernity and challenged the assumptions shared by their peers. Alexander walked in the same direction.

Here is the rub. Modern professional consensus is based on doxa rather than on episteme. Alternative views are tolerated only if they do not challenge doxa and threaten the accepted mainstream paradigm. Thus, the problem that persists in the discipline of architecture (both in practice and in academia) is the uncritical adulation of modernism that verges on fundamentalism, despite continuous attempts to unpack this stale cultural ideology (Blake, 1978, 1996; Curl, 2018; Gablik, 1984; Mehaffy & Salingaros, 2015; Millais, 2009; Samalavičius, 2017).

4. Controversies and Beyond

Alexander has often been described as a controversial figure. Yet this description has become almost a cliche that does little to explain his importance. Paradoxically, the fervor with which Alexander's views are disputed attests to his enduring importance as a social and architectural thinker. Though some of the critical reactions to his writings are well-justified and reasoned (e.g., the dubiousness of some of his recommended patterns or occasional discrepancies between structures designed according to prescribed patterns and truly beautiful buildings that do not necessarily correspond to them), many of the usual

critical responses fail to go beyond the rhetorical layers of Alexander's writings. Some of the criticism is simply shallow, such as the complaints that he used his own designs as examples of "living structures" in his books (were Le Corbusier or R. B. Fuller any different?) or that some of the images he provided lack quality. The insistence on the scarcity of non-Western material is also pharisaic, as Alexander was developing his own concepts rather than documenting any historical developments. These shortcomings, however, are often disproportionately escalated to cosmic dimensions.

His writings do contain internal contradictions, yet contradictions are inevitable for any serious attempt at revealing truth. While episteme inevitably contains some contradictions, doxa does not. These contradictions require further scrutiny.

5. Conclusions

It is obvious that Alexander has been and remains marginalized in the architectural profession. Nevertheless, this does not allow one to conclude that he has had no impact on the architectural or urban discourse since his popularity waned in the 1980s and 1990s. Like other original and non-conventional social thinkers who refrained from focusing on their professional communities, Alexander consciously distanced himself from his peers and the mainstream doxa. This enabled him to bypass the influence of architectural modernism, pursue his goals without falling prey to this architectural ideology, and develop his own (oppositional and meaningful) ways of seeing architecture and the built environment. His legacy, however, might be sustained best by further developing some of his most promising ideas and concepts as well as patiently drafting and implementing new educational programs (e.g., Building Beauty) rather than debunking criticism.

Conflict of Interests

The author declares no conflict of interests.

References

Alexander, C. (2001–2005). *The nature of order* (4 vols.). Center for Environmental Structure.

Alexander, C., & Eisenman, P. (2004). Contrasting concepts of harmony in architecture: The 1982 debate between Christopher Alexander and Peter Eisenman. *Katarxis*, *2004*(3). http://www.katarxis3.com/Alexander_Eisenman_Debate.htm

Angel, S., & Salingaros, N. A. (2022). Christopher Alexander's architectural insights and limitations. *New Design Ideas*, *6*(3), 386–401.

Blake, P. (1978). *Form follows fiasco*. Little, Brown & Co.

Blake, P. (1996). *No place like utopia*. W. W. Norton.

Cayley, D. (2021). *Ivan Illich: An intellectual journey*. Pennsylvania State University Press.

Curl, J. S. (2018). *Making dystopia: The strange rise and survival of architectural barbarism*. Oxford University Press.

Dawes, M. J., & Ostwald, M. J. (2017). Christopher Alexander's *A Pattern Language*: Analyzing, mapping and classifying the critical response. *City, Territory and Architecture*, *4*(1), Article 17.

Gablik, S. (1984). *Has modernism failed?* Thames and Hudson.

Galle, P. (2020). Christopher Alexander's battle for beauty in a world turning ugly: The inception of a science of architecture? *She-Ji: Journal of Design, Economics and Innovation*, *6*(3), 345–375.

Heynen, H. (2017). Book review: *The Aesthetics of Architecture*, Roger Scruton. *Architecture Philosophy*, *2*(2), 207–214.

Mehaffy, M. W., & Salingaros, N. A. (2015). *Design for a living planet: Settlement, science and the human future*. Sustasis Foundation.

Millais, M. (2009). *Exploding the myths of modern architecture*. Frances Lincoln.

Salingaros, N. A. (2021). *Why Christopher Alexander failed to humanize architecture*. The Side View. https://thesideview.co/journal/why-christopher-alexander-failed-to-humanize-architecture

Samalavičius, A. (Ed.). (2017). *Rethinking modernism and the built environment*. Cambridge Scholars Publishing.

Steenson, M. W. (2009). Problem before patterns: A different look at Christopher Alexander and pattern languages. *Interactions*, *16*(2), 20–23.

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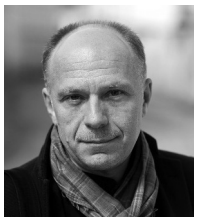

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Article

Navigating Approaches to the Use of Pattern Language Theory in Practice

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Abstract
Christopher Alexander's Pattern Language Theory (PLT) has been recognized as a valuable methodology to understand complex systems. It has been applied across domains through a variety of different approaches. This article reviews existing approaches to PLT application and reflects upon the differences between them. We find that application generally differs across four components: artefact, activity, roles and tools, informed by practitioners' diverging values and needs. We elaborate on how consciously navigating the dimensions that these components consist of can help to broaden the application of PLT in practice. We report on the development of a set of conceptual tools that aim to support this process. The resulting "activity kit" has been applied in a Dutch housing renovation project to support homeowners in communication and decision-making to illustrate the applicability of our methodology. It can be concluded that the "activity kit" is a promising approach to broaden the use of PLT and contributes to the methodological repertoire of researchers and practitioners to address complexity in today's societal challenges.

Keywords
action repertoire; design methodology; housing renovation; literature synthesis; pattern language theory

Issue
This article is part of the issue "Assessing the Complex Contributions of Christopher Alexander" edited by Michael W. Mehaffy (Sustasis Foundation) and Tigran Haas (KTH Royal Institute of Technology).

1. Introduction

Christopher Alexander's Pattern Language Theory (PLT) has been recognized as a valuable methodology for understanding and designing complex systems. In short, the simple structure of PLT has enabled people without relevant expertise to make decisions for a complex system, such as the urban planning of a community or the design of a service (Alexander et al., 1975, 1977). It has been successfully applied in various (participatory) project contexts including medical service system design (Athavankar, Khambete, Roy, et al., 2014) and policymaking for community dwellings (Palmieri et al., 2021). As PLT has been applied to different domains, changes made to Alexander's original PLT have been part of an ongoing debate (Borchers, 2000; Gamma et al., 1995; Golden, 2009). In short, it can be concluded that even though cases have qualities and characteristics that relate to PLT, oftentimes the approaches taken differ from Alexander's original theory.

However, these differences between PLT approaches and their underlying reasons are often unspecified. This might lead to misunderstanding among researchers and practitioners considering the use of PLT in a new project. Ultimately, it might decrease the effectiveness and diffusion of PLT in practice (Wania & Atwood, 2009). In many cases, PLT is applied in ways that do not (fully) align with the core goals or ambitions of a project. We take the premise that to properly use PLT, decision-making on which PLT approach to use needs to be supported as well as the use of existing approaches must be differentiated. The current work aims to broaden the use of PLT towards

a meaningful application of Alexander's scholarly work in practice. We have reviewed existing applications of PLT to identify similarities and differences among existing approaches. In the following sections, we introduce the methodology of the integrative literature review and elaborate on how the findings have informed the development of three conceptual tools. We present the conceptual tools and illustrate them with an ongoing community housing renovation project in the Netherlands and their value for navigating PLT in practice.

2. Integrative Literature Review

To improve clarity about how PLT is, and can be used in practice, an integrative literature review has been conducted. Integrative literature reviews are suitable for generating new knowledge about mature or new emerging topics by critically reviewing but also synthesizing existing, representative literature in an integrative way (Torraco, 2005). The creative process of synthesis brings together existing knowledge in a new way, for example by looking at it through a specific lens or connecting it to new ideas or conceptualizations of the author (Torraco, 2005). In this way, "new frameworks and perspectives on the topic are generated" (Torraco, 2005, p. 356). Such new frameworks and perspectives, often oriented towards applicability in practice, are of great importance for allowing PLT to be more effectively applied and broadly diffused within the practice.

A literature search was executed by the first author in 2022. The search string consisted of "pattern language" AND ("process" OR "implementation") OR "review." This search string allowed us to find articles that included anywhere in the article the exact phrase "pattern language" and at least one of the words "process," "implementation," or "review." These latter words helped us to find articles that discussed the actual use and application of PLT in practice. The search was performed on Google Scholar, with access to Google Books, Elsevier, Springer, IEEE, ACM digital library, and Wiley online library. The references provided by each document were checked for snowball sampling (Wohlin, 2014) and some relevant documents were added to the sample. After removing duplicates, the titles, abstracts and keywords were checked again to filter and formulate the sample. Articles that were only about PLT theory and not about PLT application were manually excluded by reading the title, abstract, methodology, and conclusions. Similarly, articles that investigated whether PLT was the best approach for a specific project and/or critiqued PLT were excluded as they fell outside the scope of our study. The sample refers to 46 documents reporting a specific case of pattern language application; in addition to *The Oregon Experiment* (1975) by Alexander and colleagues, seven other books or book chapters were included as well as 35 journal and/or academic conference papers, two master theses, and one doctoral dissertation. These documents cover the domains of architecture, urban design, policymaking, business upgrading, sustainability, theatre, software engineering, interaction design, and service design (see Supplementary File for further details).

The literature analysis was done in three stages, which we refer to as "deconstructing," "identifying," and "reconstructing." Each stage contained separate rounds of coding and/or clustering.

1. Deconstructing: This stage is aimed at discovering *components* that different PLT approaches have in common. We first coded information about how PLT has been executed in practice, including the advantages that using PLT was expected to have, and the actions that were taken to ensure these advantages could appear. The detailed coding scheme can be seen in Table 1. The scheme was continuously extended and revised by the first author during the coding process as new information was found relevant or more fitting wording was encountered. A total of 231 codes were generated in this stage.

Table 1. Coding scheme.

Aspect	Definition	Selection criteria	Examples of codes
Expected benefits	The benefits of PLT which are expected to take place by the practitioners when being applied in the context.	• Advantages or benefits of PLT expected to be achieved in its application. • Mentioned challenges or problems to be solved with PLT. • Research goal or project goal expected to be achieved with PLT.	Bottom-up, transfer of inspiration, participation of end users, communication between different expertise, etc.
Application approach	How PLT is executed, including the design of the application process, the people involved etc.	• Research design. • Application design, such as the activities to perform, the respondents or executors to involve, and/or other agencies involved by design. • Method of using or developing the pattern language or patterns.	Developed by experts, developed by end users, based on experience, based on expectations, etc.

Second, we clustered the codes. To enable easy clustering, all codes were documented in Excel, and imported to Miro as sticky notes. On the Miro board, all codes and corresponding text excerpts were reread carefully to understand which "aspect" of the approach was being decided on in the discussed case. This "aspect" was then included in the name of the code. The code names summarize the codes and excerpts in intuitive and straightforward words or phrases, such as "created by users," "gather from the field," "visionary," or "empirical," etc. Sticky notes with codes describing the same "aspect" were located together on the Miro board. At the same time, similar or ambiguous names were gradually unified. For example, "actions on pattern language" and "activities" were unified into "activities around pattern language." The names of sticky note clusters underwent constant refinement during the process. The clustering finally resulted in five overarching themes, namely "expected benefits," "the pattern language/patterns," "activities around pattern language," "people," and "external tools." The latter four themes represent the main aspects to decide on in applying PLT, and can thus be seen as core components of PLT approaches. For simplicity and ease of referring, the names of these four components were refined into "artefact," "activity," "role," and "tool."

2. Identifying: Since users of PLT also need to know what choices are available in relation to these four components to narrow down their options, our second analysis stage focused on listing the available choices for the different PLT components that were found. The sticky notes of the codes that had been generated and clustered on the scale of a single "component" in the previous analysis stage, were clustered more finely on the Miro board. The codes describing a pair of opposing characteristics were put on two ends of one arrow—which we refer to as "a dimension". For example, a code describing an activity led by medical experts was put opposite to a code about an activity led by an end-user without any medical expertise. Each dimension was given a name to describe the pair of opposing characteristics of the component. For the above-mentioned example, the dimension was named "Activity: bottom-up vs. top-down." A total of seven *dimensions* were generated in this step: three for the artefact component (i.e., user-created vs. professional-created; internally hierarchical vs. externally hierarchical; empirical vs. visionary), two for the activity component (i.e., circular vs. (multi-)linear; bottom-up vs. top-down), and two for the role component (i.e., end-user involved vs. end users not involved; heterogeneous vs. homogeneous). Within the tool component, codes did not show any opposing features, hence no dimension was generated here.
3. Reconstructing: Certain choices for different components fit each other and usually appear together in the PLT application. Describing such associations with a higher-level dimension makes decision-making easier for PLT users. Our third stage of analysis focused on finding such *higher-level dimensions*. First, the seven dimensions generated in the Identifying stage were clustered according to their relevance. For example, whether the activity is bottom-up or top-down is closely related to whether the artefact is created by end users or created by professionals. More specifically, if the artefact is created by end users, at least the development activity of this approach can be taken as bottom-up. Such two dimensions, although respectively for different components, were brought together. In this step, two higher-level dimensions, namely "bottom-up vs. top-down'' and "empirical vs. visionary" were formulated out of five initial dimensions. Two initial dimensions did not show many relations to the others. After finding out "which" choices of components usually appear together, we studied "why" the concurrences often happen. Inspired by the idea that the expected benefits of PLT (Wania & Atwood, 2009) and a value system are always embedded in an approach (Fincher, 1999), we related the two higher-level dimensions to PLT's benefits and values. Using the framework of values by Bos-de Vos (2020), the underlying values of both ends of each higher-level dimension were identified. For example, for the higher-level dimension "bottom-up vs. top-down," the values of "social justice" and "egalitarianism" were identified as being most in line with the bottom-up end, while "efficiency" and "mastery" corresponded with the top-down end. We also related the codes about PLT's benefits (generated in the Deconstruction stage, see Table 1) to the two higher-level dimensions. For example, the high-level dimension "bottom-up vs. top-down" was related to the benefit of PLT enabling "participation of end users."

3. Towards Conceptual Tool Development

This section includes the PLT components and dimensions that were derived from the literature review, as well as the three conceptual tools that were developed based on these components and dimensions.

3.1. Four PLT Components

As mentioned in the previous section, our analysis process revealed four components that characterize PLT application, namely artefact, activity, role, and tool. Each PLT application, regardless of any differences it has from Alexander's approach, consists of these four components. The four components also embody the differences between an approach and the Alexandrian approach.

The artefact component refers to the patterns or pattern language that is/are used in an approach. A pattern or pattern language is itself an artefact, sometimes physical, such as books or cards (Alexander, 1979; Athavankar, Khambete, Doke, et al., 2014), sometimes virtual, such as a pattern language on a website (Experiences—A pattern language for user interface design, n.d.). According to Khambete (2013), a visualized format of pattern language can embody the connections between patterns and make it simpler for users to navigate across them.

The activity component represents the actions around the artefact (pattern language/patterns) in an approach. According to Chen et al. (2007), four activities can be identified in Alexander's pattern language trilogy—i.e., the three books *The Timeless Way of Building* (Alexander, 1979), *A Pattern Language* (Alexander et al., 1977), and *The Oregon Experiment* (Alexander et al., 1975)—including developing a pattern language, and three ways of using pattern language, namely selecting patterns from the pattern language, diagnosing with the patterns, and designing with the patterns.

With the role component, we refer to the people that are involved in the application of PLT. Drawing upon our analysis of the literature, we classify all roles into three groups: experts, professionals, and end users, in terms of their relative expertise in the domain. In different PLT approaches, these three groups can be selectively involved or excluded as needed. The expert group involves researchers or senior practitioners that have the capacity of extracting methodologies from practices. In Alexander's theory, this group includes Alexander himself, as the advocate of applying pattern language. The experts usually have the highest expertise, but limited influence on the context. The professional group consists of the practitioners in the field, who are making design decisions. For example, the "full-time architects or planners" in *The Oregon Experiment* (Alexander et al., 1975, p. 35), the teachers as the designers and executors of their curricula etc. Professionals are usually criticized for making the results "idiosyncratic" (Alexander et al., 1975, p. 30) when not involving end users. The group of end users consists of the users of the system. This group is traditionally excluded from the design process. For example, in Alexander's theory, the end users of urban planning are the inhabitants who have no idea of how their habitat is designed. In education, the end users are the students who are traditionally not engaged in deciding what and how they should learn. Although end users are most subject to the changes brought by new decisions, they exert the least impact on the decision-making process. However, the end users can be engaged in a bottom-up approach, which is also what Alexander advocates in his PLT trilogy. In such an approach, end users will be able to bring in their insights and regain political power.

The tool component supports the activity component. Some tools can help align stakeholders. In the work of Khambete (2013), researchers use a value system to present end users' goals and standards for a good design. By constantly reflecting on the value system, the researchers make sure the patterns are developed and used in line with end users' needs. In Köppe et al. (2017), a "value-based workshop" was organized to identify stakeholders' common values. This also enables further collaboration in other activities. Another type of tool that is used is for framing or scoping a project. In the study of Athavankar, Khambete, Roy, et al. (2014), a service blueprint was used to decide which touchpoints should be focused on in the project. In addition, prototypes in website design (Dearden et al., 2002), master plans in urban design (Alexander et al., 1975) and storyboards in service design (Dearden et al., 2002) can achieve the same goal. Furthermore, tools for translating knowledge into patterns are often used in different approaches. The pattern format given by Alexander in his trilogy is the most used one.

Figure 1 shows how the four components mentioned above are interrelated. It illustrates how the activity component can be seen as the context of the other three: Without notifying which activity is being discussed, discussions on what artefact (i.e., patterns/pattern language) should be used or produced, which roles should be involved, and what tools should be used, cannot go on. The activity component, therefore, is the primary component to decide on when deciding on an approach for PLT application. There are various relations possible between tools and the artefact (represented with * in Figure 1). For example, in the case of design pattern cards, the cards (tool) serve as the medium for communicating the patterns (artefact), while a service blueprint (tool) helps researchers to frame or scope for the development of the pattern language (artefact; Athavankar, Khambete, Roy, et al., 2014).

3.2. Seven Initial Dimensions

In the identifying stage of the literature review, three components were found to vary across a total of seven dimensions (see Table 2). First, the artefact can be either user-created or professional-created. Since the pattern language used by Alexander was created by his colleagues and himself (Alexander, 1979); their expectations inevitably lay behind the pattern language. Compared to this, patterns created by end-users represent users' dreams and needs (Palmieri et al., 2021). Second, the artefact can be either internally hierarchical or externally hierarchical. The pattern language created by Alexander and his colleagues was internally hierarchical, which means that the connections between patterns naturally exist. Alexander initiated the concept of pattern language as a connected set of patterns, rather than a random set (a random set of patterns is sometimes addressed as a pattern "catalogue" (Salingaros, 2000). In Alexander's way, several lower-level patterns complete each other and form a higher-level pattern. The patterns are collected together

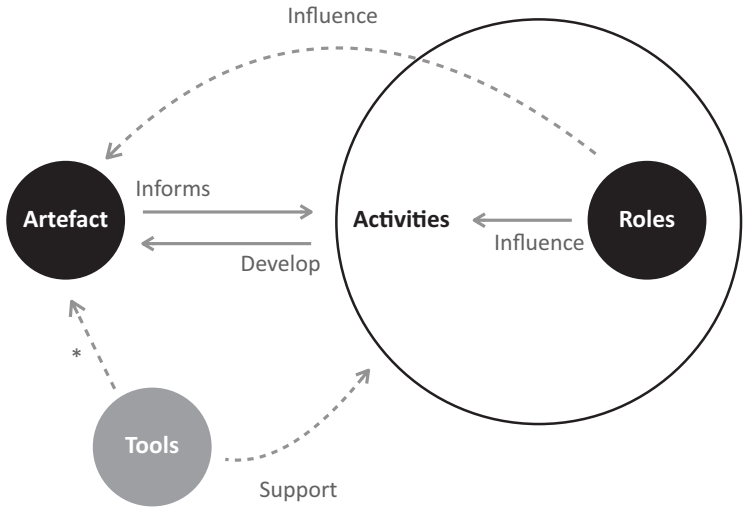

Figure 1. The PLT components and their interrelations.

because when fulfilling one larger pattern, the smaller patterns need to be fulfilled first. Compared to this, an external hierarchy is created by the pattern developer but does not occur naturally. For example, the way Gamma et al. (1995) collect patterns, is by classifying all patterns into three categories (creational patterns, structural patterns, and behavioural patterns), but not directly by the connections between single patterns. In other words, the structure or hierarchy of Gamma et al.'s patterns is imposed by the researchers' preferences rather than by the internal hierarchical relation between patterns. This hierarchy allows users to find a pattern more easily but is "forced" by the developers (Coplien & Schmidt, 1995). Third, the artefact can be either empirical or visionary. Alexander's patterns came from empirical experiences. Patterns can also be visionary. For example, end users could write their ideal living as visionary dwelling patterns (Palmieri et al., 2021). In addition, designers could use patterns as unfinished prototypes (Schön, 1983) which later on can be tested and iterated on through design activities. Fourth, the activities can be either circular or (multi-) linear. *The Oregon Experiment* (Alexander et al., 1975) presents a circular process between developing pattern language and using pattern language. The users who were involved in the design activities were encouraged to improve the patterns according to their new experiences. In turn, the improved patterns gave feedback to improve the design. In comparison, some projects such as those of Zhang et al. (2017) and Ortega-Arjona (2010) followed a linear process, without iterations on pattern language. Fifth, the activities can be either bottom-up or top-down. Alexander argued for a bottom-up approach, in which residents themselves initiate and design a complete project (Alexander, 1979). Yet in other domains, such as education (Köppe et al., 2017), the students were not involved to design the course for themselves. In real life, most cases fall between the two extremes. For example, in *The Oregon Experiment* (Alexander et al., 1975), Alexander presented a complete bottom-up design activity but a top-down pattern development activity. Sixth, for the Roles, the end users can be either involved or excluded. This dimension is similar to the "bottom-up vs. top-down" dimension for activity. Finally, the composition of roles can be more heterogeneous or more homogeneous. This depends on the nature of a project, whether it is multi-disciplinary—such as in service design or interaction design (Athavankar, Khambete, Roy, et al., 2014; Baltzer et al., 2019; Bayle et al., 1998; Borchers, 2000; Khambete, 2013; Pollmann & Ziegler, 2021)—or not—such as in software engineering (Ortega-Arjona, 2010; Zhang et al., 2017; Zhao et al., 2008).

Table 2. Overview of PLT dimensions.

Index	Component	Extreme 1	Extreme 2
1	Artefact	User-created	Professional-created
2		Internally hierarchical	Externally hierarchical
3		Empirical	Visionary
4	Activity	Circular	Linear
5		Bottom-up	Top-down
6	Roles	End users involved	End users not involved
7		Heterogeneous	Homogeneous

3.3. Two Higher-Level Dimensions

The first high-level dimension "bottom-up vs. top-down'' was synthesized from three initial dimensions, namely "Artefact: user-created—professional—created," "Practice: bottom-up—top-down," and "Roles: involving end-users—not involving end-users." These three are all about whether a change or a decision-making process is initiated by the end users (grassroots) or by someone with higher authority, such as professionals or experts. In this high-level dimension, "bottom-up" corresponds to PLT's advantage in "engaging end users" (Alexander, 1979; Palmieri et al., 2021) and human values of "social justice" or "egalitarianism" in reference to the framework of values by Bos-de Vos (2020). While "top-down" cases do not necessarily express an "injustice" value. Involving end users is not the first preference, either for efficiency or for business confidentiality.

A second high-level dimension "visionary vs. empirical" was synthesized from two dimensions: "Artefact: visionary—empirical" and "Practice: circular—linear." Both dimensions reflect practitioners' beliefs on whether a better alternative to the current best practice could exist. Or in other words, whether industry revolution/transformation is welcomed. The approaches that use visionary patterns, often use expressions such as "transformative," "challenging," or "transforming," which reflect a departure from what is considered mainstream practice. This is in line with their critiques against Alexander's approach which is "over-focusing on replicability" (Palmieri et al., 2021). Compared to that, approaches using empirical patterns were more inclined to reconfirm the traditional or existing best practices. We use "industry transformation" and "reusing known solutions" to represent the two opposite values.

3.4. Three Conceptual Tools

Three conceptual tools were generated following the results of the integrative literature review results to support use in practice. These tools aim to provide visual and textual understandability and help in differentiating between PLT approaches. More specifically, the tools inform users what aspects of a PLT approach should be decided on and motivate underlying reasons or mindsets that should be reflected when making decisions.

The first conceptual tool, the Approach Axes (Figure 2) contains two tables. Each table details one of the two higher-level dimensions: "bottom-up vs. top-down'' and "visionary vs. empirical." The characteristics of and underlying reasons for the two extremes of each dimension are introduced in each table. The characteristics include common expressions, key activity, source of patterns and user of the pattern language. The underlying reasons include the underlying values of the practitioners and their expected benefits of applying PLT. These elements were extracted from the literature.

The second conceptual tool, the "Navigation Panel" (Figure 3) is a combination of the two approach axes. The panel of PLT approaches is divided by the two axes into four areas, each representing one typical approach to using PLT. The four approaches are detailed in Table 3; a third conceptual tool that combines the Approach Axes tables and adds a slogan and a representative example for each approach.

4. Developing a Process to Decide on a PLT Approach

Three workshops with ten practitioners, researchers, and students have been conducted to evaluate the practical usability of the proposed conceptual tools in practice. A first sensitizing activity focused on letting participants think concretely about a concern, worry or difficulty (i.e., a problem) in an ongoing project. Participants were then asked to write down and share this problem with the others. The participants were then introduced to the concept of PLT and the three conceptual tools. After this, participants considered and discussed how PLT could be applied to the problem they had raised, and how the conceptual tools could support this application. Textual and graphical materials were used to facilitate the workshops. The audio of the three sessions was recorded, transcribed, coded and analysed.

In the workshops, the three conceptual tools were found to be helpful in three ways. First, they urged participants to consider and communicate their underlying values in the projects. For example, through working with the navigation panel participants were better able to articulate what they consider important and how they approach the project. This also helped them in aligning with or considering their alignment with other stakeholders in the project, as the quote below shows:

> If you are working with other stakeholders, and have to agree on what it is that you are aiming for with the project, this is a nice way to get on the same page. Because maybe I was making it too hard in my project, I was on a vision-making [visionary knowledge production], but maybe what they want is just decision-making [empirical knowledge production]. So I don't need to make it difficult for myself. (P4)

Second, the conceptual tools were considered helpful for practitioners in choosing their approach to using PLT. For practitioners already applying PLT, the tools can help position their current approach, reflect on whether they are using it in a way that is aligned with their values, and decide for a change when disconformity exists.

Third, the conceptual tools facilitated adopting a long-term perspective towards the project. Even though practitioners may find an approach to align well with their underlying values and purposes, there may exist limitations towards implementing this approach. For example, it may not always be (directly) feasible to involve end-users. In the workshops, quite a few

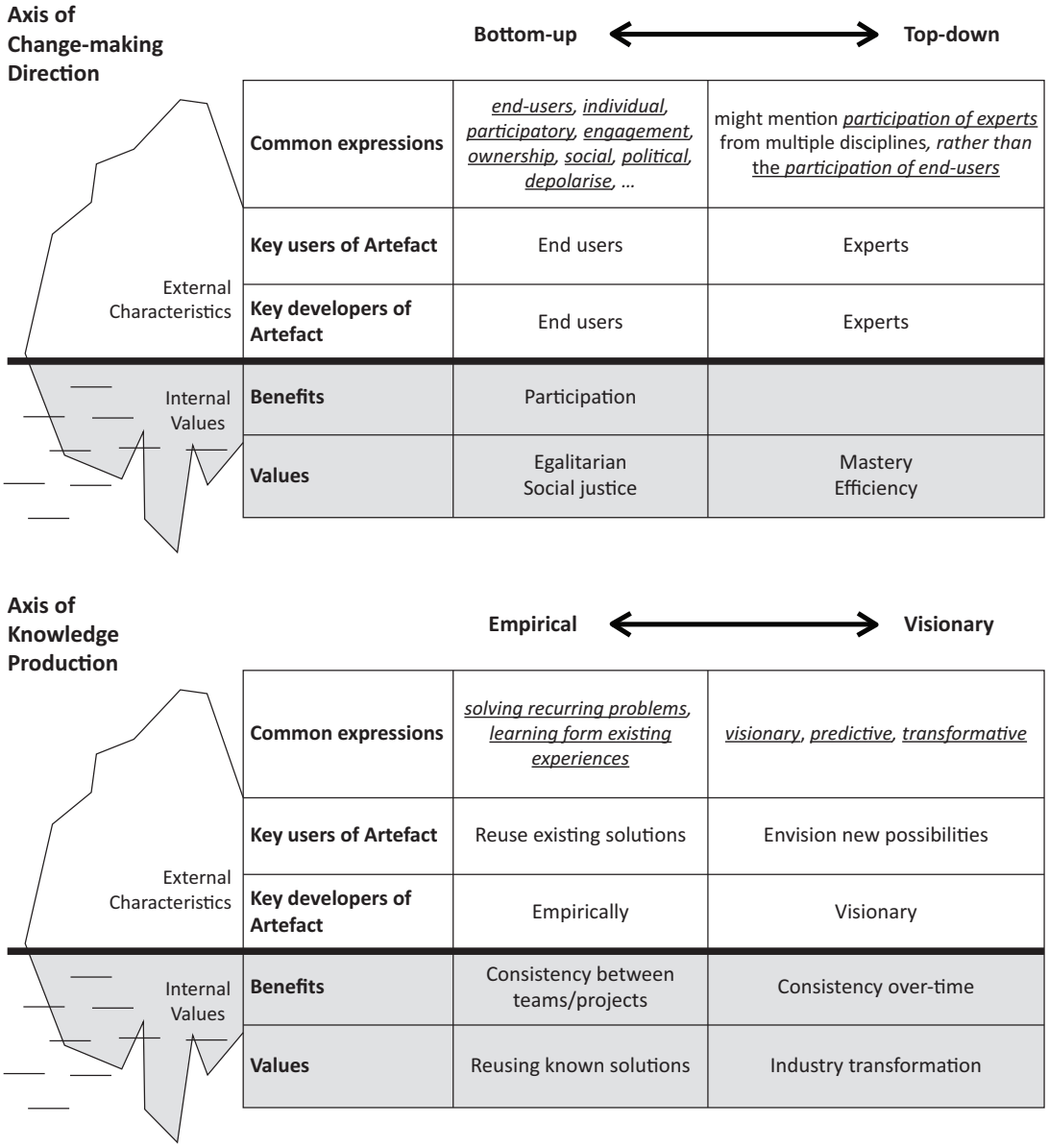

Figure 2. The Approach Axes.

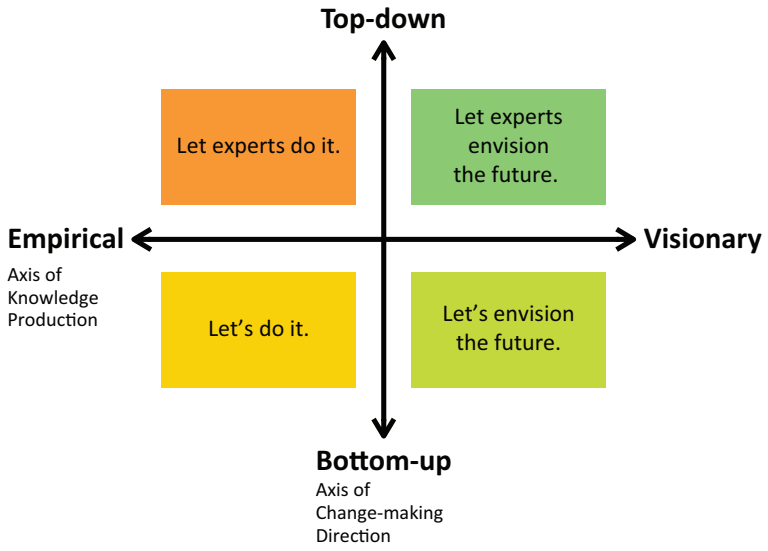

Figure 3. The Navigation Panel.

Table 3. The Approach detail table.

Dimensions	Bottom-up & visionary	Top-down & visionary	Bottom-up & empirical	Top-down & empirical
Values	Social justice, transformation	Transformation	Social justice, mastery of immediate problems	Mastery of immediate problems
Expected benefits	Participation, consistency over time	Consistency over time	Participation, consistency between projects/teams	Consistency between projects/teams
Slogan	Let's envision the future	Let experts envision the future	Let's do it	Let experts do it
Roles: users	End users	Experts and professionals	End users	Experts and professionals
Roles: developers	End users	Experts and professionals	End users	Experts and professionals
Activity	Envision new possibilities	Envision new possibilities	Reuse existing solutions	Reuse existing solutions
Example cases	Flourishing Foodvalley: Pattern language as a co-design method to approach the transition towards circular agricultural systems in a hybrid landscape (te Duits, 2022)	Towards a pattern language for hybrid education (Köppe et al., 2017)	The PhOCoe Model–Ergonomic pattern mapping in participatory design processes (Silva e Santos, 2012)	A pattern language for designing e-business architecture (Zhao et al., 2008)

participants scribbled the route between their ideal approach and the approach that was feasible at that time on the Navigation Panel, thereby creating a long-term plan towards PLT application. For example, one participant first decided that a bottom-up and vision-making approach would be the best approach for her research project. Yet she admitted that because of the difficulty to access end-users, the project might have to start from a more top-down and decision-making approach. Clarifying her project as following a curved route in the navigation panel gave her a clearer understanding that over time, she should try to involve end-users and shift from using ready-to-use solutions to inventing more radical ones.

Although the conceptual tools were helpful for some activities, participants also encountered issues when trying to use PLT in the workshops. Most importantly, participants did not consider the exact purpose of their project before starting to use PLT. This resulted in overqualified activities that did not directly contribute to their projects. For example, in their first contact with the concept of PLT, most participants immediately considered developing a pattern language for their specific problems, instead of searching for existing pattern languages that could be reused. Next to the tendency to try to reinvent the wheel, participants often felt rushed to complete a pattern language and sometimes overlooked the importance of non-professionals in developing a pattern language.

To solve the issues described above, we developed a process to decide on a PLT approach. This four-step process provides users with a reminder to consider the purpose of their project before deciding on the PLT approach to use (Figure 4).

The first step of "Understanding PLT" is optional, depending on whether the concept of PLT is new to the user or not. The emphasis is on the second step "Considering Purposes" where practitioners consider/reflect on their own purposes. This was informed by the workshop insights that presenting examples of achievable purposes could help participants take one step back to consider their own purposes:

> This part, it's getting me to think about what the purpose of pattern language is and how to use it. So I just briefly gave up making the structure and started to

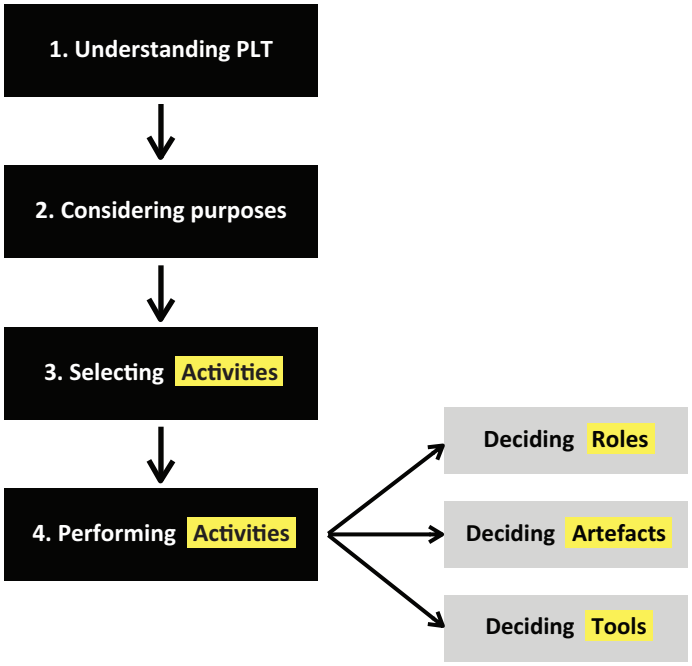

Figure 4. The process to decide on a PLT approach.

> think about the purpose….So one step back before making the plan. (P9)

In the literature, we found eight common purposes for which PLT is applied in practice. From simple to more complex, these are: (a) developing an overview of a domain; (b) finding reusable solutions/measurements to diagnose or make decisions for the current situation; (c) creating a toolkit for a participatory (design) project; (d) identifying and externalizing reusable solutions from past project experiences; (e) understanding needs or externalizing knowledge of stakeholders; (f) eliciting vision from stakeholders; (g) identifying future research priorities; and (h) building an ever-growing knowledge database for a domain. With their purpose (this can but does not necessarily need to be one of the listed purposes) clearly in mind, users can begin their decision-making on the PLT approach, corresponding to the third step. To decide on the approach, all four components—artefact, activity, role, and tool—need to be taken into consideration. Among those, the activity component was chosen as the first to decide on, since it directly impacts all the other three components (see Figure 1). Finally, in the fourth step "Performing Activities," decisions on the other three components can be made.

5. Result: The Activity Kit

The three conceptual tools and the Process to decide on a PLT approach have been synthesized into a final toolbox for supporting decision-making on PLT approaches, which we refer to as an "Activity Kit" instead of a toolkit. Activity is the first component to decide on, whereas "tools" represent the agencies in support of activities. The format of a "kit" was chosen for its practicality and interactive nature allowing customization. The Activity Kit provides a practical guide to using PLT more effectively in accordance with the four-step process (see Figure 4). It consists of an introduction to PLT, including a simple example; as well as the conceptual tools and workshop materials that help to consider the purpose(s) and to select and perform PLT application activities. For each purpose, an activity map with icons shows the recommended activities for reaching that specific purpose. For each activity, cards provide the supporting tools and other important information that enable users to perform the activity (see Figure 5). The Kit also includes an appendix with four representative cases corresponding to the four quadrants of the navigation panel. The cases present an application of pattern language where the actions are well aligned with the purpose. In the next section, we illustrate how the Kit has been used to navigate the complex challenges in a communal housing renovation project.

6. Using the Activity Kit in the Numansgors Project

A PLT approach always depends on the specific context of a project and the values of the stakeholders involved. Therefore, we introduce one specific context of study—the Numangors project—to illustrate the value of the literature insights and corresponding Activity Kit.

Numansgors is a former recreation park in the Netherlands which has been turned into a permanent residential community. The park was designed by the architecture firm Broekbakema in the late seventies and is situated along a wide tidal river. In terms of architectural and landscape aesthetics, not much has

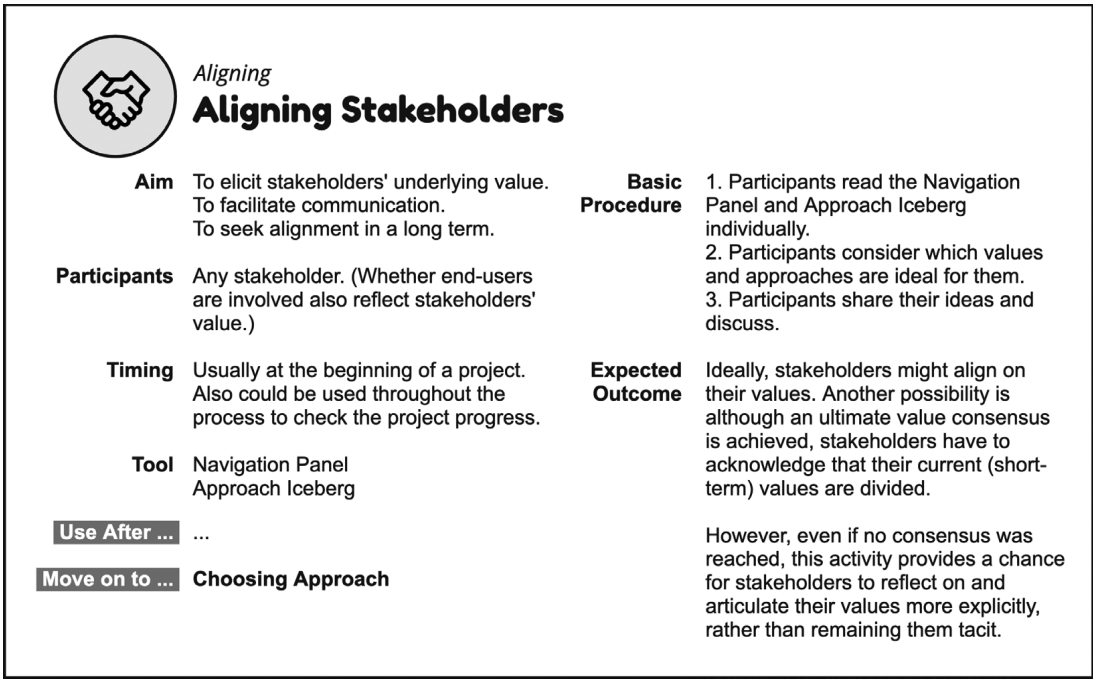

Figure 5. Example of an activity card.

changed since the construction of the park. Many of the houses, however, no longer suffice to current sustainable energy and heating standards and need to be renovated. To coordinate renovation efforts, a voluntary commission was set up. The commission struggled to deal with the differences between households in terms of financial resources and technical knowledge. Moreover, previous individual initiatives to install solar panels and outdoor heat pump installations have been criticized for cluttering the park's unique aesthetic.

The Activity Kit has been used to brainstorm ways to address the complex challenges in Numansgors. It was decided that a top-down approach was first needed to explore different renovation options on a communal level because former individual renovation attempts have led to dissatisfaction among residents. This way, residents can be equally informed about the financial benefits and the potential aesthetic consequences of their decision to renovate.

Following the instructions of the Activity Kit, the Numansgors context serves the purpose of understanding the need and externalizing knowledge of stakeholders to retain the authenticity of these insights throughout the project (purpose 5 in the Kit). Actions connected to this purpose are to align stakeholders by using the right frames (determined by getting stakeholder insights) and writing and curating patterns out of these stakeholder insights (thus developing a pattern language). Following these instructions, a survey was handed out to the residents asking them about basic household information (such as energy labels or current implemented renovation measurements), important values (e.g., the main reason for living in Numansgors), and desirable outcomes of sustainability efforts (like energy cost reduction and consistency in the technical application of measurements). Consequently, outcomes of the survey were clustered into three subjects (patterns) that recurred in every recollected form. The first was a need for a better technical understanding of sustainability measurements, including the function of these measurements and the application of measurements. The second was a need for better insight into the financial benefits of measurements, including directions to subsidies and considerations in relation to the benefits of collective measurement and individual measurements. The last was to find more consistent and easy ways to communicate.

All subjects were visualized in a pattern language framework. The pattern language framework was handed over to the commission and residents, along with instructions on how to use it. The three main subjects of the PLT frameworks have since been incorporated into a community website. The website offers technical information and financial advice (e.g., how to apply for sustainability loans provided by the local municipality), based on the experiences of residents that have already renovated. Moreover, the website includes a forum in which residents can leave questions or experiences. The commission is key in connecting problem owners to the right solutions.

7. Conclusions

The contribution of the current research is twofold. In the first place, we provide a new lens to examine and differentiate various PLT applications. Both researchers and practitioners can use the conceptual tools developed to reflect on past or ongoing cases or to work on a new application. For example, researchers can use the tools

to examine projects in which PLT is/has been applied to uncover the extent to which underlying values are in line with the characteristics of the PLT approach. In case alignment is lacking, the effectiveness of the PLT application in this project is of particular interest and needs further examination. Second, a practical toolbox named the "Activity Kit" has been generated to support decision-making on PLT approaches; practitioners can choose and perform an appropriate PLT approach in line with their values and needs. In this way, practitioners can use PLT more effectively. The main contribution of the Activity Kit is that it stimulates a broader application of PLT as a necessary first step to further broaden the methodological repertoire of researchers and practitioners needed in addressing complexity in today's societal challenges.

Although the application of the Activity Kit in the Numangors Project was merely meant to illustrate the contribution of our methodology to the application of PLT, the results of our integrative literature review indicate a promising direction to assist researchers and practitioners in navigating options towards applying PLT in practice and thereby further diffusing Alexander's thoughts. We strongly encourage further validation and strengthening of both the theoretical basis and practical use of the Activity Kit. A systematic literature review would be helpful to develop a more nuanced and detailed understanding of PLT application. Also, a thorough evaluation study of the developed Activity Kit across cases in multiple fields would be highly recommended. A unique strength of the developed conceptual tools is that they are quite general and as such applicable to all kinds of design disciplines. Yet, to take into account the unique characteristics of these disciplines, future research could focus on exploring how the contents and application of tools may (or even should) differ to fit best with the practices and norms of the contexts in which they are applied. Furthermore, a more comprehensive discussion on values may require different tools. Currently, the two axes in the navigation panel can cover most initial dimensions with simplicity, but only address several types of values (egalitarianism and mastery). These values are sufficient for discussing PLT approaches, but in many projects also other values are at play.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

The full overview of reviewed literature is available online as supplementary material in the format provided by the authors (unedited).

References

Alexander, C. (1979). *The timeless way of building* (Vol. 1). Oxford University Press.

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A pattern language: Towns, buildings, construction* (Vol. 2). Oxford University Press.

Alexander, C., Silverstein, M., Angel, S., Ishikawa, S., & Abrams, D. (1975). *The Oregon experiment* (Vol. 3). Oxford University Press.

Athavankar, U., Khambete, P., Doke, P., Kimbahune, S., Devkar, S., Roy, D., & Chaudhary, S. (2014). Exploring cards for patterns to support pattern language comprehension and application in service design. In *Proceedings of the 6th Indian Conference on Human-Computer Interaction* (pp. 112–115). Association for Computing Machinery.

Athavankar, U., Khambete, P., Roy, D., Chaudhary, S., Kimbahune, S., Doke, P., & Devkar, S. (2014). Multidisciplinary team dynamics in service design-the facilitating role of pattern language. In *Proceedings of the 6th Indian Conference on Human-Computer Interaction* (pp. 16–25). Association for Computing Machinery.

Baltzer, M. C. A., López, D., & Flemisch, F. (2019). Towards an interaction pattern language for human machine cooperation and cooperative movement. *Cognition, Technology & Work*, *21*, 593–606.

Bayle, E., Bellamy, R., Casaday, G., Erickson, T., Fincher, S., Grinter, B., Gross, B., Lehder, D., Marmolin, H., Moore, B., Potts, C., Skousen, G., & Thomas, J. (1998). Putting it all together: Towards a pattern language for interaction design: A CHI 97 workshop. *ACM SIGCHI Bulletin*, *30*(1), 17–23.

Borchers, J. (2000). A pattern approach to interaction design. In *Proceedings of the 3rd conference on Designing interactive systems: Processes, practices, methods, and techniques* (pp. 369–378). Association for Computing Machinery.

Bos-de Vos, M. (2020). A framework for designing for divergent values. In S. Boess, M. Cheung, & R. Cain (Eds.), *Proceedings of DRS2020: Volume 1 synergy situations* (Vol. 1, pp. 39–53). Design Research Society. https://doi.org/10.21606/drs.2020.374

Chen, C. T., Cheng, Y. C., & Hsieh, C. Y. (2007). Towards a pattern language approach to establishing personal authoring environments in e-learning. In V. Uskov (Ed.), *Web-based education* (pp. 13–18). ACTA Press.

Coplien, J. O., & Schmidt, D. C. (Eds.). (1995). *Pattern languages of program design*. Addison-Wesley Publishing.

Dearden, A., Finlay, J., Allgar, E., & McManus, B. (2002). Using pattern languages in participatory design. In T. Binder, J. Gregory, & I. Wagner (Eds.), *Proceedings of the Participatory Design Conference (PDC 2002)* (pp. 104–113). Computer Professionals for Social Responsibility.

Experiences—A pattern language for user interface design. (n.d.). *Homepage*. http://www.maplefish.com/todd/papers/Experiences.html

Fincher, S. (1999). Analysis of design: An exploration of patterns and pattern languages for pedagogy. *Journal of Computers in Mathematics and Science Teaching*, *18*(3), 331–348.

Gamma, E., Helm, R., Johnson, R., Johnson, R. E., & Vlissides, J. (1995). *Design patterns: Elements of reusable object-oriented software*. Pearson Deutschland GmbH.

Golden, E. (2009). Helping software architects design for usability. In *Proceedings of the 1st ACM SIGCHI Symposium on Engineering Interactive Computing Systems* (pp. 317–320). Association for Computing Machinery.

Köppe, C., Nørgård, R. T., & Pedersen, A. Y. (2017). Towards a pattern language for hybrid education. In *Proceedings of the VikingPLoP 2017 Conference on Pattern Languages of Program* (pp. 1–17). Association for Computing Machinery.

Ortega-Arjona, J. L. (2010). *Patterns for parallel software design*. Wiley.

Palmieri, T., Huybrechts, L., & Devisch, O. (2021). Co-producing, curating and reconfiguring dwelling patterns: A design anthropological approach for sustainable dwelling futures in residential suburbs. *Design Studies*, *74*, Article 101011.

Pollmann, K., & Ziegler, D. (2021). A pattern approach to comprehensible and pleasant human–robot interaction. *Multimodal Technologies and Interaction*, *5*(9), Article 49.

Salingaros, N. A. (2000). The structure of pattern languages. *arq: Architectural Research Quarterly, 4*(2), 149–162.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. Routledge.

Silva e Santos, M. (2012). The PhOCoe model: Ergonomic pattern mapping in participatory design processes. *Work, 41*(Suppl. 1), 2643–2650.

te Duits, N. (2022). *Flourishing Foodvalley: Pattern language as a co-design method to approach the transition towards circular agricultural systems in a hybrid landscape* [Unpublished Master's thesis]. Delft University of Technology.

Torraco, R. J. (2005). Writing integrative literature reviews: Guidelines and examples. *Human Resource Development Review*, *4*(3), 356–367.

Wania, C. E., & Atwood, M. E. (2009). Pattern languages in the wild: Exploring pattern languages in the laboratory and in the real world. In *Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology* (pp. 1–15). Association for Computing Machinery.

Wohlin, C. (2014). Guidelines for snowballing in systematic literature studies and a replication in software engineering. In *Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering* (pp. 1–10). Association for Computing Machinery.

Zhang, P., White, J., Schmidt, D. C., & Lenz, G. (2017). Design of blockchain-based apps using familiar software patterns with a healthcare focus. In *Proceedings of the 24th Conference on Pattern Languages of Programs* (pp. 1–14). Association for Computing Machinery.

Zhao, L., Macaulay, L., Adams, J., & Verschueren, P. (2008). A pattern language for designing e-business architecture. *Journal of Systems and Software*, *81*(8), 1272–1287.

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Commentary

Community and Privacy in a Hyper-Connected World

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Abstract
Christopher Alexander and Serge Chermayeff co-authored *Community and Privacy: Toward a New Architecture of Humanism* in 1963. This seminal contribution has largely been forgotten. Today, a human-centred framework is rarely discussed by researchers and practitioners, neither from a theoretical nor a pragmatic perspective. Nonetheless, some fundamental principles defined in that book 60 years ago are pertinent today in our hyper-connected world, and they have been illustrated by the need for human-centred housing during the recent Covid-19 pandemic. This commentary explains the spatial organization of domestic architecture that can support and sustain choices about private and public life in a world of global networks, intrusions of social media, and increasing video surveillance that challenge our autonomy and privacy.

Keywords
boundaries; global network society; housing design; private-public interfaces; transition spaces

Issue
This commentary is part of the issue "Assessing the Complex Contributions of Christopher Alexander" edited by Michael W. Mehaffy (Sustasis Foundation) and Tigran Haas (KTH Royal Institute of Technology).

In *Community and Privacy*, Chermayeff and Alexander (1963) proposed constructing built environments, especially residential buildings, with a spatial organization that enables the regulation of access between private and public areas by the mediating effects of transition spaces. This problematic was also addressed in *A Pattern Language* by Alexander et al. (1977); they described the functions and challenged the removal of transition spaces between public and private domains in contemporary residential neighbourhoods. This common trend in built environments is the manifestation of radical social changes that have supported individualism but also impacted personal privacy and communal life.

Sixty years later, I argue that the concern of Chermayeff and Alexander (1963) has largely been forgotten even though it is highly relevant in a global network society. Given that face-to-face personal contact is increasingly replaced by virtual reality, and communication with audio-visual devices are championed by social media around the world, I posit that the need to nurture personal relations and regulate unwanted real or virtual contacts is crucial for physical and mental health, and community well-being, in a hyper-connected world.

Our capacity to regulate interpersonal contact is not an easy task in a global network society. This regulation involves the capacity to control social contacts and physically withdraw to a personal space that can be appropriated psychologically and physically as explained in Hartig and Lawrence (2003). This is one inherent quality that the architecture and interior design of all housing should enable, whereas I think it has been devalued, or ignored, by too many professionals in the built environment sector (Lawrence, 1987); for example, transition spaces, such as the porch that shelters the front door of a housing unit, and the entrance hall or lobby beyond the front door, have often been deleted so there is no space between outdoors and indoors, or public and private domains. Thus, a reduced capacity to maintain our homes as the ultimate refuge between us and others in a stressful hyper-connected world has been compromised by the design of housing (Lawrence, 1987). Consequently, our autonomy has been challenged because it is increasingly difficult to control acoustic and visual privacy and

interpersonal contact at the border between the public and private domains of our daily lives.

Autonomy and responsibility are two fundamental human-centred principles that should be included in reflections about the pertinence of community and privacy in a hyper-connected world. Although individuals and groups are never independent and disconnected from their *milieu de vie*, their right to make choices is crucial in the context of increasing diversity and heterogeneity about the way we live. My interpretation of autonomy refutes claims of neoliberal ideology about individual liberty that overrides personal and shared responsibilities about our relations with others and our shared habitat (Lawrence, 2021). When these responsibilities, grounded in shared ethical principles and moral values, are agreed collectively, then community bonding and collective projects can be nurtured and sustained.

Unfortunately, the demise of shared collective spaces between public and private domains is a well-known trend supported by modern architecture that has counteracted the ability of individuals and groups to regulate interpersonal contact with others, especially friends, neighbours, and strangers (Lawrence, 1989). This has led to the many undefined and unused spaces in residential areas that remain devoid of meanings and daily functions. Notably, Jane Jacobs (1961), like Chermayeff and Alexander, also questioned this trend six decades ago in her criticisms of modern urban planning. I explained in Lawrence (1996) that this longstanding trend can be related to numerous reasons, including an incomplete understanding of the multidimensional nature of boundaries, especially how they can enable and support, or counteract and compromise, individual autonomy and shared responsibility in our daily lives.

Boundaries between public and private domains should be interpreted according to combinations of architectural/physical, behavioural/psychological, conceptual/cognitive, and legal/administrative constructs that change over time (Lawrence, 1996). Human-made boundaries are one way of expressing differences between groups of people, attributing different meanings to their activities, and separating the spaces in which they occur. Buildings shelter people and their private activities while demarcating them from the public domain. However, a restricted focus on architectural and urban design will not account for the multidimensional nature of boundaries between public and private domains. These characteristics should be complemented by others including cultural predispositions that prescribe behavioural rules and social conventions, as well as legal and administrative frameworks that delimit the roles and responsibilities of individuals and groups in public and private spaces (Lawrence, 1996). The multidimensional nature of boundaries I proposed has been illustrated by the diversity of national responses that were meant to regulate interpersonal contact after the outbreak of the Covid-19 pandemic in 2020 (Lawrence, 2020).

Research on housing and health over a century has confirmed that the incidence and transmission of infectious diseases are correlated with core indicators of housing quality. Notably, the incidence and transmission of the Covid-19 after the World Health Organization declared the pandemic on 11 March 2020 confirms interdisciplinary research about housing conditions that influence health; the main housing variables are housing size (e.g., floor area, or number of rooms), occupancy conditions (number of persons per room), and indoor air quality including natural ventilation (World Health Organization, 2018). Housing size and occupancy conditions influence the capacity of rooms to accommodate diverse activities, the nature of personal space indoors, and the ability of residents to control interpersonal contact indoors. In addition, housing cost (interpreted as a cost/quality ratio related to household income) and location (e.g., geographical and the social status of the neighbourhood) do influence residential satisfaction and quality of life (World Health Organization, 2018).

Social research since 2020 in Switzerland, for example, found that a large majority of the Swiss population have spent more time indoors after the declaration of the pandemic; housing has accommodated a larger number of functions including study, and work-related activities, that did not occur inside housing units before 2020 (Pagani et al., 2021). This research also concluded that when daily extra-domestic activities are transferred from elsewhere to indoors then a lack of indoor space for these activities threatens residential privacy and can become a source of stress for all members of households. Today, we know that behavioural, biological, cultural, economic, social, physical, and political factors need to be considered as a web of interconnected variables if a comprehensive understanding of the multidimensional nature of housing is to guide individual/private and societal/public measures to counteract public health risks. More transdisciplinary and collaborative research contributions are necessary: A triad of interrelated variables defined by interdisciplinary knowledge and professional know-how, multi-level governance, and behavioural and cultural characteristics of residents provides a transdisciplinary framework for policy definition and implementation to improve "the residential context of health" by public authorities (Hartig & Lawrence, 2003).

Global challenges such as the case of Covid-19 illustrate the pertinence of a public debate about the regulation of private lives. This recalls the concern expressed by Chermayeff and Alexander 60 years ago about how the spatial organization of buildings influences and perhaps helps reduce conflicts between individual/private autonomy and social/public responsibility. Their architectural interpretation included thresholds and transitions that can serve as boundary markers that regulate interconnections between public and private spaces. However, we have learned since then that an enlarged transdisciplinary interpretation is necessary and can build on research about the multidimensional nature of

boundaries. In sum, fundamental principles defined in *Community and Privacy* are pertinent and omnipresent. They include the conflicts and tensions between individual liberty, collective responsibility, and public commitment to resolving persistent problems and emergent global challenges (Lawrence, 2021). The interrelations between public and private, personal and communal, local and global are omnipresent not only in architecture and urban planning but many other constituents of our being in the world. Notably, these crucial subjects are inherent in public debates about the contribution of built environments to enable effective societal responses to global challenges, including mitigating infectious diseases, adapting effectively to climate deregulation and extreme weather events, promoting and sustaining affordable housing, and enabling food sovereignty (Lawrence, 2021). Today, housing, building, and urban planning have become complicated technical processes that have commodified our habitat and much of our daily activities. In contrast, innovative research and practice confirm that built environments can be the catalyst and setting for innovative responses to societal challenges particularly at the city and community level. There is an urgent need for a new mission and communal sense of purpose that upholds a humanistic perspective of human habitats grounded in ecological and ethical responsibility and just moral values.

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Conflict of Interests

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References

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A pattern language: Towns, buildings, construction*. Oxford University Press.

Chermayeff, S., & Alexander, C. (1963). *Community and privacy: Toward a new architecture of humanism*. Doubleday.

Hartig, T., & Lawrence, R. J. (Eds.). (2003). The residential context of health. *Journal of Social Issues*, *59*(3), 455–650.

Jacobs, J. (1961). *The death and life of great American cities: The failure of town planning*. Random House.

Lawrence, R. J. (1987). *Housing, dwellings and homes: Design theory, research and practice*. John Wiley.

Lawrence, R. J. (1989). Translating anthropological concepts into architectural practice. In S. Low & E. Chambers (Eds.), *Housing, culture and design: A comparative perspective* (pp. 89–114). University of Pennsylvania Press.

Lawrence, R. J. (1996). The multidimensional nature of boundaries: An integrative historical perspective. In D. Pellow (Ed.), *Setting boundaries: The anthropology of spatial and social organization* (pp. 9–36). Bergin and Garvey.

Lawrence, R. J. (2020). Responding to COVID-19: What's the problem? *Journal of Urban Health*, *97*(4), 583–587. https://link.springer.com/article/10.1007/s11524-020-00456-4

Lawrence, R. J. (2021). *Creating built environments: Bridging knowledge and practice divides*. Routledge. https://www.routledge.com/Creating-Built-Environments-Bridging-Knowledge-and-Practice-Divides/Lawrence/p/book/9780815385394

Pagani, A., Hansmann, R., Fritz, L., & Binder, C. R. (2021). How the first wave of COVID-19 in Switzerland affected residential preferences. *Cities & Health.* Advance online publication. https://www.tandfonline.com/doi/full/10.1080/23748834.2021.1982231

World Health Organization. (2018). *Housing and health guidelines*.

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Article

A Grid Is Not a Tree: Toward a Reconciliation of Alexander's and Martin's Views of City Form

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Abstract
Christopher Alexander famously declared that "a city is not a tree," while Leslie Martin declared that "the grid is [a] generator." This article investigates how Alexander's call for overlap, adaptability, and order can indeed be manifested in grid networks, as Martin claimed. Order has been measured using the entropy of street orientation, while adaptability has been denoted by the streets' betweenness values. Through the analysis of Abu Dhabi's neighborhoods and global urban areas, the study reveals that overlap, order, and adaptability can coexist in gridded street network. A fine-grain scale of the grid plays a critical role in supporting the quality of urban space. To foster adaptation, planning policies should focus on adaptability providing room for informal and spontaneous growth. We conclude by noting that this approach represents a reconciliation between Christopher Alexander's views and those of Leslie Martin.

Keywords
Abu Dhabi; adaptability; betweenness; Christopher Alexander; grid; Leslie Martin; order; urban form

Issue
This article is part of the issue "Assessing the Complex Contributions of Christopher Alexander" edited by Michael W. Mehaffy (Sustasis Foundation) and Tigran Haas (KTH Royal Institute of Technology).

1. Introduction

Christopher Alexander is quoted as having said: "We both know what the appliance is. What we need to do now is to design the plugs to connect to the current power grid" (Alexander, 2004, as cited in Mehaffy, 2008, p. 69). He uses the power grid as a metaphor for the mass production process that is the substrate of modern civilization. Nevertheless, there are great concerns over issues of mass production. Koolhaas (1995, p. 28) laments that "this century has been a losing battle with the issue of quantity." Andres Duany compares the process of mass production with automated protocols in the real estate industry that enable residential and commercial buildings to be purchased and then developed in a single transaction (Mehaffy, 2008).

Alexander's metaphor equates the plug to a mechanism that takes advantage of mass production, making manufactured products more adaptable. The plug facilitates bottom-up and self-organized processes within a top-down system. Planners need to design a functional "plug": a mechanism or special modus operandi for generating bottom-up or self-organized processes.

To create a truly adaptable and vibrant built environment, planners must go beyond the traditional view of the grid as a mere generator of order. A grid network must be designed with qualities that promote efficiency while also fostering informal qualities and diversity. By doing so, planners can overcome the limitations of mass production in planning and allow for the free adaptation of built and non-built elements such as buildings, open spaces, and social activities.

The gridiron street network is ubiquitous in urban history; it has existed since the dawn of civilization to impose order and demonstrate control over nature (Mazza, 2009). From Hyppodamus of Miletus plan

to China's Forbidden City (Kostof, 1991) and modern American cities, the grid has remained a fundamental planning language in building spaces. Its ability to facilitate rapid and efficient construction allows cities to expand at an unprecedented pace.

Leslie Martin (1972, p. 9) famously argued that the grid is not only a framework for urbanization but a tool for generating complexity in a city, associating that with "a net placed or thrown upon the ground." Meanwhile, Bettencourt (2015) recognizes that the grid, with its large number of possibilities, yields an endless array of social and economic arrangements in urban spaces. In his analysis of the gridiron network, Martin has argued that Alexander diminishes the value of such a system. However, this view seems to be at odds with Alexander's own position. In his seminal article "A City Is Not a Tree," Alexander (1965) referred to the gridiron as an exemplar of a system, which he later called a "semilattice." In fact, Alexander has used Manhattan—a gridiron urban environment—as a typical example of a grid that accommodates both order and complexity/adaptability. Thus, it is important to understand the nuances of Alexander's position on the gridiron network. Despite Martin's (1972) statement about "the grid as a generator," there is a dearth of research on the mechanism of this generator: the way a grid generates adaptability or its *modus operandi*. While several studies provide discourses about planned cities (Al Sayed et al., 2009), an analytic approach is needed to investigate the physical conditions that influence how well a grid can generate adaptability. This study attempts to explore how order and adaptability can *coexist* in a grid network and the physical conditions that facilitate these properties. Order has been measured from an analytical point of view. Boeing (2019) and Gudmundsson and Mohajeri (2013) have used entropies of street orientations to represent levels of order of a city. However, adaptability has not been measured explicitly in any research. This article devises a new approach for measuring adaptability, known as the quality of a semilattice system which in turn can be defined in terms of overlapping as stated by Alexander (1965). A semilattice, as defined by Alexander (1965), is a network of elements that are connected in a way where multiple paths between any two points are possible. This semilattice structure allows for redundancy and flexibility, as any element of this structure can be reached through multiple routes. In the context of this article, a semilattice concept is used to measure the adaptability of a grid network, as it allows for multiple connections and routes between elements whether they are nodes or edges, which can facilitate the emergence of bottom-up and self-organized processes within the top-down system.

The article examines betweenness values and entropies of street network orientations—proxies for the adaptability and order of grid networks. To categorize cities with diverse street patterns in terms of order and adaptability, the article assigns these proxies to the vertical and horizontal axes, respectively, to quantify order and adaptability for street networks. Specifically, using Abu Dhabi's street network as a case study, the article aims to answer the following questions:

1. How do adaptability and order operate and manifest in a grid network?
2. What morphological properties of a grid act as generators for adaptability and order? To what extent do adaptability and order perform in a grid network?
3. What strategies can be used to design street networks to accommodate both order and adaptability?

This article investigates seven neighborhoods in Abu Dhabi. In each neighborhood, three sample areas with the same size of one square mile are selected. To give a meaningful understanding of the way grid networks operate, Abu Dhabi's neighborhoods are compared with those of 60 other urban areas throughout the world. The cities are selected to represent diverse network types and are located in different geographical and cultural conditions. Through this comparison, a thorough understanding of the mechanism that makes a grid network become "great streets" emerges.

2. Literature Review

2.1. Virtues of a Grid Network

On the 50th anniversary of the publication of Alexander's article "A City Is Not a Tree," Porta et al. (2015) rediscovered the value of Martin's argument on gridiron networks. "The grid is a generator" is a provocative essay in which Martin (1972) pointed out that the grid is a tool to generate complexity in a city. According to Martin (1972, p. 75), a grid network is "a kind of playboard that sets out the rules of the game." The game's players are stakeholders who act according to the rules but have the freedom to use whatever initiatives and skills they have. This essay is Martin's refutation of Alexander's (1965) article. Martin criticized Alexander for diminishing the value of a gridiron network, an erroneous rejection. In fact, Alexander asserted that a gridiron is a typical example of a semilattice system and that it promotes the adaptability that is essential for "natural cities." Despite Martin's misjudgment, his support for a gridiron network was insightful: a grid is "an 'organic' growth and, without the structuring element of some kind of framework, is chaos" (Martin, 1972, p. 75). Furthermore, he stated that the grid sets a particular structure for a city but then allows a city to develop and grow in its own way. Martin's observation about the grid's merits in supporting organic growth is congruent with the quality of "the semilattice structure of natural cities" proposed by Alexander (1965, as cited in Porta et al., 2015, p. 121).

Martin recognized the grids' positive qualities. Yet, he admitted the grid's drawbacks, such as its monotony

and rigidity. The way a grid accepts and responds to growth and change is conceptualized in this article as its adaptability. To understand "the interaction between the grid and the built form" (Martin, 1972, p. 76) or the "combinatorically large number of possibilities" (Bettencourt, 2015, p. 45), we use order and adaptability as the key performance indicators for the grid.

2.2. Urban Order

Order is usually perceived as good and disorder as evil. Nevertheless, this distinction is not always sharp. Aferi (2011, p. 54) states that it is "somewhat fuzzy," and Kostof (1991, p. 44) argues that the "irregularity of unplanned cities is also a matter of degree." He emphasizes that this kind of distinction is a matter of the "metamorphosis" of regularity/planned/order vs. irregularity/unplanned/disorder. It is not hard to see the comingling of order and disorder that is pervasive in traditional cities. Therefore, the cohabitation of irregular and planned street networks is not just a natural phenomenon but also an exemplar of a good city form.

In this article, the term order is used in line with Aferi's (2011, p. 44) explicit order—"the recognizable and explicit order in street layouts, consistent setbacks, and coherent physical and visual attributes." Recent works on assessing the order of street networks use street orientation entropy as an assessment measure (Boeing, 2019; Gudmundsson & Mohajeri, 2013). This article implements their method to quantify the level of order of a grid network. There are several other methods used in the literature for quantifying urban order. One example is the spatial autocorrelation analysis, which examines the degree of similarity in spatial patterns of different urban attributes. For instance, some researchers have proposed using fractal dimensions to measure urban order. For example, Frankhauser and Pumain (2022) applied fractal geometry for a better understanding of the hierarchical organization and spatial structure of urban order. Similarly, Jia et al. (2019) employed the correlation fractal method to explore place diversity at the neighbourhood scale in Brisbane, Australia. By measuring the spatial correlation between the density of buildings in a given area and its surrounding, the study found that Brisbane's urban form lacks place diversity and is influenced by modernist planning principles. These approaches demonstrate the diverse methods available for quantifying urban order and highlight the importance of using multiple measures to capture the complexity of urban form and its function. This article uses Boeing's (2019) and Gudmundsson and Mohajeri's (2013) methods to quantify the level of order in a grid network.

2.3. Adaptability

Thinkers such as Alexander and Jane Jacobs criticized the simplified tree pattern of a city, not order nor grid-iron street patterns. Alexander particularly advocated for the semilattice structure, in which urban elements overlap and interact. Porta et al. (2015) explain further that the amalgamation of streets, block design, and placement of buildings should not separate activities from one another, but rather should promote integration between people and the built environment. The lesson here is that street patterns should "naturally overlap in space in unpredictable ways" (Porta et al., 2015, p. 123) and thereby build favorable conditions for overlapping activities to take place.

The general perception is that adaptation and self-organization happen in informal settlements (Kamalipour, 2016, p. 71), but incremental transformation also happens in a planned city, exemplified in its grid network. Adaptation is often perceived as transformation through time. To our best knowledge, adaptability has not been measured explicitly in any research. Thus, this article devises a new approach to measuring adaptability, the quality of a semilattice system which is in turn defined as overlapping (Alexander, 1965). The article finds that levels of movement on a street segment represent overlapping activities in a street network. This value of movement is known as betweenness centrality, a measurement of movement intensity a street segment through many shortest paths connecting different couples of nodes (Porta et al., 2006).

3. Methods

In this article, order and adaptability of street networks of Abu Dhabi and other international urban areas are quantified as entropies and betweenness centrality. These values are then plotted along vertical and horizontal axes.

3.1. Sample Selection

Seven neighborhoods in Abu Dhabi are selected as case studies. The selection includes West Island, Khalifa City, Al Bahya East, Al Bahya West, Mohamed Bin Zayed (MBZ), Al Falah, and Bani Yas (Figure 1). From each neighborhood, three sample areas of one square mile are selected, following the tradition of urban network study by Jacobs (2001). The neighborhood planning units (NPUs) are ordered chronologically from 1968 to 2015, representing the evolution of neighborhoods over 50 years. Each NPU is unique in terms of its street layout and level of grid-likeness. Moreover, the samples included street networks with different levels of grid-likeness, ranging from the perfect grid to high levels of fragmentation and cul-de-sacs.

To acquire a reasonable understanding of grid network structures, the study meticulously compares samples of Abu Dhabi's neighborhoods with other urban neighborhood samples taken from 60 cities worldwide (Figure 2). In order to ensure consistency, each city is represented by three sample areas measuring one

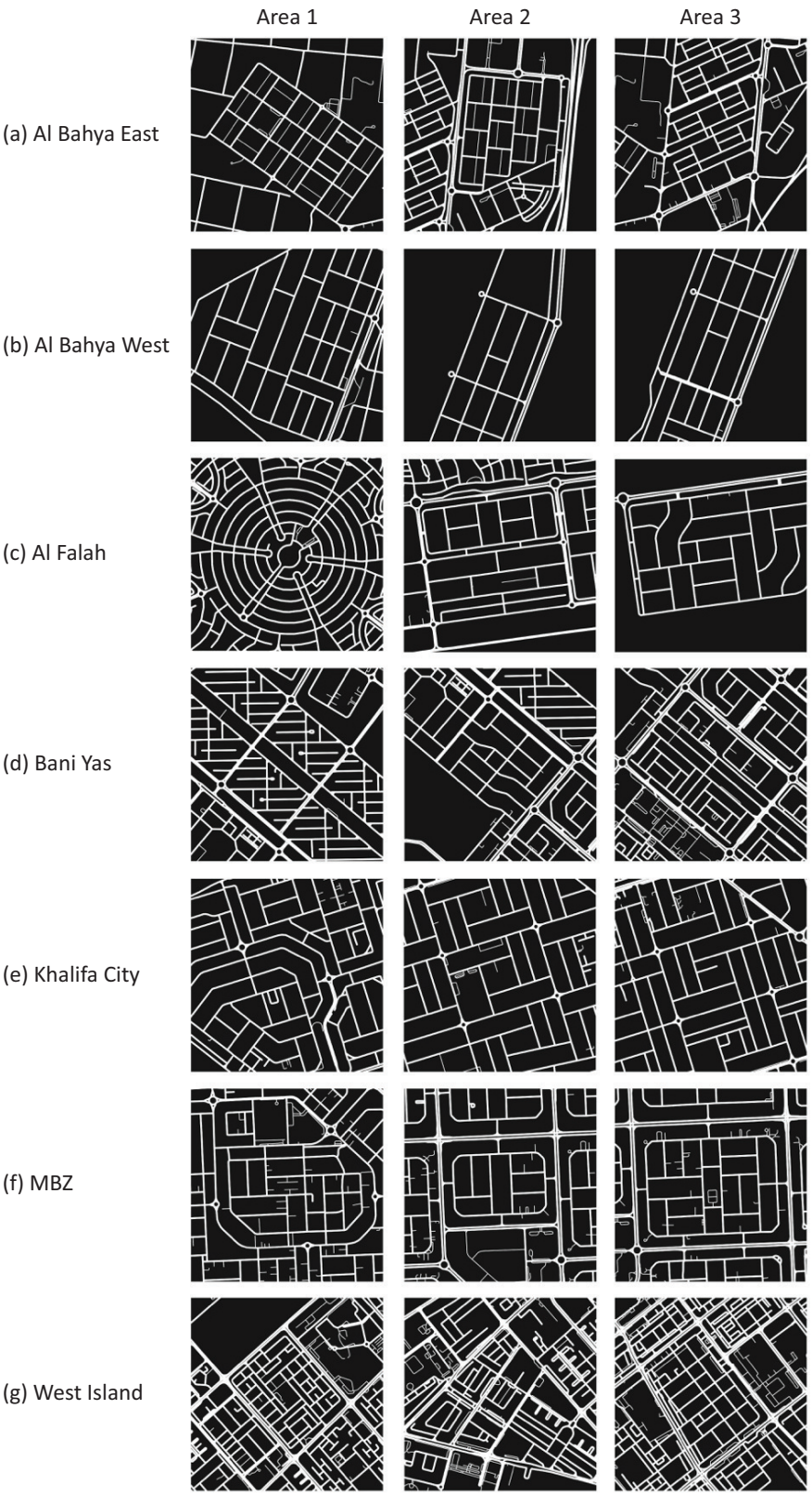

Figure 1. Street networks of Abu Dhabi's neighborhoods.

square mile, mirroring similar approaches conducted in previous studies (Jacobs, 2001; Porta et al., 2006; Scoppa et al., 2018). The street networks of Abu Dhabi and the international case studies were retrieved using OSMnx, a tool developed by Boeing (2017, 2019) that allows users to download, model, analyze, and visualize OpenStreetMap data for any location in the world. It provides a simple and efficient way to download and work with OpenStreetMap data, including street networks, building footprints, points of interest, and other features.

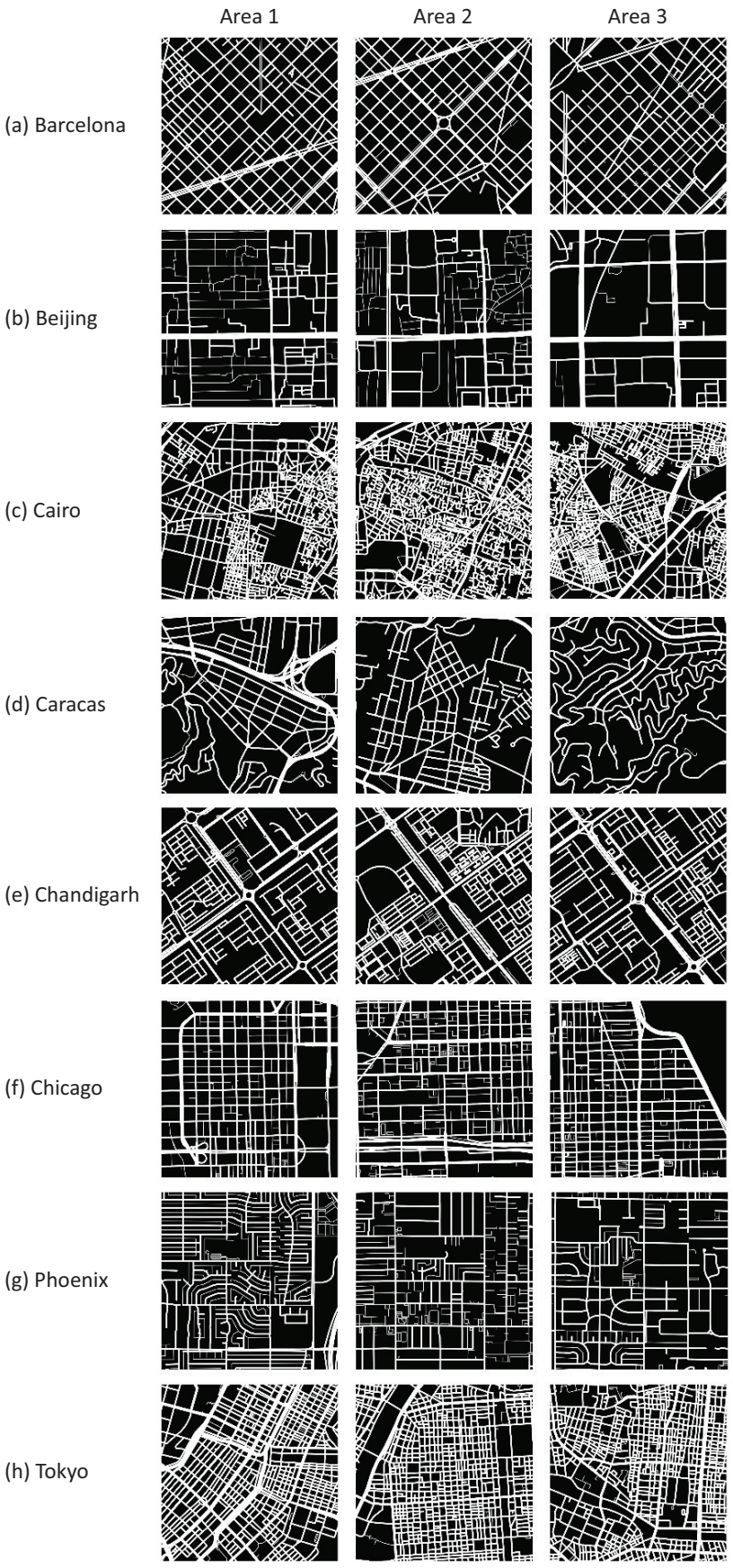

Figure 2. Street networks of selected international urban areas.

Additionally, OSMnx offers a range of network analysis tools that enable users to measure network metrics such as degree centrality, betweenness centrality, and clustering coefficients. Overall, OSMnx is a powerful tool for urban planners, geographers, and researchers interested in studying urban form and function (Yabe et al., 2022). The selection of the comparison urban areas is inspired by Jacobs' (2001) and Boeing's (2017, 2019) works. Both authors use diverse urban street networks from different regions and cultures to represent the whole gamut of street configurations, from the most connected and grid-like to the most circuitous and fragmented.

3.2. Measuring Order

According to Gudmundsson and Mohajeri (2013), the Shannon (1948) entropy of a city's network system represents the order of street orientations in that city. The higher the entropy, the higher the level of disorder in its neighborhoods. To compare the level of order of each NPU or urban area, the normalized value of orientation entropy ϕ, developed by Boeing (2017), is computed. This value represents the level of disorder or uniformity of street networks in a city or neighborhood. The smallest value of ϕ is 0, which represents complete disorder, while $\phi = 1$ represents perfect order. Values of entropy of 21 NPUs of seven neighborhoods in Abu Dhabi and 180 samples of 60 other urban areas are computed. Implementing the same size of one square mile facilitates a comparison of order levels across different geographic locations. By comparing the adaptability and order of Abu Dhabi NPUs with those of other urban areas, the mechanism for building order and adaptability in a grid network can be understood.

3.3. Measuring Adaptability

Grid is a generator of order. However, its capacity for adaptation is unknown. Kostof (1991), Lynch (1981), Porta et al. (2015), and other scholars state that a grid can adapt to different topographic regions. But the questions of how and in what way a grid can facilitate both adaptability and order and how these qualities manifest in different grid typologies remain unanswered. Alexander (1965) mentions that adaptability is represented in *overlapped elements*. He argues that a natural city (e.g., a self-organized settlement) contains various levels of overlap. This overlapping structure is what Alexander called *semilattice*, a structure that possesses many overlapping characteristics yet maintains order. To measure the flexibility of a grid and its capacity for adaptation, the article evaluates its level of overlap.

In discussing the street network, Bettencourt (2015, p. 50) argues that "while infrastructure and economic activities, for example, change radically, the fact that people need to interact over space remains." He elaborates on Alexander's idea of the overlap of a semilattice network, arguing that "it is people who, through their movement and multiplicity of functions, create overlaps between places in the city." Hence, the more the people's movement takes place on the streets, the more overlapping occurs.

Consider an example of a street segment which connects buildings A and B, as in Figure 3. When people move from building A to building B, they not only implement a movement but also carry out a functional and social activity along their path from space A to space B and vice versa. Therefore, the number of movements on the street segment represents levels of overlapping activities between buildings A and B. In centrality analysis, measuring the movement intensity of a street segment is known as betweenness, which accounts for how many times a street segment was part of multiple shortest routes connecting pairs of nodes (Porta et al., 2006). To illustrate the rationale for using betweenness as a proxy for measuring adaptability of the street networks, Figure 3 presents a diagram showing the way betweenness values represent the potential overlapping activities in a theoretical grid network. Street segment b2 represents the level of overlapping activities between A and B, A and C, and A and D. The same patterns happen with overlapping activities for B (to A, C, D), C (to A, B, D), and D (to A, B, C). A segment of streets that is selected most for walking is the segment that has the highest betweenness value. Therefore, this segment has the highest level of activity. The activities can be any social or functional movements (e.g., shopping or commuting). These activities require shared spaces, and these spaces are the streets that have high betweenness values. Thus, the authors argue that the betweenness centrality represents levels of overlapping in a network. The higher the mean value of betweenness in a street network, the more likely it will be traversed by people. This reflects the network's increased adaptability. Due to the absence of a betweenness benchmark for assessing what is the level of adaptability that is acceptable, the best assessment of betweenness values is to compare them against a cohort of cities that are known for having high levels of adaptability, such as Manhattan, Barcelona, and San Francisco (Jacobs, 1961).

To measure the adaptation, the authors calculate the betweenness values using momepy, a Python package developed by Fleischmann (2019). Using the analysis and manipulation of urban form and street networks, the package provides a range of tools for calculating various metrics related to street networks, such as block shape and size, street centrality, and connectivity. It also includes functions for visualizing and plotting network data. The momepy package is designed to work with OpenStreetMap data, making it a valuable tool for researchers and urban planners interested in analyzing and modeling urban environments.

To understand the correlation between order and adaptability, and especially to understand the impacts that order has on adaptability, a linear regression between entropies and logarithmic values of

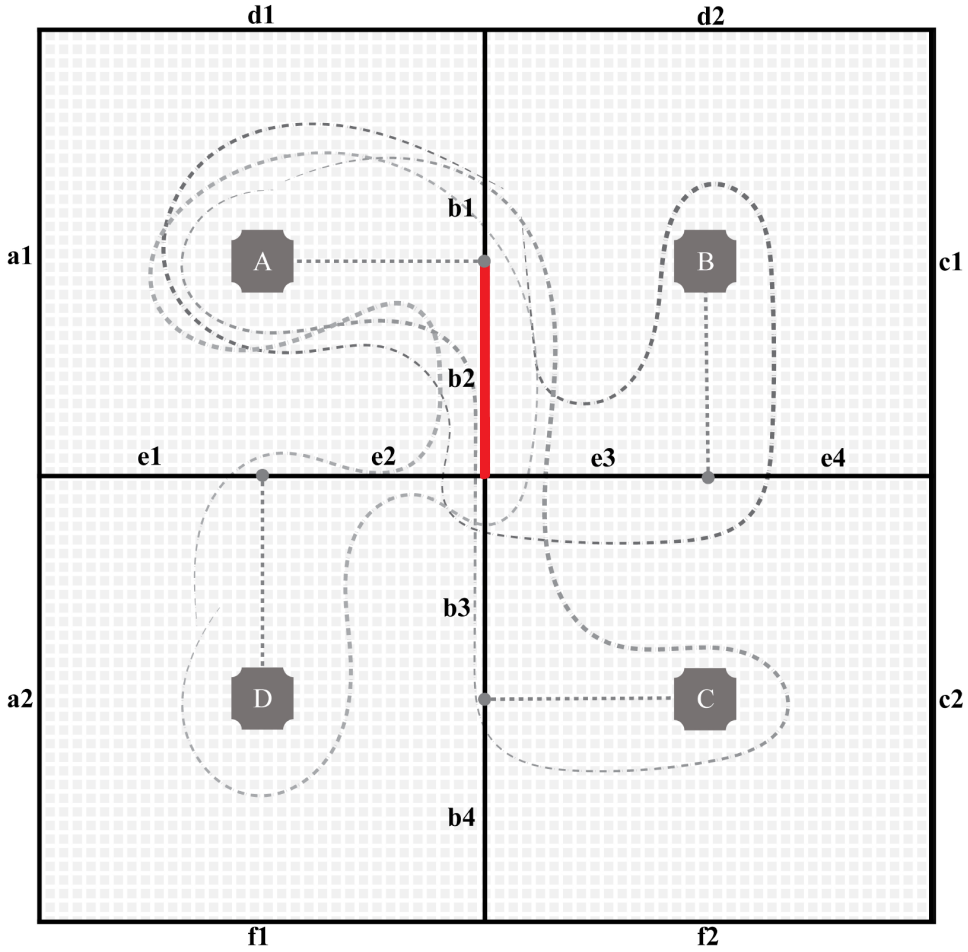

Figure 3. Overlapping activities from A to B, A to C, and A to D for the theoretical case of a grid network.

betweenness is modeled. The linear regression provides an understanding of the impact that order could have on adaptability.

4. Results

4.1. Order

Table 1 presents the indicators for the 21 samples of one square mile of the seven neighborhoods in Abu Dhabi. Among these seven neighborhoods, Al Bahya West, Khalifa City, Al Falah, and MBZ have the highest levels of order, with a ϕ of 0.98, 0.86, 0.84, and 0.83, respectively. West Island has the lowest level of order, with ϕ = 0.62. According to Boeing (2019), a perfect grid would have an entropy value of ϕ = 1. This means that West Island is 62% ordered, while Al Bahya West, at 98%, is close to being perfectly ordered. The same kind of interpretation applies to Khalifa City, Al Falah, and MBZ. The ϕ values can also be interpreted as closeness to a perfect grid. The higher the ϕ, the closer the neighborhood's street network is to a perfect grid. Moreover, order is expressed differently for the pre- and post-1990s neighborhoods. Five out of seven studied neighborhoods that have been built since 1990—Al Bahya East and West, Khalifa City, MBZ, and Al Falah—have high levels of entropy, ranging from 0.82 to 0.98. In contrast, neighborhoods built before the 1990s, including Bani Yas and West Island, have moderate to moderate-low levels of order (0.74 and 0.62, respectively). Hence, with an average value of order ϕ = 0.81 and five out of seven studied neighborhoods with ϕ values larger than 0.82, Abu Dhabi can be labeled as a city of high order.

4.2. Adaptability

Ranking Abu Dhabi neighborhoods in terms of movements—represented by the mean values of betweenness—the analysis reveals that West Island, with a betweenness value of 7,193, has the greatest number of movements (Table 1). This value indicates that West Island has the highest level of overlap. While West Island has the highest betweenness value, it has the lowest level of order, with ϕ = 0.62. In contrast, Al Bahya West has a mean betweenness value of only 118 but the highest level of order, with ϕ = 0.98. Other neighborhoods' values of order and betweenness tend to confirm the trend of lower order/higher betweenness and vice versa. The differences in betweenness values are substantially different from the highest to the lowest

Table 1. Mean values of betweenness and normalized entropies of one-square-mile samples of selected world's urban areas.

City	H_o	ϕ	B	$\log_2 B$	Block size (m)
West Island	2.74	0.62	7,193	12.81	58.3
Bani Yas	2.51	0.74	2,010	10.97	82.9
Al Bahya East	2.27	0.82	1,499	10.55	88.4
MBZ	2.3	0.83	1,323	10.37	101.1
Khalifa	2.19	0.86	838	9.71	108.6
Falah	2.17	0.84	750	9.55	136.5
Al Bahya West	1.66	0.98	118	6.88	192.8
Beijing	2.18	0.87	1,038	10.02	110
Shanghai	2.68	0.65	4,047	11.98	92.2
Tokyo	2.89	0.53	29,860	14.87	33.1
Barcelona	2.71	0.64	10,770	13.39	41.5
Moscow	2.84	0.56	21,307	14.38	43.2
Paris	2.75	0.61	7,174	12.81	50.3
Caracas	2.54	0.72	1,022	10	116.3
Boston	2.84	0.56	9,457	13.21	49.4
Chicago	2.73	0.62	10,157	13.31	47.1
Manhattan	2.58	0.69	5,895	12.53	53
Phoenix	2.44	0.76	3,315	11.69	87.8
San Francisco	2.6	0.69	11,206	13.45	45.5
Washington	2.64	0.66	12,034	13.55	47.1

values in Abu Dhabi. West Island has a betweenness value 60 times higher than the betweenness value of Al Bahya West. This significant difference among the overlapping level of Abu Dhabi neighborhoods indicates that older neighborhoods are more adaptable. Bani Yas and Al Bahya East confirm this: Bani Yas has the second-highest level of adaptability, with a betweenness value of 2,010, and Al Bahya East has the third-highest level of adaptability, with a betweenness value of 1,499.

Figure 4 demonstrates the relationship between the betweenness values and ϕ values for Abu Dhabi's NPUs. Neighborhoods in Abu Dhabi can visually be grouped into two main groups and two outliers. Bani Yas, built during the 1970s, is the only member of the first group of Abu Dhabi's neighborhoods. It has a mean value of betweenness of 2,010 and a ϕ value of 0.74, which makes it quite different from the rest of the neighborhoods but not different enough to make it an outlier as in the cases of West Island (very high betweenness/low entropy) and Al Bahya West (very low betweenness of 118/very high entropy). The second group includes Al Bahya East, MBZ, Al Falah, and Khalifa City. This group has ϕ values that increase from 0.82 to 0.86 and mean betweenness values that decrease from 1,499 to 750. As shown in Figure 4, these neighborhoods form the second group of street networks in Abu Dhabi.

5. Discussion

5.1. Abu Dhabi: A City of High Order and Low Adaptability

Abu Dhabi's neighborhoods accommodate a high level of order. Its obtained normalized entropy has a high average value of ϕ = 0.81. The level of adaptability, in contrast, is quite low. The average value of betweenness is only 1,962. Except for the two outliers of very high and low adaptability of West Island (7,193) and Al Bahya West (118), the average adaptability of the five neighborhoods Bani Yas, Al Bahya East, MBZ, Khalifa, and A Falah reaches only 1,284.

The high order and low adaptability in Abu Dhabi neighborhoods may be attributable to its history of having been planned and developed from a barren semi-island—a tabula rasa—and having used a top-down planning system since its inception. However, it is not evident whether cities with superblocks or NPUs always produce urban areas with high order and low adaptability. To unravel this issue, the authors assess a variety of grid networks, from the most fragmented to the most grid-like, of different urban regions around the world.

Sixty urban areas around the world have been selected; they represent diverse types of street networks from the most connected, organic, and grid-like to the

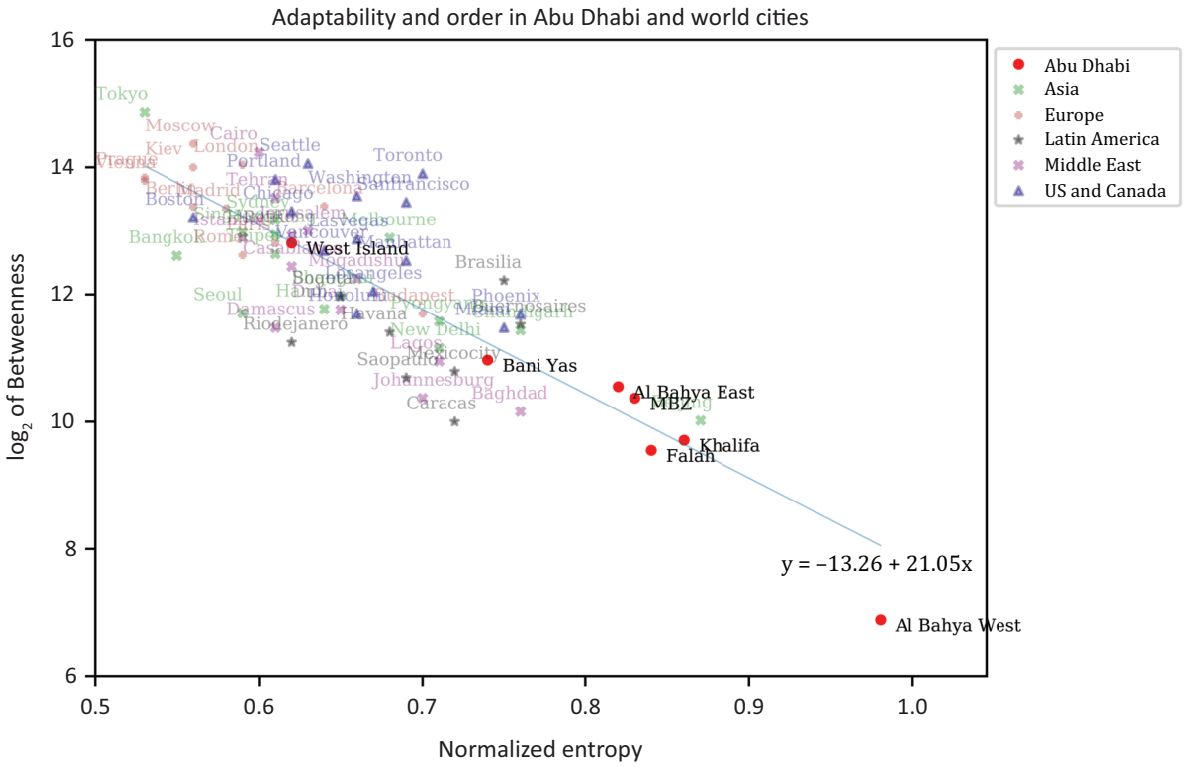

Figure 4. Relationship between order and adaptability of Abu Dhabi's NPUs against the world urban areas.

most circuitous and fragmented (Table 1). The street networks of Manhattan, Chicago, Barcelona, and Paris represent almost perfect grids yet hold a high quality of urban life (Boeing, 2019; Jacobs, 2001). Figure 4 represents the relationships of adaptability and order of different groups of Abu Dhabi neighborhoods and these global urban areas. The figure includes two outliers: Tokyo, which has an exceptionally high betweenness value and low order (29,860 and 0.53, respectively), and Beijing, which has a low betweenness value and high order (1,038 and 0.87, respectively). The adaptability and order of the world's urban areas closely follow an inverse logarithmic linear relationship. The higher the values of betweenness, the lower the values of order, and vice versa.

To assist in the evaluation of adaptability and order in grid networks, the authors propose classifications for both based on values of betweenness and normalized entropies. Values of adaptability are classified into very high (betweenness of 13,000 or higher), middle-high (5,000–13,000), middle (2,000–5,000), low (1,000–2,000), and very low (below 1,000). Similarly, values of order are classified into high ($\phi > 0.8$), middle-high ($\phi = 0.6$–0.8), and middle (ϕ from 0.5 to 0.6); the analysis revealed no middle-low or low order values among the cities tested ($\phi < 0.5$).

The comparison of levels of order between Abu Dhabi and other global urban areas reveals that Abu Dhabi's neighborhoods are more ordered than any other city in the world. For example, among the studied urban neighborhoods (except for those in Beijing), the highest level of order, $\phi = 0.76$ for Phoenix, is smaller than the value for five of the seven neighborhoods in Abu Dhabi ($\phi = 0.82$). Phoenix's ϕ value is only higher than those of Banis Yas (0.736) and West Island (0.622).

Similarly, comparing the adaptability of Abu Dhabi neighborhoods with the world's urban areas reveals that Abu Dhabi has a lower level of adaptability. Table 1 demonstrates that Al Bahya West, the neighborhood with the city's highest level of order ($\phi = 0.98$), has a mean value of betweenness of 118. This betweenness value is substantially lower than that of any comparable global urban area (the lowest mean betweenness value for the comparison cities is 1,022, in Caracas).

5.2. The Coexistence of Order and Adaptability

Figure 4 shows the relationship between normalized entropy and betweenness for Abu Dhabi and the comparison urban areas. It indicates that all neighborhoods in Abu Dhabi and the comparison cities feature an inverse logarithmic relationship between adaptability and order. For example, West Island and Prague have high levels of overlap (7,193 and 14,546, respectively) while their levels of order are low ($\phi = 0.62$ and $\phi = 0.53$).

To answer the first research question on how adaptability and order operate and are manifested in a grid network, the analysis investigates the *coexistence* of order and adaptability. An urban area that has the highest level of adaptability with a low level of order is Tokyo (the mean value of betweenness of 29,927 and $\phi = 0.53$). In Abu Dhabi, the high adaptability/low order relationship expresses a similar trend in the case of West Island

with a mean betweenness value of 7,193 and ϕ = 0.62. This relationship of high adaptability/low order becomes clearer for the rest of the other neighborhoods.

In most cases, for the "good" urban network, the level of order has an upper limit around ϕ = 0.7. From the regression calculation that is developed in Section 3, a change in the value of ϕ from 0.7 to 0.6 generates an increased value of betweenness of 5,276, and a change from ϕ = 0.6 to ϕ = 0.5 generates a greater increase in the value of betweenness of 13,204. Respectively, these are 17% and 44% increases in values of betweenness compared with the value of betweenness of Tokyo, the city with the highest level of adaptability. Because the relationship between adaptability and order is an inverse-power relationship, a small decrease in order can yield a significant gain in betweenness. This observation is correct in both Abu Dhabi and the comparison urban areas. In most cases, it appears that ϕ values of 0.68–0.7 tend to be the highest threshold for cities that have a high level of adaptability. One example is Manhattan, with ϕ = 0.68 and a betweenness value of 5,838. Thus, if a city can trade a small amount of order, a significant level of adaptability can be gained. This observation answers the first question: Order and adaptability can coexist in grid networks.

To answer the question about the morphological properties of a grid that acts as a generator for adaptability and order, the article focuses on neighborhoods and urban areas with high levels of adaptability. The street networks with nonhierarchical order tend to have high adaptability—Tokyo, Cairo, and West Island are examples. The authors consider that this nonhierarchical order facilitates movement in neighborhoods. Small block sizes and small average street lengths characterize all neighborhoods and urban areas that have high levels of adaptability, and grids with values of betweenness above 5,000, in general, have average street lengths less than 60 m (Table 1). Betweenness maps of urban neighborhoods with high and low values of betweenness in cities such as Tokyo and Beijing or West Island and Al Bahya West show striking contrasts. Observing streets in the first quantile (i.e., streets in red) of betweenness reveals an important point. Thoroughfares, streets that accommodate various types of vehicular traffic and speed (Mehaffy et al., 2010), in cities with high adaptability—Tokyo and West Island, for example—usually divide the areas into several small parts. In contrast, cities or neighborhoods with low adaptability, such as Beijing and MBZ, only have two or three of these thoroughfares, which divide the areas into much larger pieces. Therefore, neighborhoods with fine-grain street networks are often conditioned for high adaptability (Figure 5). It also means that streets in cities with high adaptability configure areas into small blocks, whereas streets in cities with low adaptability divide the sample areas into large blocks. Consequently, fine-grain networks are better in terms of adaptability.

Thus, the general guidelines for designing a street network with high adaptability and an adequate level of order are small blocks, fine-grain street networks, and nonhierarchical grades of street systems (i.e., the avoidance of classification of street networks into arterials, highways, local roads, etc.). The neighborhoods with low adaptability in Abu Dhabi and the comparison cities have opposite patterns: super-block designs, disconnections between blocks, and rigid hierarchical street systems.

5.3. The Desirable Networks: Implications for Practice

The above observations have implications for the grid as the manifestation of mass production. Findings about adaptability and order in Abu Dhabi and the world's urban areas indicate that a street network with a middle-high to a high level of adaptability (a betweenness mean of around 5,000 or above) and an adequate level of order (ϕ between 0.6 and 0.7) is a desirable network. These networks are desirable because they have both qualities: adaptability and order. A high level of adaptation equates to a high level of overlap, the very quality that Alexander (1965) used to describe "natural cities." While a grid network needs an overall framework to provide an adequate level of order, it also needs fine-grain urban elements (e.g., small streets, small and diverse open spaces, small blocks, etc.) to foster adaptability.

Several implications can be drawn from this study. First, the scale of the grid (i.e., the dimensions of a network) plays a critical role in supporting or impeding the quality of urban space. The cases of Manhattan and Barcelona are examples. Both cities have the capacity to "accept and respond to growth and change" because of their low levels of order and high levels of adaptability. The key lies in their fine-grain structure. Their average street lengths are all less than 60 m: 58.3 m in West Island, 53 m in Manhattan, and 41.5 m in Barcelona. These low numbers are critical indicators of significant overlapping of movements and activities. These street lengths are quite small in comparison with those of Beijing (110 m) and Caracas (116.3 m). The betweenness maps show that streets in the first quantile of betweenness tend to run straight through most sampled areas (Figures 3.1 and 3.2 in the Supplementary File). These movements distribute the flow of people to different parts of the studied areas, not unlike the "city mobility and fluidity of use" that Jacobs (1961, p. 117) praised.

Second, this finding implies that even though the overall framework of a grid is considered rigid in form, there are conditions that can promote its adaptability. These conditions facilitate the capacity to add new or adjust old physical components—e.g., streets or small open spaces—while maintaining the overall order. If the blocks are too big, as in the cases of Beijing and Caracas, inserted elements can disrupt and bring more chaos, while small blocks such as those of Tokyo and Cairo generally allow for inserting small physical components without disrupting the area; this is, in fact, an incremental development that urbanists advocate for in their research (Alexander, 1965; Jacobs, 1961).

Figure 5. Betweenness maps of selected samples in Abu Dhabi and world cities.

6. Conclusion

This study assesses order and adaptability of street networks. It also introduces a new method to quantify the network's adaptability. While previous research has used street orientation to measure order, this article argues that betweenness values can be used to measure a street network's adaptability. The article found that West Island has the city's highest level of adaptability and an adequate level of order. The remaining studied neighborhoods have lower levels of adaptability when compared with neighborhoods in other world cities. Al Bahya West, for example, has the smallest value of adaptability.

The article discovers that order and adaptability *can coexist*. Urban areas such as Toronto, San Francisco, Manhattan, and West Island have a high level of adaptability while still possessing a decent level of order. Furthermore, if a city can sacrifice a small degree of order, a higher level of adaptability can be obtained. A reduction in the value of the normalized entropy from 0.7 to 0.6 or from 0.6 to 0.5 increases by 17% or 44%, respectively, the value of betweenness in Tokyo—the city with the highest level of adaptability.

This study reconciles the contrasting views between Alexander and Martin. At first glance, it seemed that Alexander's view of cities as "semilattices" with interconnected elements and feedback loops implied that grid networks are not capable of accommodating adaptability and organic growth and change. In contrast, Martin promoted grid networks as a tool to provide a framework for organic growth that breaks away from rigid order, offering higher degrees of freedom and overlapping in activities.

Both Alexander and Martin's views on grid networks are actually not far from each other as this article demonstrated quantitatively. The article proves that grid networks can indeed accommodate growth and change. The regularity of the grid provides a stable foundation that enables a high degree of adaptability and flexibility in a city's development over time. In other words, the grid is a flexible and adaptable structure that can support a diverse and dynamic urban environment.

This study is a revisionist view of the gridiron network—a mechanism of mass production in an urban environment—arguing that the grid has the capacity to produce adaptability and order. The question now is not whether to abandon the grid but how to enhance its adaptability. The research concludes that scales of grid networks play a critical role in supporting or impeding the quality of urban space (i.e., highly adaptable spaces enable high levels of human interaction and support informal development). These activities are manifested in human movements and fluidity. They are facilitated by fine-grain urbanism that improves urban adaptability. Finally, a mechanism for generating bottom-up or self-organized processes can help break the rigidity of the superblocks that are present in many urban areas.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

References

Aferi, M. (2011). Order in informal settlements: A case study of Pinar, Istanbul. *Built Environment*, *37*(1), 42–56.

Alexander, C. (1965). A city is not a tree. *Architectural Forum*, *122*(1/2), 58–62.

Al Sayed, K., Turner, A., & Hanna, S. (2009). Cities as emergent models: The morphological logic of Manhattan and Barcelona. In D. Koch, L. Marcus, & J. Steen (Eds.), *Proceedings of the 7th International Space Syntax Symposium* (pp. 1–12). Royal Institute of Technology.

Bettencourt, L. M. (2015). The complexity of cities and the problem of urban design. In M. Mehaffy (Ed.), *A city is not a tree: 50th anniversary edition* (pp. 45–61). Sustasis Press.

Boeing, G. (2017). OSMnx: A Python package to work with graph-theoretic OpenStreetMap street networks. *The Journal of Open Source Software*, *2*(12), Article 215.

Boeing, G. (2019). Urban spatial order: Street network orientation, configuration, and entropy. *Applied Network Science*, *4*(1), Article 67.

Fleischmann, M. (2019). momepy: Urban morphology measuring toolkit. *Journal of Open Source Software*, *4*(43), Article 1807.

Frankhauser, P., & Pumain, D. (2022). Fractals and geography. In S. Carta (Ed.), *Machine learning and the city: Applications in architecture and urban design* (pp. 31–55). Wiley.

Gudmundsson, A., & Mohajeri, N. (2013). Entropy and order in urban street networks. *Scientific Reports*, *3*(1), Article 3324.

Jacobs, A. (2001). *Great streets*. The MIT Press.

Jacobs, J. (1961). *The death and life of great American cities*. Vintage.

Jia, M., Liu, Y., Lieske, S. N., & Chen, T. (2019). A fractal approach to explore Australian urban form and its impacting factors at neighbourhood scale. In L. D'Acci (Ed.), *The mathematics of urban morphology: Modeling and simulation in science, engineering and technology* (pp. 123–144). Birkhäuser.

Kamalipour, H. (2016). Forms of informality and adaptations in informal settlements. *International Journal of Architectural Research: Archnet-IJAR*, *10*(3), 60–75.

Koolhaas, R. (1995). Whatever happened to urbanism? *Design Quarterly*, *1995*(164), 28–31.

Kostof, S. (1991). *The city shaped*. Thames & Hudson.

Lynch, K. (1981). *A theory of good city form*. The MIT Press.

Martin, L. (1972). The grid as a generator. In L. Martin & L. March (Eds.), *Urban space and structures* (pp. 6–27). Cambridge University Press.

Mazza, L. (2009). Plan and constitution—Aristotle's Hippodamus: Towards an "ostensive" definition of spatial planning. *Town Planning Review*, *80*(2), 113–141.

Mehaffy, M. (2008). Generative methods in urban design: A progress assessment. *Journal of Urbanism: Interna-*

tional Research on Placemaking and Urban Sustainability, *1*(1), 57–75.
Mehaffy, M., Porta, S., Rofe, Y., & Salingaros, N. (2010). Urban nuclei and the geometry of streets: The "emergent neighborhoods" model. *Urban Design International*, *15*, 22–46.
Porta, S., Crucitti, P., & Latora, V. (2006). The network analysis of urban streets: A primal approach. *Environment and Planning B: Planning and Design*, *33*(5), 705–725.
Porta, S., Rofè, Y., & Vidoli, M. (2015). The city and the grid: Building beauty at large scale. In M. Mehaffy (Ed.), *A city is not a tree: 50th anniversary edition* (pp. 163–184). Sustasis Press.
Scoppa, M., Bawazir, K., & Alawadi, K. (2018). Walking the superblocks: Street layout efficiency and the sikkak system in Abu Dhabi. *Sustainable Cities and Society*, *38*, 359–369.
Shannon, C. E. (1948). A mathematical theory of communication. *The Bell System Technical Journal*, *27*(3), 379–423.
Yabe, T., Jones, N. K., Rao, P. S. C., Gonzalez, M. C., & Ukkusuri, S. V. (2022). Mobile phone location data for disasters: A review from natural hazards and epidemics. *Computers, Environment and Urban Systems*, *94*, Article 101777.

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Commentary

The Structure That Structures Us

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Abstract
Christopher Alexander explored the world of built structures. He longed for buildings and spaces that touched and triggered our own psychological and spiritual structure. From his examples of spaces we experience as alive he distilled his Fifteen Properties: aspects and qualities in buildings that quicken us. As architects, we want to learn how we can create structures that embody the Fifteen Properties. Can we do so through consciously attempting to design them? In my experience of designing, we need more than a conscious attempt. We need an awareness of the goal of our designing. And Alexander himself gives us a glimpse of that goal in *The Linz Café*: Our goal is nothing short of designing as an offering to God. What might an offering to God mean? What might it mean as an attitude free from ideology or embalmed belief? The discoveries C. G. Jung made can help us get in touch with such a goal. Our goal is our own divine centre. Our challenge as architects is to open ourselves to the images and structures that appear on our paper or screens as we design. What is their source? Can we see ourselves in them? Can we meet our divine centre in them?

Keywords
divine centre; living structures; original experience

Issue
This commentary is part of the issue "Assessing the Complex Contributions of Christopher Alexander" edited by Michael W. Mehaffy (Sustasis Foundation) and Tigran Haas (KTH Royal Institute of Technology).

Christopher Alexander has left us with wisdom in the form of quite a few buildings and quite a lot of words. How do we plough through the words to get to the essence of Alexander's experience and message? How do we make Alexander's experience our own experience? And how do we apply that experience in our own designing? We can begin by focussing on Alexander's Fifteen Properties (Alexander, 2002, pp. 144–242). Their vignette drawings sum up the visual DNA of living structure (Alexander, 2002, pp. 239–242). Once we've acknowledged that the Fifteen Properties are truly accurate reflections of structures we experience as living, how do we give form to them?

We want to have centres in what we're designing. That's probably our first conclusion after meeting the Fifteen Properties. So we do our best to make centres in the designs emerging on our screens, on our paper, or in the exploratory models we make. But is that enough? My experience tells me it isn't. Why?

Immediately I recall being in love and, for the first time, discovering how to express that love bodily. Does it help to read about other people's bodily positions? No, that would be like putting the cart before the horse. The horse is of course our own love, however young and inexperienced it may be. It's the love that motivates us, that steers our energy toward our lover. It's not a question of technique, of rules to follow, of a checklist to prove we've succeeded.

If our experience of love applies as well to our experience of designing and building, then we've already learned something essential. The source of making the centres in what we design and build is not a conscious choice or will. The source is far deeper, just as the source of our love is far deeper. We don't choose to fall in love. Our love is given to us.

Alexander uses a vast number of words and thoughts in his attempts to persuade us he's discovered something that's objectively true. If we're thinkers, the words may influence us, may even liberate us from a worldview we weren't even aware of having. But if we long for something as direct and convincing as our experience of being in love, then we need something more than words,

something more than rational explanations, something more than the necessary critique of our current culture.

What is that something? That something is Alexander's intuition in *The Linz Café* (Alexander, 1981, p. 69):

> If I look at the simplest snow hut made to cover hay in the Alps, or if I look at a great work, a wonder, like the Baptistry of Florence. . .there is, in them something which they have in common. . .they are both pictures of the human soul.
>
> It is so easy to say this. . .and so hard to make it clear. But definitely, in a specific sense, the works of art which touch us, which evoke great feeling. . .are works which have consciously, and deliberately been created as offerings to God, as pictures of the universe, or of something that lies behind the universe. . .as pictures of the human soul.

In *The Linz Café*, Alexander does not develop his intuition further. In fact, he apologises for introducing God into his experience, since, as he explains, we live in an age of not faith (Alexander, 1981, pp. 69–72).

In the preface to the first book of *The Nature of Order* (Alexander, 2002, pp. 6–24), Alexander provides a convincing critique of our age of not faith. But he doesn't delve deeply into the source of that not faith.

In my experience and reflection, our age of not faith has a source, just as the Fifteen Properties have a source. That source is in fact a new faith. The new faith teaches us that our rather primitive scientific method is the only credible source of our knowledge, and indeed of our faith, of what we truly can accept as meaningful.

The new faith teaches us not to talk about God because God, it professes, can only be ideological. And of course it is indelibly true that our species has committed dreadful sins in the name of our various gods.

This scientific method has led many of us to accept a life limited to cognition and the physical attributes of our brains. But the scientific method has also led us to study the depths of our soul, our unconscious, our experience beneath and beyond our thinking and reasoning. What has it helped us to discover?

Let's begin not with the theory, not with the reflection, but with the evidence. The evidence is the structure of the mandala (Figure 1).

If we look at this sand mandala without thinking about it, we easily meet the structure of Alexander's Fifteen Properties. Boundaries contain centres. Other boundaries contain previously contained centres. The order and the colours touch us, enliven us, quicken us. They make us feel alive.

We can study the Hindu origins of the sand mandala. We can also study the work of Carl Jung, who found in the mandala an image of the human psyche or soul. After years of encountering the inner lives of clients, after years of searching for meaningful images in human history, Jung settled on the mandala as an image of the structure of the human psyche or soul (Stevens, 1990, pp. 27–53). Jung described the centre of the mandala as our original experience of life, just as the centre of a

Figure 1. Chenrezig sand mandala. Source: Wikimedia Commons (2008).

living cell. In our original experience of life, we're not conscious. But our life is divine, not of our choosing, not of our making (Jung, 1977, p. 104). It's simply life: in us and beyond us.

In our development, we move away from our divine centre. We become aware of distinctions: night and day, mother and breast, brother and beast, mine and thine. Our ego is born. We need our ego in order to live in the world. But there's more to our world than our ego. And our own experience of developing reminds us what that is. It's our lifegiving origin. It's our divine origin. We could easily describe it as the God whom we design and build for.

The God whom we design and build for: This god lives in the centre of the mandala of our soul or psyche. This god is not an ideological god, not an article of faith. This god is an essential part of who we are. This god is our own centre. God as our own centre! Something new? Something astonishing? Something vaguely familiar? Something to be thankful for. Something that gives us energy. Something we want to build on, and for.

Why can't we, in whatever age we live in, devote our designs and buildings to God? What would stand in the way of our wish to thank our own divine source of life? Ideology. Peer pressure. A devotion to the smaller gods of design programmes and functionality and sustainability. All these influences are undeniably articles of faith. But the only article of faith we can ground in our own lives is the divine centre that gave us life, that structured and structures us, that can structure the structures we design and build.

Why shouldn't we be who we already are? Why shouldn't we open ourselves to the structure that structures us? If we're in contact with that inner structure—with our own inner structure—then that structure will automatically structure the designs we draw and build. If we design and build as an offer of thanks to our divine source, we'll find both the psychic energy and the wisdom to make living structures.

We need more than a checklist of an ideal design. We need to remember and to reconnect with the source of the structure that structures the Fifteen Properties. We need to reconnect with the structure that structures us. And then we can build a world that embodies that living structure.

Let's design and build as an offer of thanks to the structure that structures us!

Conflict of Interests

The author declares no conflict of interests.

References

Alexander, C. (1981). *The Linz Café*. Oxford University Press.

Alexander, C. (2002). *The phenomenon of life* (Book One of *The nature of order*). The Center for Environmental Structure.

Jung, C. G. (1977). *Psychology and religion. West and east* (Collected Works Vol. 11). Princeton University Press.

Stevens, A. (1990). *On Jung.* Routledge.

Wikimedia Commons. (2008). *Chenrezig sand mandala*. https://commons.wikimedia.org/wiki/File:Chenrezig_Sand_Mandala.jpg

About the Author

Jaap Dawson: Why was I as a boy fascinated by spaces and buildings? Why did I want to design them? What did they do for us? In my first study of architecture, at Cornell, I found no answers. I only learned there was apparently only one way to design, and that was according to the rules and vision of Modernism. Years later, when I took a course in depth psychology at Union Theological Seminary (as part of my doctoral study in education at Columbia) I encountered C. G. Jung. Jung helped me return to what I had known as a boy: we play and live not from the physical spaces we dwell in but from the inner spaces we carry within us. After my dissertation I moved to the Netherlands, the country my maternal ancestors had come from. I studied architecture again, this time in Dutch. And this time I was passionately interested in making buildings and spaces that reflected the inner spaces we dwell in. Along the way Alexander helped me, together with Léon Krier, Louis Kahn, and Dom Hans van der Laan. I taught architectural composition in Delft till my mandatory retirement in 2013.

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Article

Centers in the Event Domain: A Retake on the Wholeness of Urban Spaces

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Abstract
This article demonstrates that geometric analysis by itself is not enough to evaluate Alexander's wholeness in public spaces and that his theories of wholeness can—and should—be extended into the realm of events. The first section provides a summary of the theory of centers and the relevance of events with regard to the theory of wholeness. In the second section, a new way to classify centers is presented, along with insights from Alexander's works into an approach for incorporating event centers into the theory of wholeness. The final part puts these ideas to the test on a public square in Stuttgart, Germany, using a geometric analysis and an analysis of user activity to determine the performance of the square as a center. The research concludes that utilizing Alexander's theories from an event-first rather than a geometry-first perspective is an approach especially well-suited for public spaces.

Keywords
abstraction; event-centers; events; public square; space; theory of wholeness; urban space; user activity

Issue
This article is part of the issue "Assessing the Complex Contributions of Christopher Alexander" edited by Michael W. Mehaffy (Sustasis Foundation) and Tigran Haas (KTH Royal Institute of Technology).

1. Introduction

Throughout his career, Christopher Alexander was concerned with three main themes: (a) human well-being, (b) how the built environment could support well-being, and (c) how the built environment evolved over time. However, in his later and more abstract work, *The Nature of Order* (TNO), he invested more heavily in questions of morphology at the expense of social and temporal activities (Alexander, 2002a). The results of this decision can be observed in the development of these theories since their publication. For example, several researchers have attempted to develop the mathematical approach to wholeness described in TNO and apply them to the scale of buildings and objects (Billig, 2018; Salingaros, 1997). However, public spaces in the urban environment such as town squares or plazas involve a greater number of complex elements such as human flows and interactions or temporary events, which make them difficult to evaluate geometrically. Nevertheless, some works in urban morphology have also explored how mathematical definitions found in the theory of wholeness can be applied to the urban domain: for example, to measure the liveliness of cities through a geometric analysis of street networks (de Rijke et al., 2020; Jiang & de Rijke, 2022). These studies focus on a single component within the definition of wholeness, such as connectivity between the streets at different scales.

By contrast, Alexander's earlier works are more directly concerned with events, especially on the larger scales. Mehaffy and Salingaros (2015, p. 149) identify that cities are composed of overlapping networks of events on physical and temporal scales, an idea that follows from the concept of functional overlap described in *A City Is Not a Tree* (Alexander, 1965). Mehaffy (2019) also identifies six different areas of Alexander's potential contributions to the science of cities including an increased focus on the evolution of the city as an emergent and complex phenomenon, and an emphasis on aesthetics as an indicator of life-supporting order in cities. There is a missing link between these theoretical ideas and the theory of wholeness and centers presented in TNO. The analysis of urban spaces according to the theory of wholeness has either remained form-based and leaned on mathematical analysis or included non-form elements while remaining more abstract.

This could be due to many factors. Firstly, Alexander does not focus as much on events as he does on geometry in TNO. With the primary concern being the process of form-making and formation, it makes sense to approach the problem with geometry in mind first and presume that the form will generate social life within the geometry. However, this also means that a way to study geometry in Alexandrian terms exists, while a way to study events as direct contributors to wholeness does not. Secondly, the visual observation of a geometric pattern, a building, or the map of a city only requires the object of study and the observer. The study of events requires a series of preliminary steps before being directly accessible, such as the collection of event data at specific times, or the abstraction of data into a visual format. Most likely this difficulty, added to the lack of exploration of the topic by Alexander himself, led to an underdevelopment of theories in this area.

This study proposes that it is more suitable to apply Alexander's theory of wholeness not only to the geometries of large spaces but also to the events that occur within them. This type of analysis makes it easier to identify the wholeness of larger spaces by examining more centers than a purely geometric analysis would allow. The following three subsections outline the necessary background: a summary of the theory of centers as it evolved throughout Alexander's career, the relevance of events in evaluating urban spaces, and how events can be viewed as centers. The theory regarding the characterization and evaluation of centers is developed in the following sections: namely the ideas of canvas, substance, and abstraction. These ideas are used to classify the different types of centers that either Alexander himself or other scholars identified in previous works. Finally, in Section 5, these ideas are applied to a public square in Germany.

1.1. Centers and the Theory of Wholeness

In TNO, Alexander takes a fundamental and geometric approach to answer the question of how spaces can improve human well-being. His core tenet is the proposition that geometries, objects, buildings, and spaces possess a property called wholeness. Objects with more wholeness are full of life and promote a greater sense of well-being. The wholeness of a space or an object depends on its geometric composition; certain configurations result in more wholeness than others.

To explain these configurations, Alexander develops a theory of centers. Centers, which are typically geometric configurations in space, are points of focus that have a sense of geometric unity. The way the centers sit in relation to other centers increases or decreases the level of the wholeness of the global system. In other words, a system of centers is a field-like structure, the wholeness of which is defined at each point by the intensity of its local centers. Centers themselves are composed of other centers at a smaller scale, which serve the wholeness of the center at a larger scale. This recursiveness across scales is the first important property that is attributed to centers that create wholeness, named "Levels of Scale" by Alexander (2002a, p. 146). The hierarchical relationships between centers at different scales can be represented as a graph network. Recent explorations of such representations have led to the development of mathematical methods that quantify the number of scales in these graphs, finding that more distinct levels of scale lead to greater wholeness (Jiang, 2015).

In addition to Levels of Scale, Alexander noticed that there are more geometric relationships between centers that promote wholeness. There are 15 of these properties, for example, "Alternating Repetition," "Boundaries," "Void," and "Contrast." These properties are observable in nature and set guidelines for organizing centers in ways that will increase wholeness. A two-dimensional example that aids in understanding this definition and the 15 properties is shown in Figure 1. The pattern that resembles a flower, and the interlocking pattern beside it, are centers that have Alternating Repetition. The spaces that are between them are centers that display the Void property. This border which is composed of a repeating pattern of flowers, interlocking patterns,

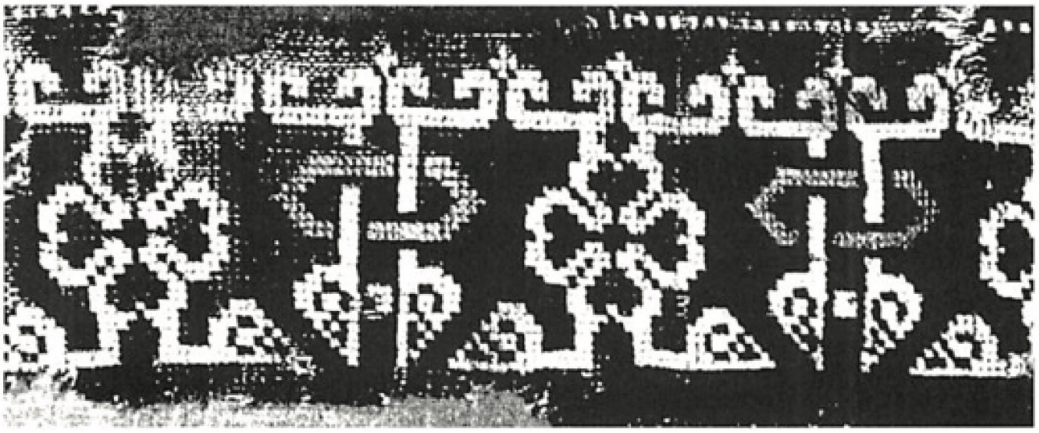

Figure 1. The border of an Anatolian carpet. Note: In TNO, this image is used to explain the concept of centers. Source: Alexander (2002a, p. 119).

and voids, is itself a center that displays the Boundary property at a larger scale. It is, of course, impossible to adequately summarize a four-volume study in two paragraphs, so the reader is referred to the original text or shorter summaries and commentaries (Gabriel & Quillien, 2019; Galle, 2020).

1.2. The Link Between Geometry and Events

The theory of wholeness as presented in TNO is mainly about the geometric configuration of centers. Due to this heightened focus on geometry, social and temporal concerns seen in some of his earlier works lose ground in TNO. One purpose of this article is to bring back these social elements to the forefront. In *The Social Logic of Space*, Hillier and Hanson (1984, p. 26) draw attention to the connection between the social and the spatial by stating: "Society must be described in terms of its intrinsic spatiality. Space must be described in terms of its intrinsic sociality." Alexander agrees with this view and adds, "it is not really possible to keep function and space separate," and that an integrated view is necessary (Alexander, 2002a, p. 417).

More recently, Kiss and Kretz (2021, p. 59) published an anthology in which they compiled essays from established authors who view the city with a "relational approach" where space is seen as an "amalgam of the social and the material." On this point, they identify a similar line of thinking between Aldo Rossi, Christopher Alexander, and Kevin Lynch. For Rossi, cities consist of "cultural types" which are happenings that are at once social and material (Rossi, 1984). Cultural types are similar to the patterns in *A Pattern Language* (APL) in the sense that both patterns and cultural types are a composite of spaces and the events that happen in them. Similarly, Lynch (1981) defines urban form as the spatial arrangement of people doing different things. In all these examples, form and actions constitute an inseparable composite, indicating that events and form are two sides of the same coin.

The concepts of "space," "place," and "event" are directly related to this relational approach. Prior to the last few decades, space was seen as absolute in the field of human geography, namely as a single container in which things happen (Amin, 2007; Murdoch, 2005). Harvey (2004) defines two additional views of space: relative and relational space. Relative space is defined by the relations between events, objects, and processes in time. The concept of relational space goes a step further, in asserting that processes define their own spatial frame and that space does not exist without processes that define it. (Harvey, 2004; Jones, 2009). In both definitions, the incorporation of events and processes means that it is not possible to disentangle space from time.

While there are many definitions of place, Cresswell (2008, p. 135) highlights that "place describes a way of relating to the world," and that the idea of "experience" is key to its definition. Therefore, place is about how humans relate to, and experience, their environment. Similarly, Seamon (2013, p. 150) defines place as "an environmental locus in and through which individual or group actions, experiences, intentions, and meanings are drawn together spatially and temporally." This spatial and temporal whole creates "place ballets," a routine of events recurring in a supportive physical environment (Seamon, 1984).

1.3. Events as Centers and Generators of Wholeness

Even though first elaborated in TNO, centers and wholeness are constant themes throughout Alexander's career and wrap the entirety of his works together. For example, the concept of center applies to many of the patterns in APL (Alexander et al., 1977). Each pattern presents a rule with which a strong center is created (Alexander, 2002b, p. 344), and consists of a design problem to solve, an explanation of how it solves this problem, a sequence of steps to apply this pattern successfully, and other patterns that are connected to it at the scales above and below. While most patterns are geometric solutions to problems that arise in architectural and urban design, there are also patterns that tackle problems of societal organization ("Old People Everywhere"), or those that are about a process rather than the resulting geometry ("Gradual Stiffening"). Seamon (2018) also identifies the different ways in which Alexander's patterns highlight the events and experiences of places in his works. For example, "Degrees of Publicness," "Promenade," and "Dancing in the Street" are all different examples of patterns that contain events as part of their description. Such patterns highlight the link between events and the built environment and provide clues as to they work together to create wholeness. Patterns or strong geometric centers enable processes or events to take place. These events then become part of the structure of that space and increase its wholeness (Alexander, 2002a). Figure 2 is a diagram that takes these ideas and presents a starting point for this research. The two types of centers shown in the figure, static centers of the built environment and dynamic event-centers, are defined in the following paragraphs.

Urban form is in a constant process of change (Moudon, 1997), and different urban systems such as streets or buildings change at different rates (Oliveira, 2016). Therefore, geometric centers in the built environment are not static at long timescales. A significant portion of Alexander's work is also devoted to the process of building, which includes this temporal component (Alexander, 2002b). For example, the complete lifecycle of a building can be considered an event, even though a building consists of static geometric centers for most of its life. However, Alexander does not usually consider this temporal component in analyses of the existing built environment. His analyses are usually done by identifying centers in photographs, diagrams, and plans. Therefore, this research will also regard centers in the

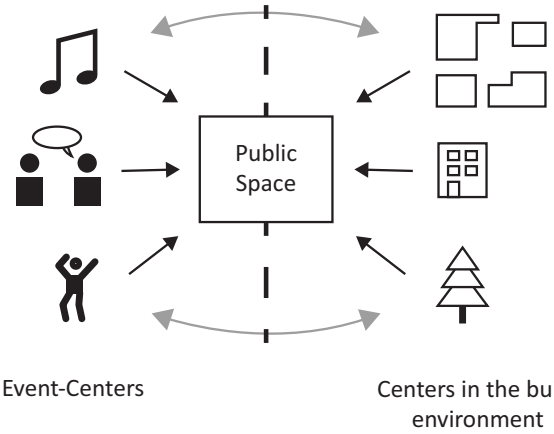

Figure 2. A thought diagram of centers contributing to the wholeness of an urban space. Note: Geometric centers of the built environment and dynamic event-centers happening and disappearing in time are both part of the wholeness of public spaces.

built environment as unchanging and examine them as such. This includes temporary installations such as shopping stands, as they are unchanging at the timescale of the observation of wholeness.

In contrast, event-centers are regarded as dynamic, with a rate of change that is detectable at the scale of observation of the research. Examples for such centers are people sitting and conversing on a park bench, or children playing behind it. Alexander (2002a, p. 391) describes these centers as follows: "…we now understand this wholeness to include centers which grow and fade as life goes on during the dynamic minute-to-minute actions and events which are occurring there." Such events that create life may be sustained by other centers, some of which are also events. Static centers in the built environment invite and shape events, while events can result in changes in static centers. For example, providing a place for people to dance can lead to people dancing in the street (Alexander et al., 1977). Conversely, social events such as protests can lead to political decisions which cause change in the built environment.

To examine the wholeness of a public space, both static centers and event-centers must be investigated. Dynamic centers such as people sitting down or having a conversation interact with the centers in the environment, changing the physical nature of the space, and therefore its wholeness (Alexander, 2002b, p. 348). Thus, an analysis of wholeness without events is incomplete.

2. Characterizing and Visualizing Centers

Examples of centers in Alexander's work are varied. To understand events as centers, one must first take the step to recognize the different types of centers within his works. To do this, an analogy from painting is borrowed. Like a painting, each center or pattern exists on a canvas and is made of a type of paint, from here on referred to as a substance. The canvas describes the dimension in which centers occur, while the substance describes the matter, object, or concept with which the center is composed. Figure 3 categorizes patterns and centers with this analogy. There are four canvases: 1-D space, 2-D space, 3-D space, and 4-D Space-Time (three dimensions of space plus one dimension of time). Each row in Figure 3 adds a new dimension to the canvas, while each column is a different substance.

Alexander evaluates the wholeness of spaces through the configuration of centers in space. This can be the configuration of colors and patterns on a carpet (as demonstrated in Figure 1), or it can be the configuration of "subcultures" in a city as demonstrated in the pattern "Subculture Boundary" (Alexander et al., 1977). The concept of substance highlights the difference between these examples. In the latter case, the boundary is made up of space in which there is a lack of said subculture, or a mix of said subculture with another subculture. This boundary is not visually observable as in the first case; nevertheless, it contributes to the wholeness of the system by interacting in space with other similar centers through the 15 properties. Figure 3 separates event-centers into their own classification by grouping them onto the canvas of Space-Time.

3. Seeing the Whole Through Abstraction: Wholeness Fluctuating in Space

The idea that centers can exist in different dimensionalities, composed of completely different objects or substances, and still generate wholeness, in the same way, is key for incorporating events into the theory of centers. However, observing centers in substances such as culture or function is not as straightforward as observing colors on a carpet. Alexander addresses this using abstraction, which solves two issues: (1) by abstracting invisible "substances" such as function or culture into colors, the centers can be visualized, designed, or evaluated; and (2) abstraction allows the designer to have an overview of the entire system at once.

Abstraction

Substance / Canvas	Color and Texture	Objects	Culture	Sounds	Actions
1D Space	*A pattern on a black and white strip	*A wooden beam with brass caps at the ends.			
2D Space	*Figures on a carpet	*A collonade	*The pattern IDENTIFIABLE NEIGHBORHOOD		
3D Space	*A garden	*A building	*The pattern MOSAIC OF SUBCULTURES		
Space-Time ("The realm of events")	*Light beams from windows lighting an interior space	A ball rolling on a road.	An interaction of people from different subcultures on a street	*A song, or *birds chirping (the change in sounds over time)	*Children playing in a park, or *people conversing

Figure 3. Examples of different "substances" painted on different "canvases" existing in different dimensions. Note: Examples from either APL or TNO were chosen whenever possible and are marked with an asterisk.

Other fields such as sociology also deal with abstractions to and from physical space. For example, Bourdieu (2018) proposes that social agents have a location in "social space" revealing their social and political status. The structure of social space manifests itself in physical space, for example in the location of suburbs or slums in a city, and those who can afford them. Through this relation, Bourdieu (2018) claims that social space is more complete than physical space and that physical space is a projection of social space that can only be understood through an abstraction (physical geography). Similarly, Latane and Liu (1996, p. 27) define social space as a "structure that determines people's relationships to each other," defined and shared by multiple minds. However, they acknowledge physical space as an important driver for shaping social structures and view it less as a projection and more as fundamental. This approach is similar to that of Alexander, who builds his entire theory of wholeness on the structure of physical space, to which the social space contributes.

Latane and Liu (1996) also acknowledge the difficulty of representing social space due to the number of different features to consider, such as human movement or information flow through different media. Therefore, they suggest capturing each feature in separate models representing different aspects of social space. This is similar to the process of abstraction that Alexander takes in the third volume of TNO, in which he gives the example of designing a neighborhood starting with the spatial distribution of different functions (Alexander, 2005). In this exercise, a neighborhood has four main types of space: pedestrian space, gardens, buildings, and space for cars. The spatial configuration of these four types of space determines the wholeness of a neighborhood. To visualize the entirety of the system of centers, each function is given a color and abstracted onto a 2-D map, after which the designer can experiment with the configuration of colors in a manner similar to a board game (Alexander, 2005, p. 304). Since "function" is not a visible center, it is necessary to perform this abstraction that allows the designer to observe differences in function as colors and to understand the complexity that they entail. The original caption of Figure 4 draws attention to the complex relationship among the colors, and the complex structure to which it gives rise.

In addition to allowing the designer to visualize and use invisible centers, abstraction also serves the purpose of giving an overview of the whole. In one of his more recent works, *Harmony-Seeking Computations*, Alexander (2009) hypothesizes that natural processes that might, at first, seem to be generating order in an emergent manner also display the property of preserving the whole. This is an important realization because it rejects the proposition that a purely bottom-up design approach can lead to wholeness. By extension, this means that an act of designing that preserves wholeness always requires access to an overview of the whole. This topic is also relevant in observing wholeness. In many cases, wholeness can only be partially observed but is nevertheless a property of the whole. For example, an observer standing in a sparse part of town might conclude that the wholeness of that area is weak, even though this area might be serving a greater purpose at a larger scale. Therefore, the wholeness of the neighborhood must be viewed as a property that fluctuates depending on where the observation is made. This understanding fits within Alexander's description of centers as "field-like" phenomena (Alexander, 2002a).

4. Adding the Time Component: Wholeness Fluctuating in Time

Centers that are events add another level of complexity to the definition of what a center can be. Alexander

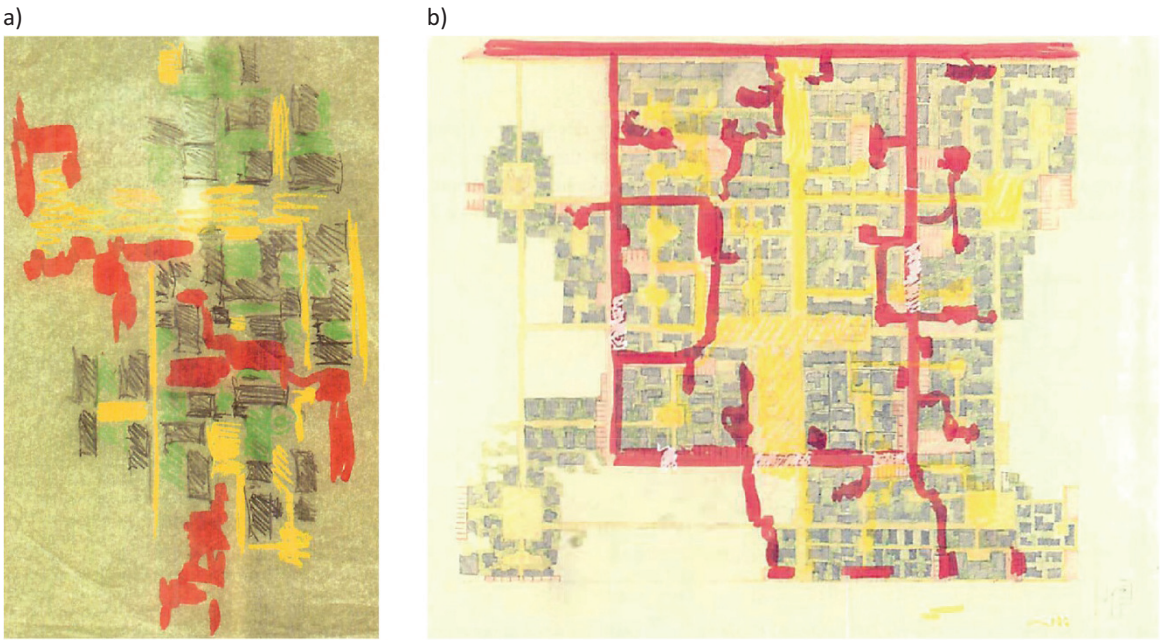

Figure 4. Two images from TNO: (a) the process of designing with four colors representing four functions and (b) the resulting 2-D map of a neighborhood. Source: Alexander (2005, p. 308).

includes the chirping of birds or playing children as examples of these kinds of centers and writes that they take place in "the realm of actions" (Alexander, 2002a, p. 391). Similar to geometric shapes in space, these events can be long or short in time and can form overlaps and interactions. It is not enough to observe the entirety of the space in question to gain a complete understanding of wholeness because the wholeness that is created by events fluctuates in time as well as in space; a park that is lively during the day might present a different picture at night. Therefore, a space must be observed for a long period of time in order to yield a more accurate impression of its wholeness.

To visualize these centers and the relationships between them, the process of abstraction developed in the previous section can be used. The closest example to this can be found in *A City Is Not a Tree* (Alexander, 1965). Here, Alexander highlights that cities that arise spontaneously over time contain overlaps between different functions, as opposed to those that are deliberately created by designers. For example, he criticizes the separation of university campuses from the city, which restricts the overlap between university life and city life that would otherwise happen through activities such as pub-crawling, coffee-drinking, the movies, etc. Without this separation, the static parts of the city which are university and residential buildings, and the dynamic parts of the system which are different actions of the citizens occur in the same space. This spatial overlap of actions creates life. To explain this concept, Alexander uses Figure 5. It is an abstraction, albeit less direct, helping the observer to understand geometrically what overlapping functions might look like. The overlap of triangles in different configurations creates a multiplicity of shapes and gives the painting its structure.

There are different ways in which the overlap of events can be observed directly in the time domain. One idea is given in Figure 6. Inspired by abstractions in Alexander's works, it focuses on visualizing events and their overlap as colors. This provides a way to gain an overview of the fluctuating wholeness of events specific to a place. Other substances such as age groups or

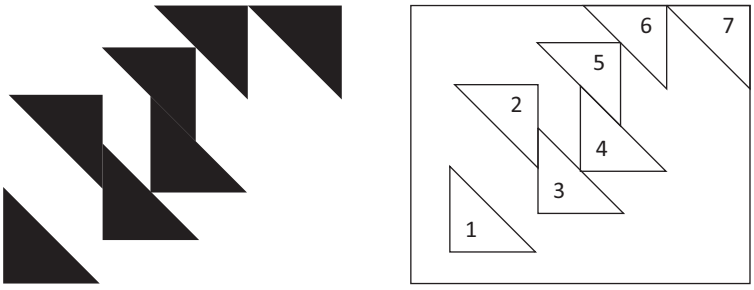

Figure 5. Simon Nicholson's painting. Note: In *A City Is Not a Tree*, this painting is analyzed to highlight the overlap between geometries, and how all the spaces are made up of overlaps. Source: Alexander (1965, p. 20).

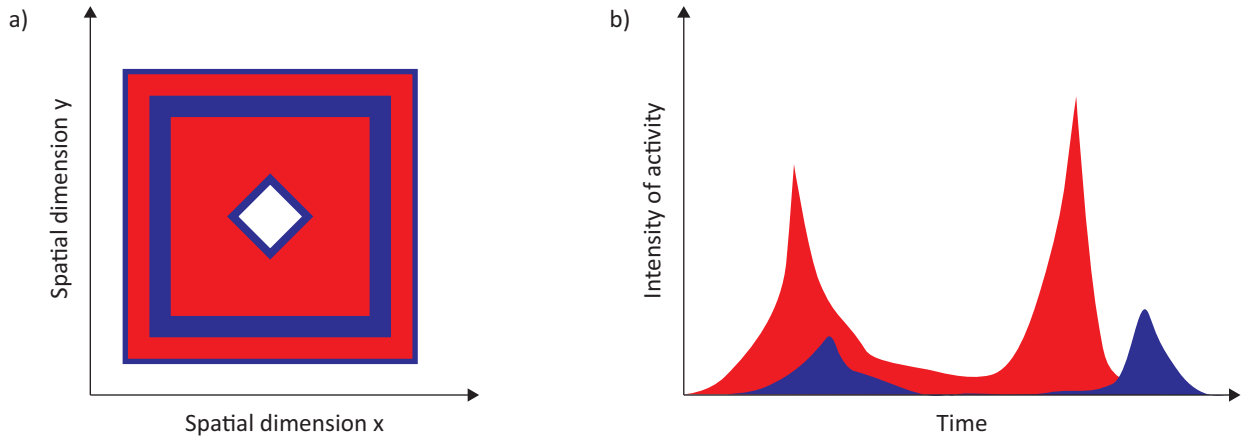

Figure 6. (a) Colors in spatial dimensions can be observed as centers and (b) the overlap of activities can be visually observed as centers through abstraction into colors.

activity lengths could also be abstracted and graphed instead of activity types. However, since types of activity are the closest substance to Alexander's abstractions shown in Figure 5, the type and intensity of activities were chosen as the axes.

This interpretation of Alexander's theory of wholeness results in the following conclusions: (a) temporal elements are an essential part of wholeness and must be analyzed to gain a correct understanding of public spaces, and (b) events must be observed in large sections of time to give a conclusive evaluation of the wholeness of a space.

5. Case Study

This evaluation of a public square in Germany is intended to show the importance of evaluating events in analyzing the wholeness of the square, and that evaluating purely geometry can lead to ambiguous results. Firstly, a geometric analysis of static centers in the square is performed following similar examples from Alexander's works. Then, event analyses at multiple times are performed and evaluated for their effects on the static centers. The previous sections provide the necessary theoretical background for the investigation.

The most important novel point being addressed here is the issue of visualizing event-centers. The closest Alexander comes to addressing this is abstractions like the one shown in Section 3. From all the examples of event centers given in the earlier sections, it could be summarized that *living beings doing things in proximity to geometric centers increases the wholeness of a region of space.* Therefore, this study aims to map the location of human users of the square to identify their contribution to the geometry of the plan.

5.1. Methods

Geometric analysis is performed in the plan, where centers and 15 properties in the square are identified. It is important to keep in mind that even though Alexander provides a somewhat reproducible method with which to analyze the wholeness of spaces, there are no concrete criteria for evaluation available when applying them. Centers are highly personal, and the feelings of the observer as they move through the space are key to identifying the wholeness of a place (Alexander, 2004). Nevertheless, there are examples of wholeness analyses in the plan: e.g., the analysis of the Cathedral of Chartres (Alexander, 2005, p. 194) or the plan of the Alhambra (Alexander, 2002a, p. 187). In these examples, Alexander examines the shapes of built structures and the spaces that they create as centers according to the 15 properties. Similarly, in this research, centers in and around the square are identified and their geometric relationships are examined.

For the mapping of events, this research leans on the observational methodologies described by Whyte (1980) and Gehl and Svarre (2013). In order to understand how a plaza is used, Whyte (1980, p. 23) observes the locations of sitting pedestrians on a "sighting map," a map of the plaza with hand-drawn symbols to identify additional information about age or gender. In their example, this mapping takes around five minutes to complete. Gehl and Svarre (2013, p. 26) describe this method as "mapping'' or "behavioral mapping," used to indicate "where people are standing and sitting." The result is a frozen picture of the area, revealing a snapshot of the locations and activities of the people within. Similar to Whyte's methodology, mapping is done by an observer walking through the area. Ng (2016) gives a comprehensive explanation of behavioral mapping and examples of previous research using this method.

In this research, behavioral mapping is used to identify the locations of groups and their activities. It was observed that the users of the square interact in groups. Just as a handshake event requires a group of two people (Alexander, 2002a, p. 304), a conversation event requires a group of multiple interacting individuals. Therefore, to conserve the nature of the event centers as they

occur in space, each group of interacting individuals was mapped as separate entities. A researcher moved through the public square in a pre-specified path, noting down the locations and activities of the users on a map. A single map took between five and ten minutes to create, depending on the number of users in the square. In cases where the number of users exceeded what is manageable through direct observation, photographs were taken to aid the researcher in creating the maps of highly occupied areas. More specifically, photographs were only used at 17:00 and 17:30 on the weekend to manage the large numbers of individuals in the square (Figure 9D). The data was collected in late March and early April, in sunny weather conditions. Unlike many behavioral mapping studies which report only the statistics of users and activities, the geometric nature of this work necessitates the reporting of the maps themselves, similar to the research done by Gümüş and Yılmaz (2022) and Askarizad and Safari (2020). As identified by Ng (2016), privacy is a concern when performing this kind of research. Care was taken to make sure all data is anonymous. No gender data was collected.

Activities are divided into six groups: talking, watching, eating, social drinking, playing, and other activities (begging, foraging, doing a survey, etc.). Talking was determined to be the default activity for groups while watching was the default activity for individuals. In cases where multiple activities are performed at the same time, such as eating and talking, activities that are different from default take priority (in this case, eating takes priority over talking). There is constant traffic of individuals and groups who are actively walking, running, or biking in the square due to it being a transport hub. Unless they engaged in a stationary activity such as getting caught up in a conversation with a stationary user, these were not included in the data. There are ambiguous cases where the identification of a stationary activity can be difficult. For example, a biker could be moving through the square to reach a destination or could be making circles and performing tricks in which case they are an active user of the square. Usually, a few seconds of observation was enough to clarify their inclusion in the data. This does not mean that traffic of moving pedestrians should not be considered centers. However, as most of the event examples in Alexander's works are of a stationary nature, this work only examines such events.

5.2. Marienplatz

Marienplatz in Stuttgart is a public square with an area of approximately 6,000 m^2. It is surrounded mostly by residential buildings and functions as a central location where people can gather and socialize (Figure 7a). The square is pentagonal in shape and is surrounded on four sides by roads. It also functions as a transport hub, with an underground metro station situated to the northwest of the square, and a cable car station that is near the center of the square. The square is divided into two areas by the cable car station. One side of the square is connected to the front of a building, where restaurants and tables are situated.

In 2003, after decaying into a spot with excessive illegal activity, a redesign of the square took place that was controversial due to the lack of differentiating elements in the new design, resulting in a large, empty space. This space that is marked with the number 1 in Figure 7c is the heart of the square and will be referred to as Area 1. It is a big open space where events such as festivals, concerts, protests, and flea markets take place. On the northwest side, it is bounded by steps that serve as seating.

5.3. Geometric Analysis of Centers

Seen in the larger urban fabric, Marienplatz benefits from constant traffic thanks to being a transportation hub. While there are smaller squares around it such as Erwin-Schöttle-Platz to its west, it is the biggest square of its kind in the neighborhood. As a center, the square displays the Void property. Its boundaries—the steps, the fountain, the cable car station, and surrounding trees—are all strong centers (Figure 7b and 7c). These boundaries are connected to other centers such as the restaurant or the basketball court, enhancing the strength of the boundary. These not only act as geometric centers but also as centers of activity. The boundary is full of Contrast, showing different kinds of centers that provide hubs for different activities, such as benches for sitting or drinking, ping pong tables for playing, etc. The shapes of the centers and voids display the "Positive Space" property as described by Alexander. However, the overall shape of the square does not display the natural coherence and symmetry that Alexander covets in the examples given in TNO.

Area 1 itself is large and lacking definition, as there is not a lot of geometric differentiation in the middle of the square. It is somewhat reminiscent of the example that Alexander (2002a, p. 224) uses to describe the Void property: an empty square in Tibet. The size of the square is much larger than what is advised for a public square in APL and TNO (See pattern "Small Public Places"). Gehl (1987, p. 153) also observes that desolate and empty spaces need supports such as benches, columns, plants, etc. to provide people with places to stop, which are severely lacking in Area 1. This results in a lot of the citizens moving through the square without spending much time in it or preferring to stay at the peripheries. From the perspective of this analysis, mainly because of the scale of the space and the lack of differentiating centers, the central area does not seem to promote wholeness geometrically. However, due to the richness of the boundaries and the activity they attract, the center may not feel totally desolate. An analysis of events at different times must be conducted to reach a conclusion on the center's wholeness.

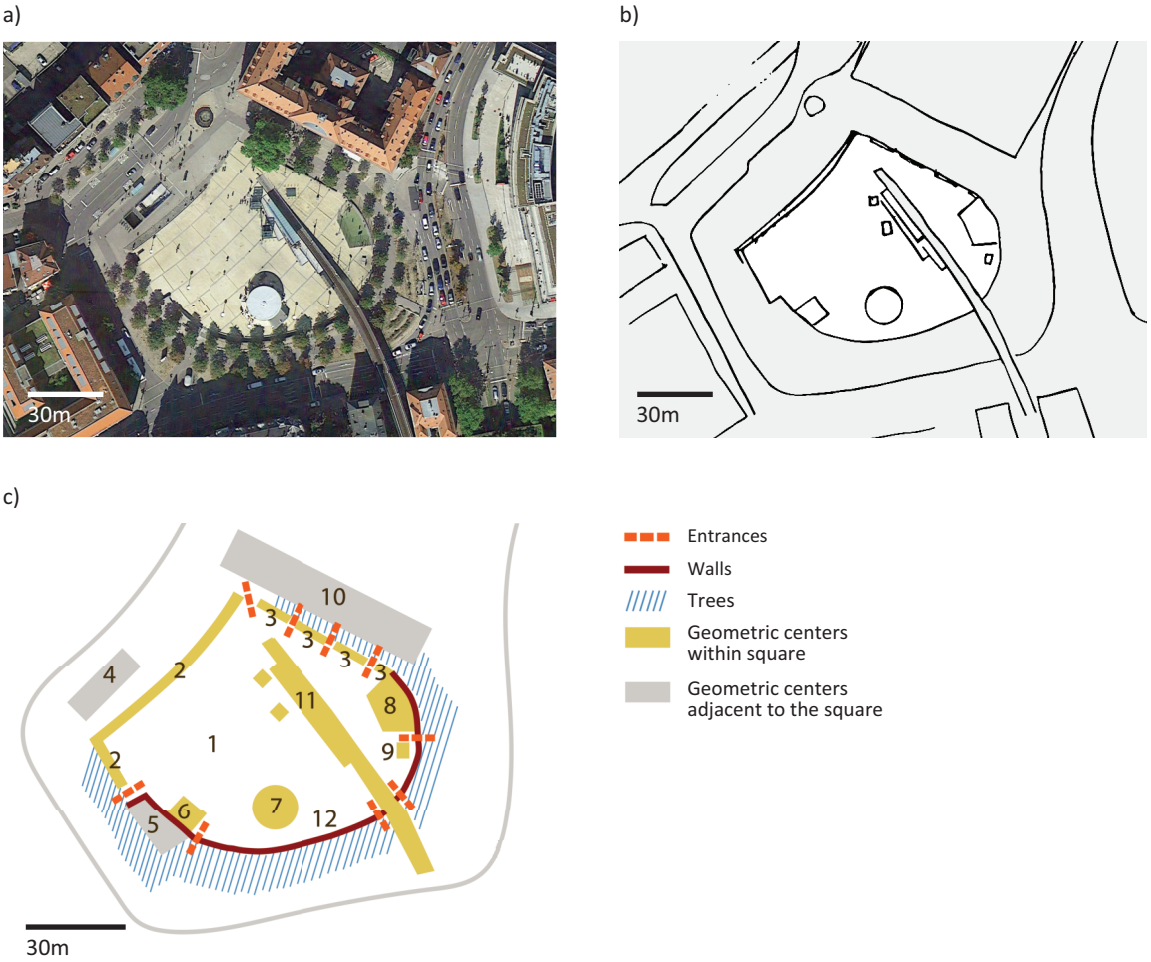

Figure 7. (a) Satellite image of Marienplatz in Stuttgart, Germany functions as a transport hub and a leisure space (Google Earth Pro); (b) a hand sketch of the area showing the study area in white, and the surroundings in gray; and (c) a center map where important geometric centers in the built environment are identified and numbered: 1. Empty space at the center of the square (referred to as Area 1), 2. steps serving as seating, 3. stone benches, 4. bus and metro station, 5. children's playground, 6. water fountain, 7. ice cream hut, 8. basketball court, 9. ping pong table, 10. restaurants on the periphery, 11. cable car station, and 12. wall enclosing the square.

5.4. Event Analysis

The events that occurred in Marienplatz were observed at different times to determine the location and variety of activities performed by persons in the square. As described in the methods section, the ages and activities of users in the square are recorded by a researcher on a behavior map. Users of the square were observed on four different occasions. The first three were on the same weekday: morning at 8:30, afternoon at 13:00, and evening at 19:30. In each case, one behavioral map was created. The final observation was done on a weekend from 17:00 until 20:00. In this final observation, a behavioral map was created every half an hour for a total of six maps. Figure 8 displays photographs and the percentages of activities in the square. Figure 9 displays the behavior maps.

The activity in the square changes drastically over the course of the weekday. Barely anyone uses the square in the morning (Figure 9a). At lunchtime, the most prominent activity is eating (Figures 8a and 9b). The activity is concentrated in the boundaries, suggesting that a rich boundary of multiple centers displaying many of the 15 properties attracts activity, strengthening the boundaries further. A farmer's market took place on the afternoon that the observation was made, which resulted in additional geometric centers attracting further activity to the middle of the square. Nevertheless, most of Area 1 is still empty and lacks any centers at lunchtime.

In the evening, the prominent activity is social drinking (Figures 8b and 9c). The square shows a very different structure of centers to before, with most of the empty area being used as a leisure space for groups to sit and drink. The spacing between the groups is similar throughout the square, indicating that there is a specific distance with which groups feel comfortable. This is not surprising, as similar phenomena were observed by Whyte (1980). The groups grow inward from the boundaries to occupy empty spots and do not disperse across the empty square. It is also worth noting the lack of

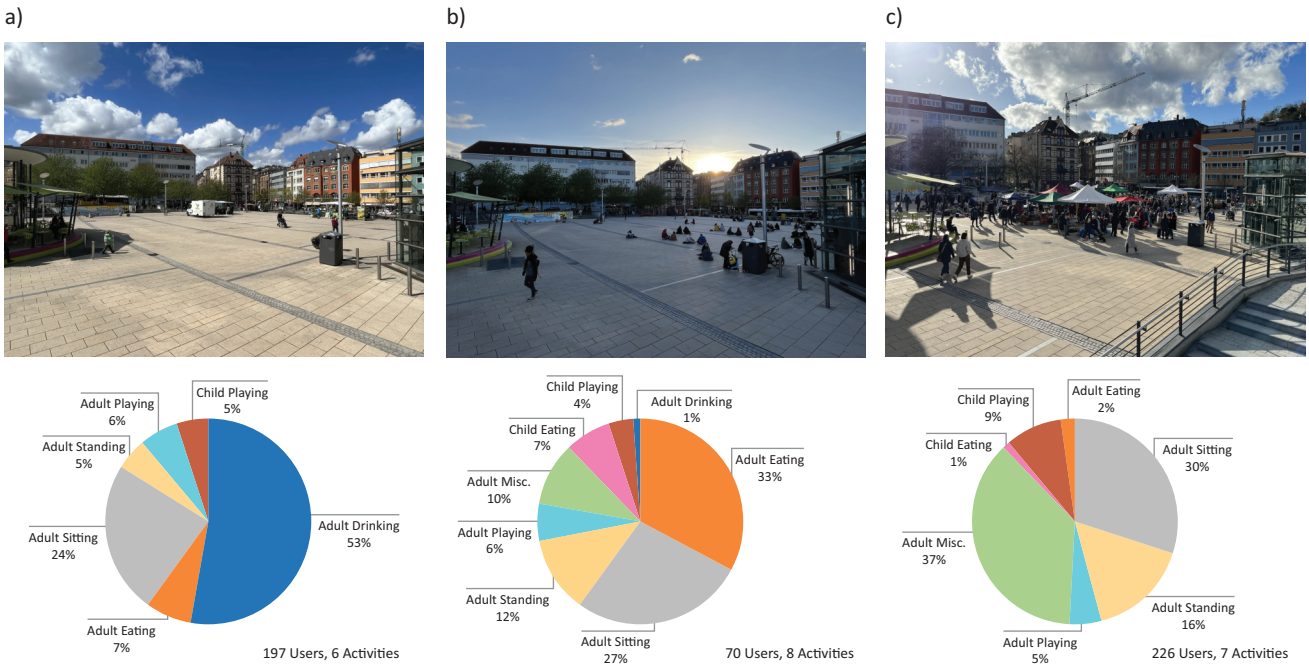

Figure 8. Photos and pie charts of the range of different activities in the square at (a) weekday 13:00; (b) weekday 19:30; and (c) weekend 17:00. Notes: These photos are to give a visual idea of what the square looks like. Only the photograph shown in Figure 8c was part of a set of photographs taken to aid in the creation of the behavior maps (see Sub-Section 5.1 for details).

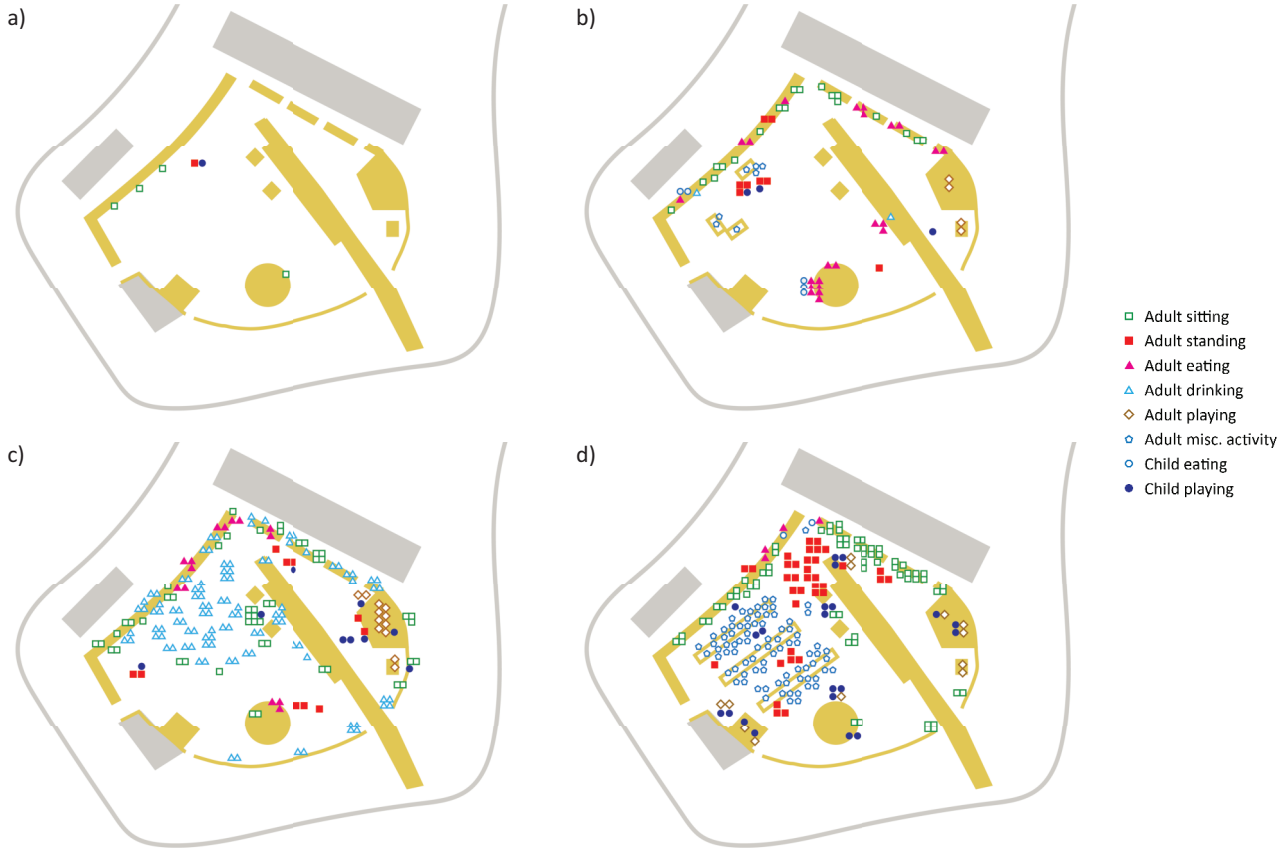

Figure 9. Behavior maps of Marienplatz generated at four different times: On a weekday at (a) 8:30; (b) 13:00; (c) 19:30, and on a Saturday at (d) 17:00. Notes: The flea market event on Saturday resulted in the users buying or selling goods being identified under adult miscellaneous activity. Multiple symbols which are spatially connected indicate groups of interacting individuals.

events directly on the northeast side of the cable car station, even though its scale is more appropriate for a public square. This could be due to environmental effects such as sunlight that remains longer on the west side compared to the east. There could also be a more social reason, where the larger area is designated as the appropriate place for drinking in the evenings after hosting other events such as festivals and markets. Finally, it could be that people simply enjoy the feeling of openness in the space when there are other groups to share this with, a more Alexandrian explanation of The Void as a center. In either case, the structure of the space has changed due to the activity of the square, affecting the saliency of the surrounding centers, and therefore their wholeness (Alexander, 2002b, p. 347).

The final observation was made on a weekend at a flea market event (Figures 8c and 9d). Similar to Figure 9c, the square is full of life. This time, temporary shopping stands act as centers in addition to the event-centers, giving form to the events. This shows that the interplay of event-centers and geometric centers arising from objects can bring an otherwise barren area to life. It also highlights the importance that empty spaces have in the urban context.

Due to this flea market being a temporary happening, multiple maps were created for three hours between 17:00 and 20:00 as elaborated in Sub-Section 5.4 to observe the changes in the life of the square as it ended. The number of users performing each event is displayed in Figure 10 for an abstracted view of events stripped from their geometry, making it possible to visualize the fluctuating nature of event-based wholeness in time. This kind of analysis gives an idea of the overlap between different events in the square as discussed in Figure 6. For example, at 19:30, most of the individuals in the square are either playing children or drinking adults. This is an overlap of different event centers in the temporal domain, similar to what is described in *A City Is Not a Tree* (Alexander, 1965).

For this research, interacting groups and individuals performing actions were each considered to be events. However, a flea market event is itself a large event-center both in spatial and temporal terms, containing many individual smaller events. From this perspective, Figure 10 could be seen as the temporal interplay of different small events such as children playing or adults drinking, or the overlap between the larger events "flea market" and "quiet evening at Marienplatz."

6. Conclusion and Discussion

This study opens up a new way to think about and utilize Alexander's theories on wholeness. The categorization of centers according to the canvas-substance analogy given in this study provides a method to classify the examples of centers in TNO while putting a needed emphasis on how they differ. The discussion on abstraction in Alexander's works provides examples of how other centers that are not directly visible can be visualized and evaluated. Specifically, the idea that the wholeness of spaces is not a constant value but a fluctuating, field-like property through space and time informs the incorporation of events as a part of the theory of wholeness.

Event analyses tap into the event side of Seamon's (1984) "place ballet" concept elaborated in Sub-Section 1.2, examining the wholeness generated by the space-event composite from a new perspective. Nevertheless, observing centers in the event domain

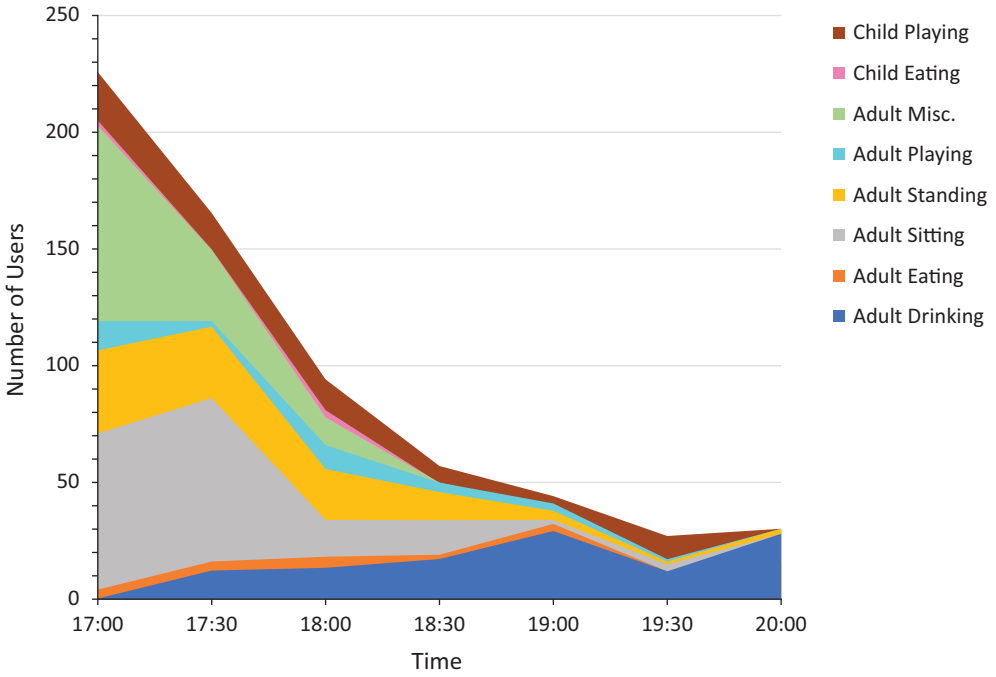

Figure 10. The evolution of events through time at Marienplatz on a weekend.

is intended to be used in combination with a geometric analysis of centers. The case study presented in this work shows the necessity of this approach. The event analysis in Section 3 makes it clear that Marienplatz functions as an important space within the urban fabric that hosts a large number of different event-centers at different times, even though it is far from wholeness enhancing in its form. There could be multiple reasons for the success of this space in terms of events, such as the lack of other large empty spaces in the neighborhood dedicated to hosting a variety of events, or the richness of the boundaries in terms of restaurants, cafes, and other points of interest. These multiple factors that affect the usage of the square, some of which are centers of geometry or function, are difficult to pin down in their entirety. Jacobs calls this a problem in "organized complexity," where the variables that affect the square are all interrelated in unpredictable ways (Jacobs, 1961, p. 433).

The approach presented in this article still suffers from an oversimplification of the complexity involved in designing and evaluating public spaces. Nevertheless, Alexander's concern with observing the whole throughout the process of design, and his use of abstractions for identifying centers of different "substrates" address some of this complexity. By drawing attention to these tools, this article demonstrates that the theory of wholeness includes elements other than geometry that have direct applicability in urban design.

Much work has been done in exploring the hierarchical nature of static spatial centers at different scales. Since dynamic centers such as events have not yet been explored to the same depth, there are questions as to how to approach them as hierarchical centers. A hierarchical approach, this time including the temporal dimension, can be a future line of research. Figure 10 provides a starting point for this direction. Furthermore, actions are not the only events related to the wholeness of spaces. Sounds and smells, for example, could also be mapped and explored in similar ways. Solving how the nature of such centers can be addressed remains a potential next step for this research.

Due to the limitations of the manual behavioral mapping method, the mapped area was restricted strictly to the boundaries and the square itself. However, urban areas are very closely linked to their surroundings in complex ways. A more complete picture could be attained by incorporating more surrounding centers, particularly the centers numbered 5 and 10 in Figure 7c, which are directly adjacent to the area investigated. Another addition to this research could be the incorporation of pedestrian flow. The constant stream of people contributes to the feeling of the space even when they do not stop in the square. Data collection is another critical point that can be optimized. Images and video provide access to data in larger slices of time, which could reveal more of the interactions between events. Another approach could be the collection of data using social media sources instead of observational methods.

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Conflict of Interests

The author declares no conflict of interests.

References

Alexander, C. (1965). A city is not a tree. *Ekistics*, *139*, 344–348.

Alexander, C. (2002a). *The nature of order: The phenomenon of life*. Center for Environmental Structure.

Alexander, C. (2002b). *The nature of order: The process of creating life.* Center for Environmental Structure.

Alexander, C. (2004). *The nature of order: The luminous ground.* Center for Environmental Structure.

Alexander, C. (2005). *The nature of order: A vision of a living world*. Center for Environmental Structure.

Alexander, C. (2009). *Harmony-seeking computations: A science of non-classical dynamics based on the progressive evolution of the larger whole* (Revised and expanded version of a keynote speech). University of California, Berkeley; University of Cambridge. https://www.livingneighborhoods.org/library/harmony-seeking-computations.pdf

Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I., & Angel, S. (1977). *A pattern language: Towns, buildings, construction*. Oxford University Press.

Amin, A. (2007). Re-thinking the urban social. *City*, *11*(1), 100–114. https://doi.org/10.1080/13604810701200961

Askarizad, R., & Safari, H. (2020). The influence of social interactions on the behavioral patterns of the people in urban spaces (Case study: The pedestrian zone of Rasht Municipality Square, Iran). *Cities*, *101*, Article 102687. https://doi.org/10.1016/j.cities.2020.102687

Billig, N. (2018). *Istanbul: Informal settlements and generative urbanism* (1st ed.). Routledge.

Bourdieu, P. (2018). Social space and the genesis of appropriated physical space. *International Journal of Urban and Regional Research*, *42*(1), 106–114.

Cresswell, T. (2008). Place: Encountering geography as philosophy. *Geography*, *93*(3), 132–139.

de Rijke, C. A., Macassa, G., Sandberg, M., & Jiang, B. (2020). Living structure as an empirical measurement of city morphology. *ISPRS International Journal of*

Geo-Information, *9*(11), Article 677. https://doi.org/10.3390/ijgi9110677
Gabriel, R. P., & Quillien, J. (2019). A search for beauty/a struggle with complexity: Christopher Alexander. *Urban Science*, *3*(2), Article 64.
Galle, P. (2020). Christopher Alexander's battle for beauty in a world turning ugly: The inception of a science of architecture? *She Ji: The Journal of Design, Economics, and Innovation*, *6*(3), 345–375. https://doi.org/10.1016/j.sheji.2020.03.002
Gehl, J. (1987). *Life between buildings: Using public space*. Van Nostrand Reinhold.
Gehl, J., & Svarre, B. (2013). *How to study public life*. Island Press.
Gümüş, İ., & Yılmaz, E. (2022). An evaluation of the relationship between everyday life rhythms and urban morphology: The square of Bursa Kent Meydani shopping center, Turkey. *SAGE Open*, *12*(2), 1–22. https://doi.org/10.1177/21582440221104090
Harvey, D. (2004, May 29). *Space as a key word* [Paper presentation]. Marx and Philosophy Conference, London, UK.
Hillier, B., & Hanson, J. (1984). *The social logic of space*. Cambridge University Press.
Jacobs, J. (1961). *The death and life of great American cities*. Random House.
Jiang, B. (2015). Wholeness as a hierarchical graph to capture the nature of space. *International Journal of Geographical Information Science*, *29*(9), 1632–1648. https://doi.org/10.1080/13658816.2015.1038542
Jiang, B., & de Rijke, C. (2022). Representing geographic space as a hierarchy of recursively defined subspaces for computing the degree of order. *Computers, Environment and Urban Systems*, *92*, Article 101750. https://doi.org/10.1016/j.compenvurbsys.2021.101750
Jones, M. (2009). Phase space: Geography, relational thinking, and beyond. *Progress in Human Geography*, *33*(4), 487–506.
Kiss, D., & Kretz, S. (2021). Introduction to relational theories. In D. Kiss & S. Kretz (Eds.), *Relational theories of urban form: An anthology* (pp. 19–65). Birkhäuser.
Latane, B., & Liu, J. H. (1996). The intersubjective geometry of social space. *Journal of Communication*, *46*(4), 26–34.
Lynch, K. (1981). *A theory of good city form*. MIT Press.
Mehaffy, M. W. (2019). Assessing Alexander's later contributions to a science of cities. *Urban Science*, *3*(2), Article 59. https://doi.org/10.3390/urbansci3020059
Mehaffy, M. W., & Salingaros, N. A. (2015). *Design for a living planet: Settlement, science, and the human future*. Sustasis Press.
Moudon, A. V. (1997). Urban morphology as an emerging interdisciplinary field. *Urban Morphology*, *1*(1), 3–10.
Murdoch, J. (2005). *Post-structuralist geography*. SAGE.
Ng, C. F. (2016). Behavioral mapping and tracking. In R. Gifford (Ed.), *Research methods for environmental psychology* (pp. 29–51). Wiley.
Oliveira, V. (2016). *Urban morphology: An introduction to the study of the physical form of cities*. Springer.
Rossi, A. (1984). *The architecture of the city*. MIT Press.
Salingaros, N. A. (1997). Life and complexity in architecture from a thermodynamic analogy. *Physics Essays*, *10*, 165–173.
Seamon, D. (1984). Phenomenologies of environment and place. *Phenomenology + Pedagogy*, *2*(2), 130–135.
Seamon, D. (2013). Lived bodies, place, and phenomenology: Implications for human rights and environmental justice. *Journal of Human Rights and the Environment, 4*(2), 143–166.
Seamon, D. (2018, October 26–28). *Ways of understanding wholeness: Place, Christopher Alexander, and synergistic relationality* [Revised proceedings version of the first-annual Christopher Alexander Keynote Lecture] [Paper presentation]. Portland Urban Architecture Research Lab (PUARL) 10 Year Anniversary Conference, Portland, OR, USA.
Whyte, W. H. (1980). *The social life of small urban spaces*. Conservation Foundation.

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Article

A World of a Thousand Independent Regions: Confronting the Ever-Increasing Refugee Problem

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Abstract
Based on Pattern 1 "Independent Regions" in the book *A Pattern Language* by Alexander et al. (1977), we investigate a fundamental socio-spatial alternative for reorganizing our world, countries, and metropolitan regions. When put into the context of large worldwide problems, such as climate change, nuclear danger, pandemics, overpopulation, and refugee crises, the innovative idea of "independent regions" presents itself as a promising alternative to the current imbalance of few large and dominant countries in contrast to a wide majority of smaller and medium-sized countries. Working on the development of a refugee pattern language (RPL), this alternative can help to solve larger worldwide problems including the human-made refugee problem. In RPL pattern "3.2 A World of Independent Regions," we explore this bottom-up alternative based on fundamental principles with an ideal population size for governing itself democratically and equity among regions in a world community. Other considerations include the potential to reduce the root problem of refugee creation of big countries vs. small counties, in cooperation with independent regions, and world regions. Updating this concept involves considering suggestions and new ideas that might make the outcome richer in overlaps, assembly, and scope. The relevance and vision of this concept and pattern are probably most visible and needed in the current turmoil of a transforming world.

Keywords
independent regions; pattern language; refugee crisis; refugee pattern language; structure of world; world problems

Issue
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1. Introduction

The origin of the idea of "independent regions" (IRs) can be found in the politico-geographical studies of concerned citizens and scholars, particularly in Austria, England, and France right after WWII. These concerned citizens searched for solutions for a well-functioning structural organization of the world containing the study of IRs. As Borras-Alomar et al. (1994, p. 29) point out, "Authors like Leopold Kohr, Dennis de Rougemont or Guy Heraud constitute the key players in what can be considered here as the 'prehistory' of contemporary political opinions…of 'Europe of the Regions.'" When Alexander took up the topic of IRs 15–20 years later the world was still recovering from WWII, but it was also the beginning of a new epoch of hope, economic progress, democracy, and working together.

INDEPENDENT REGIONS is the very first pattern in the book *A Pattern Language* (Alexander et al., 1977) with 253 "patterns of events, patterns of space, and patterns that are alive" ("attempting to create life"; see Figure 1). It seems to stand at the top, as a building block of a new socio-spatial order. It is the only pattern that explicitly addresses a worldwide geo-social problem. For our times, we might formulate the question of "how to structure the human world in a way that it can work best and survive?" This needs a critical perspective and updating of context, new concepts, and criteria. While

we contemplate additional concepts, such as "bioregionalism," "ecoregions," or *If Mayors Ruled the World*, we will consider IRs as the main concept and building block to pursue, albeit enriched by additional concepts. This study, although large in scope and complexity, is relevant for providing new insights and suggestions to meet the often dangerous contemporary challenges of our era, especially in the search for solutions to the global refugee problem.

Humankind has maneuvered itself into a number of large problems that threaten our survival on Earth. Climate change, including rising sea levels and increasing heat and wildfires; the dangers of war and terrorism; pandemics; overpopulation; refugees; over-urbanization; and threatening dominance of a few powerful countries over the rest are global conundrums. These problems all need answers and solutions. The impact of Alexander on confronting problems of this kind is first visible in the application of the PL approach that he invented. Particularly, it is noticeable in the updating, adapting, and exploring of the idea of IRs. While his input as a scientist, mostly an empiricist, as well as a structuralist, mathematician, planner, architect, and contemporary humanist, is unquestionable. His political-philosophical view is less clear yet might be relevant in a topic as critically important as the survival of organic life on earth based on the idea of IRs. In the liberating years of the late sixties to the mid-eighties centered around capitalist and Marxist ideas, Alexander was more interested in a third option of a new society and civilization built around concepts of wholeness and value, and a humanistic bottom-up and piecemeal growth perspective. In his article "Value: A Reply to Protzen," he emphasizes one value as his philosophical base and asks: "What kind of political process, in a neighborhood, will allow the people to shape the neighborhood according to their own culture?" (Alexander, 1977/2022). More pronounced, we can find a view that is closely related to an actual project: "Understand that the battle between system-A and system-B is not merely a clash between two theories of architecture. More profoundly, it is a clash between two systems of thought, human organization and social activity" (Alexander et al., 2012, p. 60). Finally, the importance of practical reality and empirical depth is emphasized as a necessary ingredient: "The social and economic revolutions—revolutions that have been debated for the last 250 years or more—suddenly come into clear focus when we find ourselves dealing with the actual making of the world, in concrete terms" (Alexander et al., 2012, p. 482).

In confronting the refugee problem, the study and application of the PL method led to the pattern of IRs, which proved to be helpful in addressing the refugee problem from a new and innovative angle appropriate to the scale. These new and progressive ideas seem to come up especially during and after large global disasters, such as WWII. They are now reappearing in a world where the younger generation refers to itself as the "last generation," and refugees have reached 100 million worldwide and continue to grow (The Last Generation, n.d.).

2. Methodology and Format

Pattern Languages were first published as a theory and method in *The Timeless Way of Building* (Alexander, 1979) and *A Pattern Language* (Alexander et al., 1977). They have been adopted in many more disciplines than architecture, from social sciences to computer software, and now for confronting the refugee crisis. The reoccurrences and continuity of human migration and displacement, with all its problems and complexities, suggest the employment of the PL method.

In the work of RPL, we collect data and analyze case studies on contemporary refugee groups: Conducting field studies to meet refugees in different circumstances and support with conversations and interviews. Scrutinizing patterns of sequences from escaping, resettling, and returning in conjunction with scales of country, city, neighborhood, and building, help categorize these patterns into clusters. In the domain of refugees, a complex dynamic between hosts and refugees requires tools that ensure mutual benefits, such as social interaction,

Figure 1. A Pattern Language APL1 Independent Region(s) plus Refugee Pattern Language RPL3.2 A World of a Thousand Independent Regions.

conferences, and qualitative conversations. We also conduct seminars and produce and test housing designs and neighborhood projects with our students. While assisting vulnerable persons it is important not to be damaging to a host society but rather promote equity and endorse the coinciding interests of both sides. The pattern and PL approach is in itself a method of research and design and therefore needs some minimal introduction as such. It can be reasonably well explained in three illustrations. In Table 1, we can see two different columns of table of contents juxtaposed with RPL and APL. These show the sequences, clusters (or chapters), and patterns ordered according to their context in *A Pattern Language* (Alexander et al., 1977). They are also the two main pattern languages, P+PLs, referred to and applied in this article. Figure 2 shows the build-up of a new PL, where one or two patterns are at the center connected to other patterns in a system or language or relations diagram, in one particular context area or domain: IRs and Refugees. Table 2 shows the build-up of an individual pattern format in detail, with all its components at the example "Welcome Countries."

Both domains support the life of people. With the selection of patterns from both domains, that is APL and RPL, we have created an initial system of connections between these various concepts, creating a PL. We have prominently placed the "independent region" at the center, followed by connections that make the IR stronger. Also closely placed is the pattern "extended refugee family" that starts to create relations to IRs, but also relations to patterns, such as "Welcome Countries." We have placed two potential concepts to the right, that may become relevant in "A World of Independent Regions": ecoregions and bioregions.

Table 1. Juxtaposition of the two shortened and condensed PLs applied in our investigation: (a) RPL and (b) APL.

"The Sugar in the Milk: Refugee Pattern Language" RPL	*Pattern Language: Towns, Buildings, Construction APL*
Cluster 1: The Refugee Family	Cluster: World
Cluster 2: Leaving Place—Escape Journey	1. Independent Regions
Cluster 3: Welcome Country—Arrival Place	Cluster: Region
1. Welcome Countries—Refugee Declaration 1951 (1967)	2. The Distribution of Towns
2. A World of Independent Regions—Refugees	3. City Country Fingers
3. From Countries to Independent Regions	4. Agricultural Valleys
4. Walk-To Countries	5. Lace of Country Street
5. Taking in a Million People	6. Country Towns
6. Sanctuary Cities and Counties	7. The Countryside
Cluster 4: Arrival City—Urban Life and Infrastructure	Cluster: City
Cluster 5: Refugees in Neighborhoods and Communities	8. Mosaic of Subcultures
Cluster 6: Buildings, Facilities, Neighborhood Support	9. Scattered Work
Cluster 7: Housing, Living, and Live Work	10. Magic of the city
Cluster 8: Work and Work Learning	11. Local Transport Areas…
Cluster 9: Design and Construction	253. Things from your Life
Cluster 10: Anti-Patterns	

Note: "Refugee Pattern Language" is an ongoing manuscript that is partially published in papers and conference presentations. *A Pattern Language* is a fully published book, that serves as the model for RPL, albeit in a modified form (see also PUARL, n.d.). Patterns from RPL and APL are applied in a PL together (see Figure 2). Box 1 exemplifies the format of a pattern and pattern language.

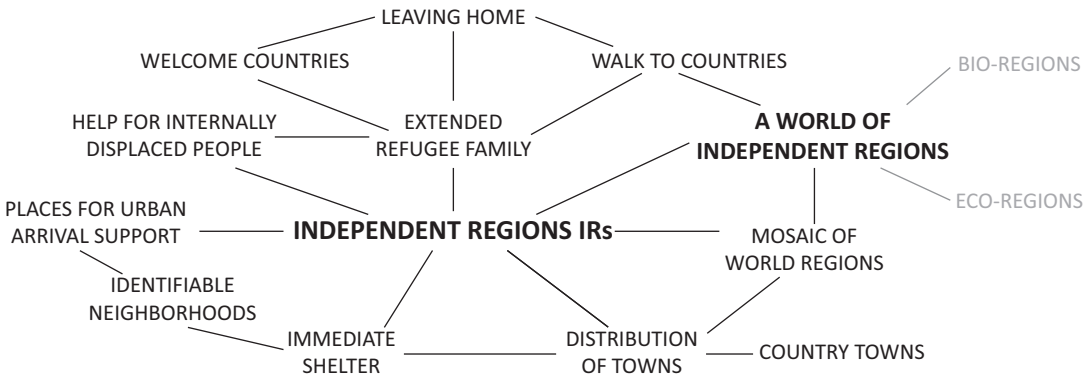

Figure 2. New PL relations diagram composed of patterns from APL and RPL.

Box 1. Pattern format using the shortened example of "RPL3.1 Welcome Countries."

- **Figure 3.** Illustration that captures the essence of the pattern: Crowds of people at Berlin Railway Station offering shelter to Ukrainian refugees. Source: Marsh (2022; see also Neis et al., 2018).

- **Title:** Welcome country** with or without asterisks about the quality of the pattern.
- **Links:** To other patterns (APL, RPL): IR may offer a solid and serious but also visionary alternative to the current highly unbalanced world system. "APL8 Mosaic of Subcultures" alludes to the possibility of bringing cultures, regions, and countries into balance with each other.
- **Definition of the problem**: "A welcome country is positive and open to help and welcomes refugees….Unfortunately, not all countries are welcoming to refugees or provide asylum services."
- **Investigation and discussion of pattern:** Here, empirical or analytical facts are discussed to demonstrate the validity of the pattern; a number of possible solutions are discussed:

  Only 149 of 193 countries have signed into the 1951 UN Refugee Conventions and its 1967 Protocol. Moreover, not all of the 149 countries felt obliged to actually follow the convention.

- **Solution proposals:** Text that shows the solution/proposal of the problem. This also includes the physical and social connections that are needed to solve the problem. The solution/proposal is given in the form of an instruction so that the reader knows what to do or how to proceed:

  Strategize your country (or "Independent Region" if applicable) in a way that it always has the capacity to welcome refugees. First, refugees will get formal protection under the asylum status, according to the non-refoulment clause in the Refugee Convention… Employ the existing social system to support refugees, or even improve the system. Keep in mind that welcome takes place at the policy level, and public opinion but also media as well as personal level.

- **Illustration of the proposal**
- **Links to other patterns** (APL, RPL): "RPL3.2 A World of Independent Regions" can be strengthened by patterns such as "APL2 The Distribution of Towns" and "APL6 Country Towns."
- **References:** In text and at the end of each pattern (new feature).
- **Web platform** (new feature)

Pattern "3.2 A World of Independent Regions" addresses multi-level problems and opportunities that the world community, regional associations, countries, and regions need to address at the social modus and spatial level of IRs, and at the level of cooperation between different IRs, different levels of scale and area responsibilities. Individual patterns create the depth of each concept, and they also create the overall depth of a PL. Presentation of this pattern is conducted in the original format: "*Problem—Investigation/Text—Solution/Suggestion*," and links are essential to forming a PL.

3. Results and Discussion of One Pattern: RPL 3.2 A World of Independent Regions—And Refugees

Links: "RPL1.1 The Extended Refugee Family" provides an overview of their problems and needs; "RPL2.1 Help for Internally Displaced People," asks for disaster assistance within a country; "RPL3.1 Welcome Countries" encourages nations to take in refugees; It is also relevant for "APL1 Independent Regions" as a major encouragement of providing help and showing sympathy and empathy; "RPL3.2 A World of Independent Regions—And Refugees" is relevant for supporting regions and countries cooperating with each other in an organized fashion in order to reduce the number of refugees.

Problem: *What are Independent Regions? How could a world of IRs help to restructure and improve our social and spatial life so that large-scale world problems, such as the ever-increasing refugee crisis, could be drastically lessened or avoided altogether? How can IRs participate and be instrumental in solving refugee problems?*

Based on the 1951 Refugee Convention and its 1967 Protocol, the remaining 46 countries should finally sign the Convention. Each country should be obligated to provide full support for refugees worldwide and offer better coordination among them. However, that may not work in the current state of the world organization, where a few very large and powerful countries can dominate the world with their military might and their veto right in the UN.

As the engineer-architect Buckminster-Fuller would argue, do not stay with criticizing the past, but propose a new and better system. Here, we explore the question on a structural level as originally proposed in the pattern "Independent Regions" (Alexander et al., 1977, pp. 10–15). The argument implies that the world should be regrouped into a "thousand independent regions," and it is anticipated that the restructuring will include significant improvements in world balance and cooperation for solving large-scale problems. This could considerably reduce the numbers of refugees because: (1) IRs are easier to self-govern democratically than the larger country system; and (2) the system would protect smaller countries and IRs as equals, rather than what is seen in the current system of being vulnerable to domination, attack or even military invasion by larger or more powerful countries (see Figure 4).

Before we go any further, we need to take a critical look at the pattern of IRs, update the argument for today's world, and also refer to recent developments and ideas that can inform the concept of IRs. Since 1977 the world has changed dramatically—social technology has influenced communication and politics tremendously—and ecology and sustainability are dominating the discussion of how to live and survive on Earth together. Here we refer to three concepts that are related to IRs: ecology and ecoregions, bioregionalism, and *If Mayors Ruled the World*.

Ecoregions are defined by nature and scientifically based on wildlife and vegetation. They are relevant as additional elements to IRs and may form buffer zones or commons between IRs. In other words, these areas have their independent rights of existence and they may add up to the mosaic of world regions. Bioregions: Apparently, the term was coined by Allen Van Newkirk, founder of the Institute for Bioregional Research in 1975 and Michael V. McGinnis wrote the first book that explains the theoretical and practical dimensions of Bioregionalism (McGinnis, 1999.) Like IRs, these regions are not always dependent on political boundaries. A bioregion tends to be larger than an IR;

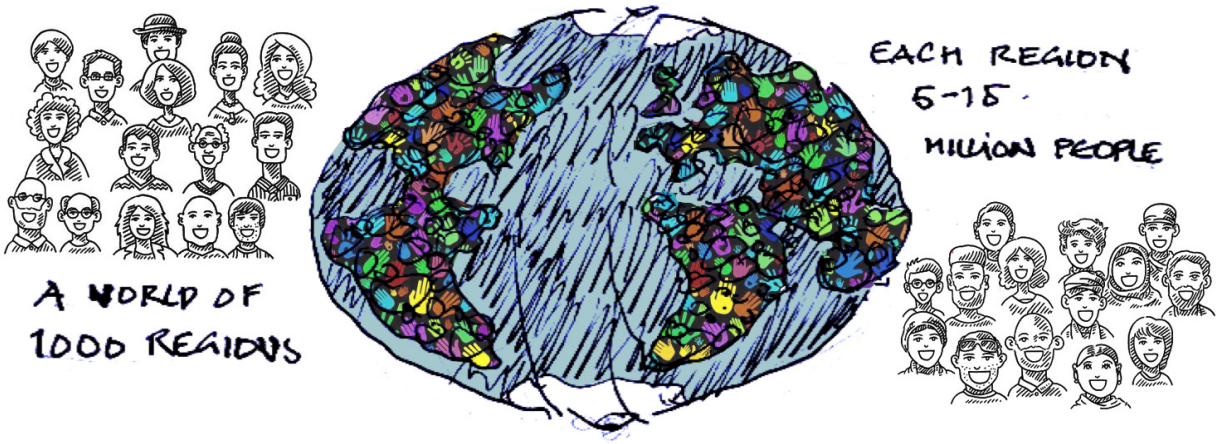

Figure 4. A world of a thousand independent regions with each region 5–15 million people.

for example, when we consider the bioregion of the North American Cascadia Region, this consists of most of Oregon and Washington, the Alaska Panhandle, the far north of California and the west coast of Canada. It also easily includes the smaller Ecotopia Region that Callenbach (1975) wrote about in his famous novel with the same name. Third is the challenging book by B. Barber, entitled *If Mayors Ruled the World* (2013). Barber (2013, p. 3) argues that nations were "the perfect political recipe for the liberty and independence of autonomous people and nations. It is utterly unsuited for interdependence." These three arguments might enrich and update the understanding of an IR and more specifically world regions where IRs cooperate.

With reference to *the raison d'etre* of new IRs, Alexander writes "Metropolitan Regions will not come to balance until each one is small enough and autonomous enough to be an independent Sphere of Culture" (Alexander et al., 1977, p. 11). Four conditions and criteria of IRs have been proposed (Alexander et al., 1977, pp. 10–14). These four are updated and two new conditions are added regarding inner strength or resiliency and ability to cooperate, and recent developments and ideas have been considered.

(1) The nature and limits of human government largely determine the population size of IRs, so that a region can govern itself effectively and all people can participate in direct democracy. The biologist Haldane (1926) asserts:

> Just as there is a best size for every animal, so there is a best size for every human institution. In the Greek type of democracy all the citizens could listen to a series of orators and vote directly on questions of legislation. Hence their philosophers held that a small city was the largest possible democratic state. (J. S. B. Haldane, 1926, in Alexander et al., 1977, p. 11).

As population size increases, direct communication decreases. Governments of a region become less effective, unmanageable, and are prone to break down. While the original APL estimates 2–10 million per IR (Alexander et al., 1977, p. 11), other proposals suggest 3–12 million. To give it more flexibility, some also added 5–15 million as a reasonable alternative (Letter by Lord Weymouth, 1973, in Alexander et al., 1977, p. 12). We partially work with the increased number of 3–12 million, but also use higher numbers when appropriate. The numbers could increase for two reasons. First, there are far more people in the world today than in 1975 (3 billion in 1975 to 7.8 billion in 2023) and various world demographic development calculations have estimated a 10 billion world population by mid-century before it will level out. Countries and IRs will have to absorb more population than the ideal numbers suggested. Second, we consider how modern tech media have improved communication for direct plebiscites or other large-scale democratic involvements that affect citizen participation and refugees' integration decisions. Better communication thus allows IRs' population to increase considerably. Still, we need to be careful and ensure that democracy can function when there are major problems because of refugee arrivals. Here we follow the number 5–15 up to 20 million (see Figure 5b with Switzerland as a potential example of a future IR).

(2) Equity among Independent Regions in the world community is easier to establish than with unequal countries, especially when IRs are all relatively similar in their limited population size. When IRs are too limited in population, they may not have an equal say in a world government. Therefore, a minimum of 2–3 million population is needed. Lord Weymouth of Warminster, England, makes the following point in *World Federation: A Thousand States* in his Letter to the *New York Times* dated March 15, 1973:

> Working backward from an estimate of the global population in the year 2000, which is anticipated to rise to 10,000 million mark [10 billion H.N.], I suggest, that we should be thinking in terms of an ideal regional state of something around ten million, or between five and fifteen million, to give greater flexibility. This would furnish the U.N. with an assembly of equals of 1000 regional representatives: a body that would be justified in claiming to be truly representative of the world's population. (Lord Weymouth in Alexander et al., 1977, p. 12)

With the right population size, IRs can self-govern more efficiently and democratically in a world of IRs and metropolitan areas. Because the demands of direct democracy need a rather developed social system built on freedom of the press, citizen responsibility, the rule of law, and free and open elections with different independent

Table 2. Conditions and criteria for Independent Regions.

	Conditions and Criteria	Results and Outcome for Refugees
1.	The nature and limits of human government	Range of 5–20 million people for each IR
2.	Equity among regions in a world community	Each IR will have one seat in a World Organization
3.	Regional planning considerations	Will include plans for refugees' accommodations
4.	Support for intensity and diversity of human cultures	Refugees are part of the Mosaic of Life
5.	Resilience of each Independent Region	Infrastructure and Defense will be strengthened
6.	Cooperation between Independent Regions	Includes cooperation for taking care of Refugees

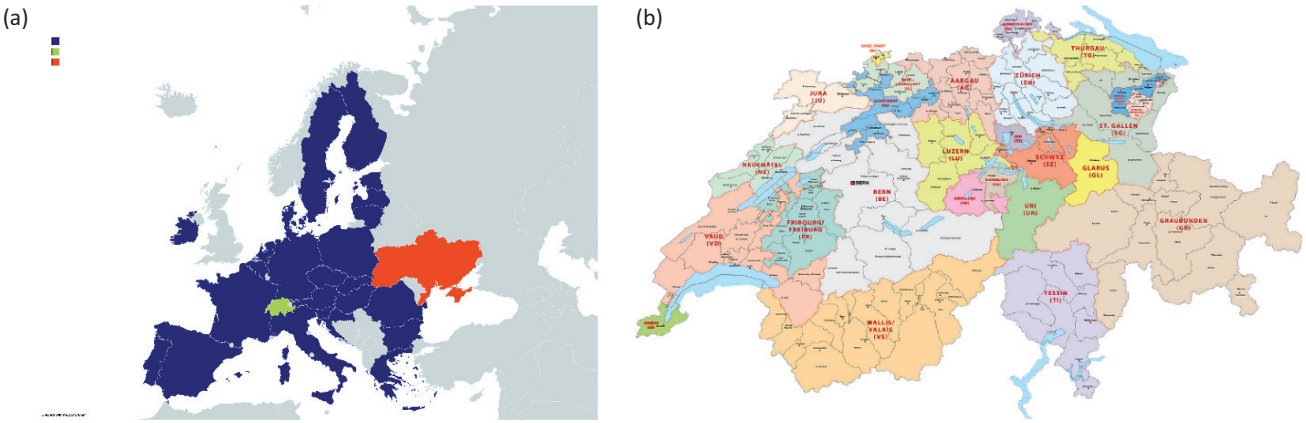

Figure 5. Map of EU Countries with Switzerland as a neutral embedded country: (a) EU countries in dark blue provide Temporary Protection Directive for Ukrainian refugees to move freely within the EU, are free to work, and receive housing and social benefits. (b) Map of Switzerland as a theoretical example of a potential new IR with cantons as the basic local historic and geographic unit of governance. Source: WorldAtlas (n.d.).

political parties. We can see examples from the future "IR of Switzerland" with a long democratic tradition since 1848 as well as the "IR of Singapore" with a recent democratic tradition. It is certainly easier to self-govern on the regional level than on the scale of huge countries like the US, Russia, China, or even the UK, or Germany. In short, equity among IRs would be most just when all IRs have the same one vote each in a World Federation of Thousand Regions, and when IRs are roughly about the same size in population.

(3) Regional planning considerations can strengthen a territory to support its own governance and encourage cohesion. Arbitrary boundaries that randomly cut across natural boundaries make it difficult for people to connect within an IR and develop deep knowledge to solve problems in their land, cities, and countryside. This means that the definition of regions should be strengthened by both natural boundaries, like rivers, oceans, forests, mountains, and man-made connections (including bridges and railways), as well as ecological, economic, and social-cultural qualities. In the event of human displacement, IRs need to employ action plans to handle either natural or man-made emergencies. New concepts such as ecoregions and bioregions need to be integrated into large-scale regional planning and cooperation between IRs.

The French economist Jean-François Gravier (1965) has proposed the idea of a Europe of the regions which cross present national and subnational boundaries, for example, the Basel-Strasbourg region which includes parts of France, Germany, and Switzerland. Furthermore, APL provides concrete patterns for regional planning within a framework of Independent Regions. "Within each region work toward those regional policies which will protect the land and mark the limits of the city" (Alexander et al., 1977, p. 15). Original regional patterns that support regional planning as part of an APL network are suggested for pages 16–40: (a) The distribution of towns, (b) City country fingers, (c) Agricultural valleys, (d) Lace of country streets, (e) Country towns, and (f) The countryside.

Any of these patterns are appropriate for the distribution and inclusion of refugees into a new land. "The distribution of towns" is relevant regarding the widespread distribution of new populations which include the growing population of immigrants and refugees. The pattern "Country towns" could play a relevant role in the welcoming of new inhabitants, such as absorbing forced migrants in agriculture, and possible including initial experiments with circular economy. The pattern "Countryside" reveals a fresh view, reminding us of a countryside that belongs to everybody and therefore needs to be carefully organized such that it promotes agricultural production and use for all kinds of people, beyond a purely utilitarian use of the land as huge fields, lacking animals, bees, and people.

(4) Support for intensity and diversity of human culture, with regard to refugees, has become a relevant topic. The widespread distribution of IRs, or small countries, can provide a new space system in which all cultures can find a home within. Many of the new IRs could be delineated in a way that any culture can find a place within an already existing IR, or they can find a place within a newly emerging IR. Others may want to develop a new culture in the overall process of human evolution and new needs from environments. What is described here is a life of freedom and possibility in a world of IRs that allows for a chance of rich cultural life within a variety of diverse cultures.

A word of caution: Forced migration can still occur, especially due to natural disaster-induced displacements such as floods, storms, earthquakes, famine, or droughts, even in a world of IRs. Thus, there need to be policies and strategies in place in such cases to absorb large numbers of refugees. Alternatively, new IRs may be formed to accommodate populations that had to evacuate from their own land, like the Rohingya people from Myanmar or the internally displaced people of Palestine.

The question is how refugees can continue to develop their own culture in a new land while concurrently trying to adapt to a dominant culture and a new system of life.

Resiliency and Cooperation are relevant for fighting the contemporary large-scale problems of the world, which have become primary concerns for survival and living together. Hence, IRs (and countries alike) are dependent on two major features. First, they need to be more resilient and resistant to large challenges and disasters, and second, they need to cooperate with each other to tackle large issues and challenges.

(5) Resiliency refers to a "capacity to recover quickly from difficulties" (Resilient, n.d.). To establish resilient IRs, the region has to develop its own economy, social cohesive structure, and safety plans for any potential disasters, especially as related to climate change, war, or conflict. The region might also need a military protection force to keep the country or IR safe and resilient, maybe in the form of the Swiss protection system where everybody has to take on defense obligations, learn some specialized military activities and become part of a territorial organization. At the point of a thousand IRs, IRs are equally large and well-equipped economically, socially, and culturally. They should be each resilient enough to govern themselves and take care of possible future problems, whether expected or unforeseen (Figure 6).

(6) Cooperation is fundamental to the function of a world government of a thousand regions, especially when it comes to dealing with worldwide problems such as climate change, refugee crises, or pandemics. While the world government has important centralized functions in various departments such as UNHCR and WHO, etc., IRs must also be able to cooperate naturally with each other. The large-scale issues between IRs and the world government may be scaled into world regions like regional federations, associations, or unions similar to what the EU offers. There needs to be a cooperative system that "independent world regions" can provide at their administrative level as well as human structures through modern democracy and competent communicative technology.

Because of their relative population size within a range of 5–15 million or up to 20 million, IRs can potentially rely on more internal cohesiveness. At the same time, they can be equal partners in a world federation or union without fear or domination from huge countries of more than 100 million or more. IRs thus can become bulwarks in strengthening their territories and also assist areas that have problems and need help in recovery.

No matter what, the most important task is to always strengthen IRs and help to support each other to solve problems that challenge IRs in significant ways. In the case of a refugee crisis, it is important to make sure that IRs are consistently resilient and well maintained so that no citizens will be displaced or lose their human rights protection, and basic human rights as refugees with the

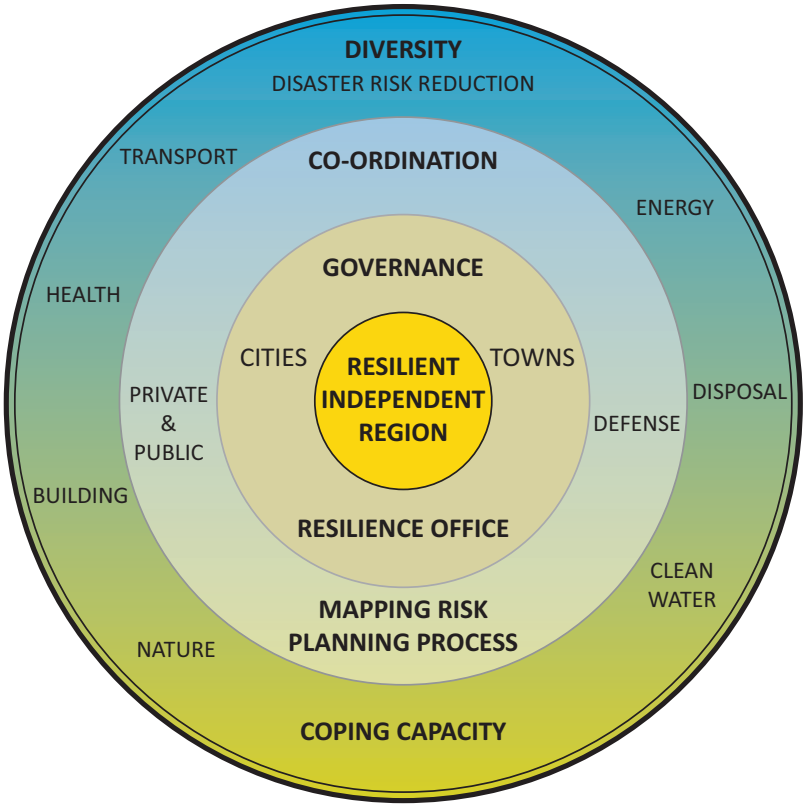

Figure 6. Diagram of characteristics of structure and organization of resilience in IRs with emphasis of governance, coordination, and diversity, as well as protection from and coordination with the outside. Source: Adapted from Barrott (2021).

support and cooperation of other IRs, and with the help of the world regional federative administration.

Therefore, in the current dominant large-country system, all the remaining 46 non-signing countries must sign the UN Refugee Convention and actively develop a refugee support system within their country. At the same time, we look for opportunities to establish IRs in an organic bottom-up process with countries that form already more than two-thirds of the world's smaller countries. Working towards the evolution of IRs, each region will have a population of 5–15 up to 20 million, within its own geographical and natural boundaries, a circular economy, and will be autonomous and self-governing. Each IR has an equal seat in a world government without the intervening powers of larger countries. Furthermore, emerging "independent regions," will become resilient, and work together to assist with each other's problems, such as refugee crises, in a new world of self-governed, equitable, and free IRs.

Links: "RPL3.3 A World of Thousand Regions" explores transitions from countries to IRs. "RPL3.4 Walk-To Countries" (or IR's) can be very useful in creating first safe-havens. "RPL4.2 Places of Urban Arrival Support" suggests safe places for refugees arriving in new cities. "RPL5.4 Identifiable Neighborhood for Refugees" provides safe havens for refugees. "RPL6.1 Immediate Shelter" guarantees a roof over one's head.

4. Outlook and Conclusion

With the pattern 1 "Independent Regions" in the book *A Pattern Language* (Alexander et al., 1977), Alexander has given us an idea and a concept to approach our current large-scale world problems in new and promising ways. While this idea framed as the first pattern of the book seemed to be a talisman rarely ever used practically, it gave the sense that taking care of the entire world is its primary task. In our case, and for current times, it has helped the authors start to explore a potentially totally different order of the world. In the end, it might be a more useful and practical approach to solve current large-scale problems, including the refugee crisis that has affected more than 100 million people as of the Spring of 2023.

Furthermore, Alexander has given us a method of working with patterns, not only as individual pieces but forming them together, in what is considered a system or language, to better understand large and complex problem areas. It is because of this build-up or format that one can take a complex problem, and work on individual patterns, but with the intention to bring all pieces or patterns together in one area of activity. Patterns end with instructions and are therefore also a set of instructions that work together. What we may call here the PL method (some call it methodology), has become very attractive in numerous disciplines and professions outside architecture, for which it was invented and developed originally. It is also a solid method for interdisciplinary research and cooperation. This fact can also be found in the combination of patterns of the two domains APL and RPL. The primary objective of APL is to improve the lives of people with very specific patterns or several of them together. The aim of RPL is to support and help refugees in their arduous and demanding lives in the same way.

A critical IR perspective has resulted in the updating of the criteria as well as an expansion of the conditions for an IR. Four existing criteria were updated, such as the increase of the population number for an IR, and additional arguments for the remaining three have been provided. Resiliency and cooperation were introduced as two new criteria because of the need for protection in a more dangerous world and because of the need to work more closely together. Most importantly, three additional complementary as well as competing concepts were introduced. These are appropriate for our times with regard to sustainability, biodiversity, and governance, and result in a more complex picture of a new world with IRs, ecological regions, and bioregions. Because of the need for cooperation between all these entities, we looked at a scaled structure in particular for IRs to work together with IR neighbors, in clusters as well as associations or unions of mosaic of world regions.

Instead of pursuing the way of ever larger countries with hegemonial or world domination ambitions, this proposal tries to proceed in the opposite way by emphasizing the scale of human living within an entity that people can understand and govern well by themselves. The strong criticism of Leopold Kohr has encouraged our support and development of IRs because of his warning, "the bigger the power and size of a State, the bigger the potential risk of driving towards conflict with serious destructive effects" (Borras-Alomar et al., 1994, p. 30). However, without a clear democratic and cooperative structure it needs to be seen if smaller countries and IRs will not turn on each other, fighting for limited resources such as water, food, and energy. But at a minimum, we assume that smaller countries and IRs are less likely to start wars with each other.

The observations and arguments in this article reinforce the proposition of a new socio-spatial entity called an "independent region" for the benefit of mankind including a drastic reduction of refugees. One might wonder if the idea of IRs with 5–20 million inhabitants each and self-governing based on strong democratic principles shall be a better way for organizing, structuring, and administering our world altogether (see Figure 7). It is not only because of contributions to solving refugee problems but also because the arrangement of IRs has the potential to solve more large-scale problems beyond the refugee crisis.

As the Club of Rome argues, we need a new enlightenment that is based on tradition and culture, but that also works with a new understanding to tackle the large-scale problems in the world at the right levels of scale and with the power and understanding of science, new

Figure 7. Invitation to create an open world of IRs, bioregions, and ecological regions as a mosaic of world regions from the bottom up.

philosophy, and passion (von Weizsäcker & Wijkman, 2018). The idea of IRs, and their formation, thus, should become part and parcel of this new enlightenment.

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Conflict of Interests

The authors declare no conflict of interests.

References

Alexander, C. (1979). *The timeless way of building*. Oxford University Press.

Alexander, C. (2022). Value: A Reply to Protzen. In H. Davis (Ed.), *Early and unpublished writings of Christopher Alexander: Thinking, Building, Writing* (pp. 117–123). Routledge. (Originally published in *Concrete*, *8*(1), 1977)

Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I., & Shlomo, A. (1977). *A pattern language: Towns, buildings, construction*. Oxford University Press.

Alexander, C., Neis, H. J., & Alexander, M. (2012). *The battle for the life and beauty of the earth: A struggle between two world-systems*. Oxford University Press.

Barber, B. R. (2013). *If mayors ruled the world: Dysfunctional nations, rising cities*. Yale University Press.

Barrott, J. (2021). *Building resilience in African cities: A think piece*. weADAPT. https://www.weadapt.org/knowledge-base/cities-and-climate-change/building-resilience-in-african-cities

Borras-Alomar, S., Christiansen, T., & Rodriguez-Pose, A. (1994). Towards a "Europe of the regions"? Visions and reality from a critical perspective. *Regional Politics & Policy*, *4*(2), 1–27. https://doi.org/10.1080/13597569408420896

Callenbach, E. (1975). *Ecotopia: The notebooks and reports of William Weston*. Banyan Tree Books.

Gravier, J. F. (1965). L'Europe des regions [The Europe of regions]. *Revue économique franco-suisse*, *45*(3), 42–48. https://doi.org/10.5169/seals-886627

Last Generation. (n.d.). *Home*. https://www.last-generation.org

Marsh, S. (2022, March 4). Berlin's main train station becomes Ukrainian refugee welcome center. *Reuters*. https://www.reuters.com/world/europe/berlins-main-train-station-becomes-ukrainian-refugee-welcome-center-2022-03-04/

McGinnis, M. V. (1999). *Bioregionalism*. Routledge.

Neis, H., Meier, B., & Furukawazono, T. (2018). Welcome City: Refugees in three German cities. *Urban Planning*, *3*(4), 101–115. http://doi.org/10.17645/up.v3i4.1668

PUARL. (n.d.). *Home*. https://refugee.uoregon.edu

Resilient. (n.d.). In *Oxford Learner's Dictionaries*. https://www.oxfordlearnersdictionaries.com/definition/english/resilient

von Weizsäcker, E. U., & Wijkman, A. (2018). *Come on!: Capitalism, short-termism, population and the destruction of the planet*. Springer. https://doi.org/10.1007/978-1-4939-7419-1

WorldAtlas. (n.d.). *Maps of Switzerland*. https://www.worldatlas.com/maps/switzerland#admin1Section

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Article

The Pattern Language Approach as a Bridge Connecting Formal and Informal Urban Planning Practices in Africa

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Abstract
This article explores the use of the pattern language approach in bridging the gap between formal and informal urban planning practices in the African context. This study focuses on a case application within the urbanised region encompassing the Nakivubo wetland located in Kampala, Uganda. As in other cities in Africa with a colonial past, Kampala's planning system signals a profound gap between a technocratic, European paradigms-based type of planning and the everyday practices of citizens. This results in a "dual city," with formal and informal communities using resources and spaces differently, leading to spatial segregation and non-implementation of urban plans. To overcome this challenge, the pattern language approach is utilised in this research to link formal and informal practices through facilitating meaningful community participation and integrating tacit knowledge into the planning process. To achieve this, the researchers conducted fieldwork and interacted with the local community in informal settlements to develop informal patterns, while analysing the history and current organisation of formal planning institutions in Kampala to formulate formal patterns. The patterns were used as input for a community workshop, which resulted in a pattern language of wetland management practices and a framework that begins to bridge both formal and informal domains of urban practice. By using the pattern language approach as a tool to understand informal practices and their possible incorporation into a planning process that captures the needs of citizens, this research offers relevant insights into achieving sustainable and inclusive urban environments.

Keywords
community participation; formal practices; Kampala; informal practices; informal settlements; pattern language

Issue
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1. Introduction

In 2012, the Kampala Physical Development Plan (KPDP) was launched alongside the formation of the Kampala City Council Authority (KCCA). This marked the beginning of a new era for the Ugandan city, with fresh leadership and a renewed commitment to progress, following a history of corruption and inaction under its predecessor, the Kampala City Council (Goodfellow, 2010). The KPDP received praise for its transformative vision, particularly the proposal to create a central urban park (CUP) by designating the Nakivubo wetland (see Figure 1), the city's largest, as a green open space to encourage tourism with facilities for recreation, sport and culture (KCCA, 2012). However, the proposal failed to consider the informal communities living and working in the wetland and its surroundings. Consequently, these communities are unaware of the proposed CUP and continue to inhabit the wetland. Despite the enthusiasm surrounding the KPDP, the much-anticipated park exists only on paper, and its implementation is yet to commence 10 years on.

This is a case of competing realities, which are commonplace in Kampala and across cities in the Global South (Goodfellow & Titeca, 2012). While formal

Figure 1. The Nakivubo wetland area. Source: Google Earth.

planning authorities have one idea for the use of a resource or space, informal communities are using it in another way. This divergence in priorities between formal and informal practices is ubiquitous throughout the urban planning process in Kampala, resulting in significant obstacles to achieving meaningful and sustainable change (Goodfellow, 2010).

This article departs from the hypothesis that the pattern language approach can provide a means of reconciling these competing realities. To test this assumption, we explore the development of a pattern language which is inclusive of formal and informal practices and its implications for practice in the context of Kampala, Uganda. For that, we conducted fieldwork and interacted with a local community in an informal settlement in Kampala to develop informal patterns. We also analysed the history and current organisation of formal planning institutions in this city to formulate formal patterns. The resulting patterns were used as input for a community workshop towards their validation. Its outcome was a pattern language of wetland management practices and a framework that begins to bridge both formal and informal domains of urban practice. By using the pattern language approach as a tool to understand informal practices and their possible incorporation into a planning process that captures the needs of citizens, this research offers relevant insights into achieving sustainable and inclusive urban environments in the African continent.

2. The Pattern Language Between the Formal and the Informal

"A Pattern Language" is one half of a single volume written by Christopher Alexander, that endeavours to propose a novel approach to architecture and planning (Alexander et al., 1977). The book defines a pattern as a recurring problem in architecture and its core solution and presents one possible pattern language which encompasses 253 patterns ranging from rooms, houses, neighbourhoods, and towns. Patterns can also be understood as tried-and-tested solutions that have been subjected to various conditions over time (Salingaros, 2000). The authors of the book contend that society should adopt a shared "pattern language" as a means of breathing life into buildings and towns. The aim of the book is to furnish users with a common, dynamic language that can evolve over time as more patterns are discovered. Although it is not intended as a manual per se, the book serves as a springboard for users to develop their own pattern languages. The patterns are presented in a consistent format to facilitate clarity and are organised from the largest scale (towns and regions) to the smallest

(construction details). It is worth noting that the patterns are interdependent and are supported by the larger patterns in which they are embedded as well as the smaller patterns that they themselves embed (Alexander et al., 1977).

Since its inception, Alexander's work has been met with mixed reception (Bhatt, 2010). While some in academia have shown interest—particularly in the areas of user empowerment, community participatory design, in the use of patterns in the design process (Bhatt, 2010)—practitioners in the field of architecture, for which the work was intended, have not fully appreciated the significance of patterns (Salingaros, 2000). Critics have taken issue with the generalisations made in the book, arguing that the patterns inhibit creativity and diminish intellectual capabilities (Bhatt, 2010). They contend that design cannot be reduced to a few diagrammatic languages (Cai, 2018) and that the "Alexandrine" patterns lack thorough research and empirical content (Dovey, 1990), rendering them inapplicable in other contexts. Additionally, some criticise the implication of participatory socialism, deeming it impractical in our current capitalistic and individualistic societies (Dovey, 1990). The proponents of the pattern language approach argue that patterns are not just theoretical constructs but are grounded in empirical observations (Salingaros, 2000), providing a direct link to our experience of the built environment (Bhatt, 2010). According to them, these patterns, as put forth by Alexander, have a personal and intuitive resonance with users (Cai, 2018), and offer a philosophical critique of the "modern alienated condition" by transforming functional spaces into socially interactive ones (Bhatt, 2010). They argue the book's overarching goal is to make architectural knowledge accessible to the everyday user by creating a system of knowledge that "blurs the distance" between professionals and laymen (Bhatt, 2010).

When discussing the Alexandrine patterns, proponents and critics alike tend to focus solely on the content of the 253 individual patterns created by Alexander and his colleagues. However, we argue that while it is important to analyse each pattern's architectural merit, such a narrow discourse fails to fully acknowledge the broader and more holistic approach of the pattern language as a whole. This article aims to demonstrate the usefulness of the pattern language approach in urban planning, especially in the context of contemporary planning in cities of the Global South. Our focus is on how this approach can facilitate communication between professionals and laymen, as these cities often struggle with bridging the gap between the two. Our interest lies in the idea that complex planning information, or what we refer to in this article as formal practices, can be deconstructed into comprehensible units of knowledge, while citizens' innovative activities or informal practices, can be documented in formats that can be understood by both experts and non-experts.

While employing the pattern language approach, we make use of patterns and the pattern field. According to Salingaros (2000), the pattern language's value lies in the connective rules that govern how patterns relate to each other. These rules are analogous to the rules of linguistic language (Cai, 2018), which allow individual words to be combined into meaningful sentences. In the same way, the connective rules give a pattern language its meaning, elevating it beyond a mere catalogue of patterns (Salingaros, 2000). To visualise the links between patterns, Salingaros (2000) proposes a "connective map" or pattern field (van Dorst, 2013). This pattern field serves as a framework for establishing connections between patterns and is the foundation of our argument in favour of the pattern language approach. Our article focuses on the effectiveness of this approach in integrating formal and informal practices in wetland management in Kampala, as demonstrated by a community workshop held in Kasanvu, an informal settlement on the outskirts of the Nakivubo wetland. We developed "informal" patterns through fieldwork and expert interviews in informal settlements and "formal" patterns by analysing the history and organisation of formal planning institutions in Kampala. These patterns formed the main input for the workshop, resulting in a pattern language of wetland management practices and a pattern field that established connections between the formal and informal patterns.

The pattern language approach has been utilised in a limited number of cases in Africa. Steyn (2006) employed the Alexandrine patterns to portray Malindi, a coastal town in Africa, while Eglin (2020) applied it to convey the vision for Mooiplaas, a community in South Africa's Eastern Cape province. Despite a handful of such examples, the pattern language approach has not been extensively studied in African planning literature. It is clear that a gap exists in terms of utilising the pattern language as a means of comprehending informal practices and their integration into the formal planning process, as well as a tool for fostering meaningful community involvement.

In this context, it is crucial to clarify the meanings of formal and informal practices. Formal planning practices refer to the activities of institutions mandated with urban planning and management. This encapsulates the discipline of urban planning, which has been primarily defined by Western scholarship and practice over the last century (Yiftachel, 2006). While there are variations in formal planning practices across the world (Nadin & Stead, 2008), it is widely acknowledged that the Western canon has been dominant, and this has had varied consequences for planning practices globally. In Sub-Saharan Africa, planning has largely adopted French and British technocratic paradigms inherited from colonial times, which are not well-suited to address local realities (Home, 2015). In some instances, formal planning has shifted from a technocratic approach, where the planner was solely responsible for city planning and design, to the rise of urban governance as a guiding concept in planning. This shift has resulted in

a redistribution of power from the planner to various urban actors with a stake in the urban planning process (Healey, 1996). This is the case for Kampala, where the responsibility of urban wetland management is distributed across various national- and city-level agencies, notably the KCCA, the Ministry of Water and Environment (MWE), and the National Environment Management Authority (NEMA) which is a semi-autonomous parastatal agency under the MWE. These institutions are mandated with the planning and management of the Nakivubo wetland to ensure its sustainable use albeit lacking the resources and capacity necessary to oversee project implementation (World Bank Group, 2015). These institutions carry the mantle of the colonial legacy that is embedded within the top-down planning frameworks (Guma, 2016) that guide city development. Power is concentrated at the top by overseeing councils or committees which dictate almost all decisions (Guma, 2016), guided by an array of legal tools including policies and regulations (World Bank Group, 2015).

Informal practices can be generally defined as the activities undertaken by groups of people or communities that are outside of the formal processes (McFarlane, 2012). The term "informal" has recently gained popularity in contemporary urban planning theory as more scholars call for the recognition of other ways of city-making outside of the mainstream Western models (Bhan, 2019). Informal practice is not limited to a specific context but rather exists in all arenas of urban planning from formal institutions to informal groups and communities (Roy, 2011). This article focuses on informal practices within the Nakivubo wetland communities, specifically in the two informal settlements of Kasanvu and Kitintale, which are among Kampala's 57 informal settlements (Richmond et al., 2018). Despite the challenges of living in a wetland, the residents here engage in a wide range of activities, some of which are detrimental to the area's sustainability (Richmond et al., 2018). However, there is an opportunity to harness the innovative and existing socio-economic practices in these communities to upgrade the Nakivubo wetland area in a sustainable manner. By involving the local community in the upgrade process, the planning becomes more participatory and empowering (Das, 2015). Moreover, this approach utilises the residents' local knowledge, which has been refined over time through developing resilient and sustainable forms of survival (MacPherson, 2013).

Informal practices can serve as a means for realising urban development projects, essentially functioning as an extension or practical arm of formal practices. However, we submit that for Kasanvu and Kitintale's informal practices to significantly impact urban development, there needs to be a "formalisation" of these practices, as well as an "informalisation" of formal practices. This involves systemising the informal practices to be integrated into existing formal planning structures and simplifying formal practices to align their objectives with the existing informal practices. The following sections detail an attempt to harmonise Kasanvu and Kitintale's informal practices with KCCA and NEMA's formal practices using the pattern language approach.

3. Methodology of Using the Pattern Language Approach

The formal practices pertaining to the management of wetlands are outlined in the policy documents and institutional structures of KCCA and NEMA. These practices required documentation in a clear and concise format. In contrast, informal practices are interwoven into the physical environment and socio-economic practices of the wetland communities. Observing these practices was crucial before recording them in an organised and comprehensible manner. As mentioned in the previous section, a pattern language has two key components: patterns and the pattern field. Patterns are used to condense diverse information from various sources into easily understandable blocks of knowledge (Hausleitner et al., 2022; Hill, 2020), while the pattern field provides an overview of these patterns and facilitates dynamic connections between them (van Dorst, 2013). In addition to written information, patterns also incorporate visual representations, which facilitate understanding for a broad audience, such as the research participants. The use of patterns allowed for the collection of information on practices to be stored in a condensed and consistent format, and the pattern field facilitated the identification of connections between formal and informal practices.

3.1. Formal Patterns

We began the process of formulating the formal patterns by documenting the formal practices of wetland management by the city authorities. There are primarily two institutions that have the mandate of planning and management of the Nakivubo wetland area: KCCA and NEMA. The formal practices were ascertained from an analytical review of the wetland management policy documents which are the National Environment Act (MWE, 2019), National Environment (Wetlands, Riverbanks, and Lakeshores Management) Regulations (NEMA, 2000), KPDP (KCCA, 2012), and the Kampala strategic plan (KCCA, 2014). The formal practices were made into so-called formal patterns which constituted three categories, namely: the institutions, their policies, and the derived spatial actions. As a way of ordering the patterns, it was important to ascertain the scales on which they operate in relation to the governance structure of Kampala City. The scales, therefore, consist of the national scale, city scale, division scale, ward scale, and zone scale. The scales provided the first level of organising the patterns; at each scale, similar patterns were merged, and redundant patterns were removed through an iterative process (see Table 1).

3.1.1. The Institutions and Policies

KCCA is the governing authority for Kampala city under the Ministry of Kampala and Metropolitan Affairs. The authority is divided into political and technical wings. The technical wing (TW) is composed of 10 directorates, two of which have sections that are directly involved with wetland management, planning, and design. These are the Environmental Management Unit (EMU) under the Directorate of Public Health Services and Environment (DPHSE) and the Landscape Section under the Directorate of Physical Planning. The political wing is composed of five division mayors, each governing over one of Kampala's divisions. Under each division mayor is a division urban council with a Department of Public Health and Environment (DPHE), concerned with environmental management. The division is then divided into wards, each with a ward urban council that includes a Secretary for Production and Environmental Protection (SPEP). The wards are then divided into zones, the smallest unit of formal administration in the city, each with a zone urban council that also includes a SPEP.

NEMA is an agency under the MWE with a mandate of regulating and coordinating environmental management in the country. NEMA appoints a Lead Agency (LA) which then appoints an environmental officer (EO) to prepare the National Environmental Action Plan (NEAP) for the wetlands sector and also assist the local governments, in this case Kampala, with the preparation and approval of the City Environment Action Plan (CEAP). The CEAP is prepared by the EMU, in conformity with the NEAP and takes into account the Division Environment Action Plan (DEAP) and the Zone Environment Action Plan (ZEAP) which are prepared by the DPHE and the SPEP respectively.

3.1.2. The Spatial Actions

As part of its urban climate change strategy, KCCA undertakes to develop natural systems that minimise urban flooding as a way to mitigate risks posed by climate change. In order to meet the city's need for more green open spaces and parks, the KPDP proposes that the wetlands within the city be transformed into a green system of urban parks. This will prevent the wetlands from further encroachment and allow for the restoration of their ecological functions. To complement Lake Victoria, which is situated in the south of the city, the plan proposes that the Nakivubo wetland area be turned into a CUP because of its substantial size, central location, and connection to the lake shoreline. According to the plan, connecting the wetlands to the Lake Victoria shoreline will ensure continuity of ecosystems across the urban landscape thus strengthening the overall urban parks and lakefront green system. In the environmental regulations, wetlands are considered of great national and local importance as ecological systems that act as a habitat for flora and fauna. It is also proposed that wetlands are used to host research and tourism activities because of their biological diversity and ecological importance.

At the division level, the city proposes the development of "environmental slum upgrading projects" (ESUP) through the creation of land banks to allow for land titling and encouraging incremental housing projects to improve the livelihood of slum residents and their overall environment. The strategic plan (Kampala City Council Authority, 2014) suggests developing comprehensive community service master plans to ensure collaboration between social groups and community initiatives to guide investment. These initiatives could include wetland conservation by local communities where the traditional use of wetland resources can be permitted.

Table 1. Patterns from formal practices used in the workshop.

Scale	Institutions	Policies	Spatial actions
National	Technical Committee on Biodiversity Conservation, Environment Officer	Environment action plans and disaster management plans	Natural flood mitigation systems, wetland conservation, and management strategies
City	Landscape Section, Environment Management Unit	KPDP and build environmental sustainability	Slum upgrading, linear lakefront system, wetlands to urban parks, and an agriculture resource centre
Division	DPHE	Local Environment Action Plan and Environmental Impact Assessment	Connected green spaces, research and tourism initiatives, and wetland habitat for flora and fauna
Ward/Zone	Environment Protection Group	ZEAP and participatory planning platforms	Upgrade of drainage channels, coordinated community activities, urban agricultural schemes, and waste management initiatives

The local communities can receive training on sustainable urban agricultural practices from the resource centres and apply this knowledge through urban agricultural schemes (UAS). To tackle the urban flooding issue, the strategic plan proposes an increase in waste management initiatives (WMI) and sanitation projects (SP), and the widening, reconstruction, and greening of the primary and secondary drainage channels of the city in order to improve its water retention and drainage capacity.

3.2. Informal Patterns

In February 2022, we conducted site visits and interviews with residents of the Kasanvu and Kitintale informal settlements to document their everyday practices related to flood resilience, mitigation, and adapting to living in a wetland environment. These practices primarily took place in public spaces, such as pathways or open compounds. However, we found that these spaces were not only important for flood resilience but also for the overall social and economic resilience of the community. This highlighted the importance of public spaces to the sustainability of these communities and helped us identify four working scales for the informal patterns: neighbourhood, street, courtyard, and house. We categorised the informal patterns into two groups: local actors and on-the-ground initiatives (see Table 2).

3.2.1. Neighbourhood Scale

In informal settlements, sizable empty fields are commonly used as playgrounds for children. These open areas also serve as temporary water retention areas during heavy rainfall, releasing the water gradually into the ground. Some of these grounds even host socio-economic activities such as brickmaking, as the wetland areas have clay soils and a constant presence of water which are ideal for construction materials that are in high demand. Additionally, due to the high volume of waste transported along with stormwater that ends up in informal settlements, some residents engage in waste sorting and recycling activities in these open spaces. Water collection sites and communal social areas are often found near or within these open grounds. The community leaders are the key local actors in the neighbourhood, usually held in high regard by the residents. These leaders may be proprietors of a local business, manage the neighbourhood school/church, or serve as leaders in other capacities. They are the best-suited individuals to act as custodians over the initiatives existing at the neighbourhood scale.

3.2.2. Street Scale

A pedestrian path runs alongside the Nakivubo Channel, created to improve access to various parts of the settlement. However, this path serves multiple purposes beyond simple convenience. It acts as a boundary for the Kasanvu informal settlement and also functions as a buffer from the channel in case of overflow. Locally crafted bridges have been installed on the pathways that intersect with sizable drainage systems within the informal settlements, which has helped in improving accessibility and safety of the communities. Additionally, small drains have been dug in some parts of the pathway and filled with stones to facilitate drainage during rainy weather. In certain areas, the drains are equipped with a mesh that acts as a sieve, catching solid waste to prevent blockage downstream and keep the channel clear.

Shopkeepers play a vital role in the community's street-level activity since many of the shops are located along the pathways. Shop owners often construct bridges over the drains to provide customers with access to their stores. They may also assume responsibility for repairing these bridges and maintaining the drains near their establishments.

3.2.3. Courtyard Scale

Open spaces of different sizes and shapes are intentionally incorporated between houses in settlements to facilitate accessibility, drainage, and social activities. These spaces may include central water sources, such as boreholes and metered water from the national water and sewerage corporation, which serve multiple households within the courtyard. Additionally, residents share sanitary facilities such as showers and toilets, which are typically situated in central locations within the settlements. The key actors at this scale are the water and toilet attendants who are tasked with collecting dues from residents to maintain and sustain these facilities.

Table 2. Patterns from Informal practices used in the workshop.

Scales	Local actors	On-ground Initiatives
Neighbourhood	Community leaders	Open grounds, waste recycling, brick making, community social space, urban green space, community conservation activities
Street	Shopkeepers	Streets as drains, access bridges over drains, waste filters, channel street
Courtyard	Attendants	Common space for waste, sanitation projects.
House	Residents	Elevated floor level, water harvesting, garden/agriculture lots

3.2.4. House Scale

New residents in the Kasanvu settlement, particularly those located close to the channel, have adopted a new method of construction to combat the effects of flooding. This involves elevating the floors of their houses on wooden stilts. In contrast, long-time residents with older homes have opted to construct barriers across their house openings or around the perimeter to prevent water from entering their homes. Additionally, due to the abundance of water and fertile soil, some residents have taken up urban farming. They have allocated portions of the wetland area to cultivate crops for personal consumption and commercial purposes. At the household level, the primary actors in Kasanvu are the residents themselves. They are responsible for building structures that are resilient and safe, and for engaging in urban agriculture.

4. Pattern Testing in Community Workshop

The patterns derived from the practices described in the previous section became the key input for a workshop organised in February 2022, in Kasanvu. The patterns were presented in a visual format of a pattern card, each consisting of the title, a short description, and an illustration or image. The workshop was attended by urban planners from NEMA and KCCA representing the formal institutions, and residents of Kasanvu and Kitintale informal settlements, who included the youth and elderly.

The workshop was organised in three sessions: prioritisation of patterns, creation of a shared vision with the selected patterns, and feedback on the workshop process. In the first session, lasting about one and a half hours, the workshop process was explained to the participants, who were then divided into two groups. Each group of participants was given a set of pattern cards in random order and asked to discuss and deliberate on them. The participants had to select their preferences for the patterns by use of a colour coding scheme: blue (*most agreed with*), green (*agreed*), yellow (*unsure*), and orange (*least agreed with*). A significant proportion of this session was dedicated to the explanation of the patterns to all the participants so that they were able to make an informed decision on the selection. The patterns deriving from the informal practices were much simpler to explain and understand because the images used on the pattern cards were more representational of the actual practices. On the other hand, the patterns from the formal practices were much more abstract and had more technical terms. This made them harder to explain and also to translate into the local dialect.

The second session which lasted for one hour involved the creation of a shared vision where the participants were asked to position on a map where their most preferred patterns would be best implemented. The idea behind this session was to test how well the patterns had been understood by the participants and if they could be used as a tool to co-design a shared vision for the neighbourhood, taking into consideration the interests of the formal institutions and the residents of the informal settlements. However, the majority of the participants were not able to understand or interpret the map and as a result, they were not able to make informed decisions about where the selected patterns could best be employed. It was also difficult to grasp the essence of the exercise since the patterns were too many, as were the participants. This resulted in a heightened responsibility of the workshop moderator in steering the discussion.

In the last session of the workshop, the participants shared their experience with the workshop by filling out a survey, the results of which showed that the majority were able to follow the process and freely express their opinions albeit having trouble understanding the contents of some pattern cards.

5. Results: A Pattern Language of Wetland Management Practices in Kampala

The resulting set of patterns is presented in Table 3, below.

As mentioned earlier, this article aims to investigate the potential of pattern language in connecting informal and formal urban planning practices. Hence, after refining the patterns through the workshop, the next step was to develop a pattern field (see Figure 2) in order to establish connections between the patterns. In developing the pattern field, we considered two aspects; first was the scales on which the patterns existed and second was the categories in which they could be grouped. These aspects thus became the two axes for the pattern field: the categories on the horizontal axis (Political, Socio-Economic, and Spatial) and the scales on the vertical axis (National, City, Division, Zone, Neighbourhood, Street, Courtyard, and House).

The resulting pattern field of the combined formal and informal patterns on wetland management consists of the following: the institutions mandated with wetland management in Kampala, their formulated policies and resulting goals and actions, and the existing on-ground initiatives of informal communities, and the local actors. The pattern field can thus be understood as consisting of four quadrants: the institutions in Quadrant 1, their goals in Quadrant 2, the on-ground initiatives in Quadrant 3, and the local actors in Quadrant 4 (see Figure 3). Currently in the urban planning and management of wetlands in Kampala, the most prominent and existing link is between the institutions (NEMA and KCCA) and their goals, in other words, between Quadrants 1 and 2. Through the development of the pattern field however, there are connections made between the goals of the institutions and the existing on-ground initiatives (Quadrants 2 and 3), and between these initiatives and the local actors (Quadrants 3 and 4). The pattern field also illustrates how the local actors can then be

Table 3. Patterns after the workshop.

Scale	Spatial	Socio-economic	Political
National	Natural flood mitigation systems (NFMS)		Ministry of Kampala and Metropolitan Affairs (MKMA), Ministry of Water and Environment (MWE), National Environment Management Authority (NEMA), Lead Agency (LA), National Environmental Action Plan (NEAP)
City	Wetlands to urban parks (WUP)		Kampala City Council Authority (KCCA), Technical Wing (TW), Environmental Officer (EO), Environmental Management Unit (EMU), Directorate of Public Health Services and Environment (DPHSE), City Environment Action Plan (CEAP)
Division	Connected green spaces (CGS)	Environmental slum upgrading projects (ESUP), Research and Tourism Initiatives (RTI), Wetland habitat for flora and fauna (WHF)	Department of Public Health and Environment (DPHE), Division Environment Action Plan (DEAP)
Ward/Zone	Upgrade of drainage channels (UDC)	Community training programmes (CTP), Urban agricultural schemes (UAS), Waste management initiatives (WMI), Sanitation projects (SP)	Secretary for Production and Environmental Protection (SPEP), Zone Environment Action Plan (ZEAP)
Neighborhood	Communal open grounds (COG)	Waste recycling (WR), Brick making (BM), Community social space (CSS)	Community leaders (CL)
Street	Streets as drains (SAD), Access bridges over drains (ABD), waste filters on drains (WFD), street along channel (SAC)		Shopkeepers (SK)
Courtyard	Open spaces between houses (OSBH)	Centralised water points (CWP), communal toilets (CT)	Attendants (AT)
House	Elevated floor level (EFL)	Animal rearing (AR), Garden/ agriculture lots (GAL)	Residents (RS)

incorporated into the existing governance structures of formal planning for wetland management (Quadrants 4 and 1).

6. Discussion

Through our work, we have discovered that the development of a pattern language and the community workshop are mutually beneficial processes. The workshop plays an integral role in the iterative process of pattern language development, while the pattern language approach enhances the workshop. By using patterns as input for the workshop, the participants found the process engaging and less overwhelming. The patterns captured the activities and initiatives of local residents, making them better understood and appreciated by all workshop attendees. It was particularly empowering for the residents of the informal settlement to explain

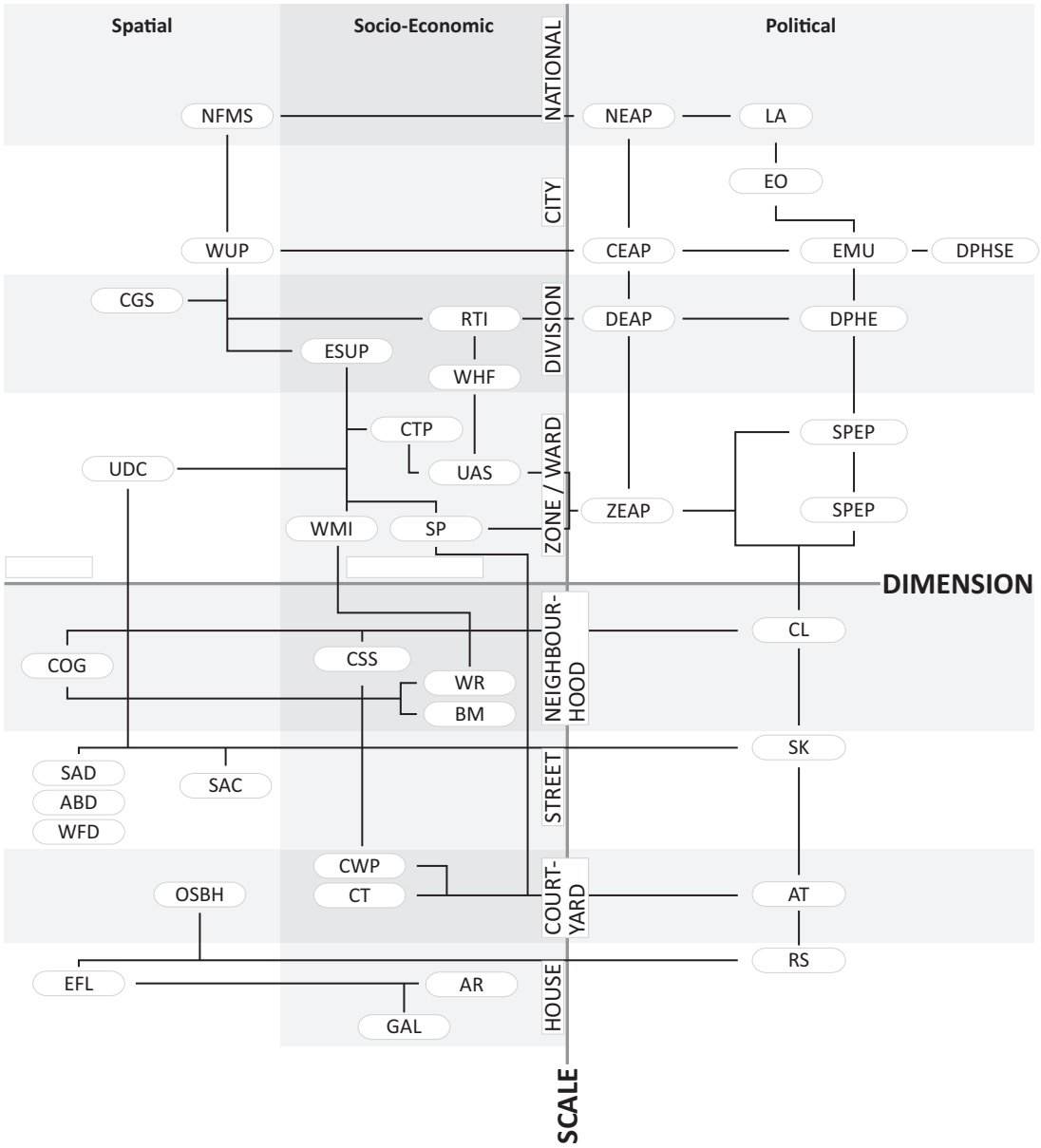

Figure 2. The pattern field. Note: The acronyms represent the respective patterns; refer to Table 3 for the full terms of the abbreviations. Source: Namwanje (2022, p. 114).

the informal patterns to the representatives of KCCA and NEMA. Formal patterns, on the other hand, condensed information from lengthy policy documents into succinct points that were easier to comprehend and explain. This facilitated an effective exchange of information where residents were made aware of the plans of KCCA and NEMA for their environment, and they were able to provide feedback and ask questions. The workshop provided an avenue for patterns to be revised based on the input of participants from formal and informal institutions. Essentially, the workshop acted as a mirror, reflecting information from the formal and informal arenas of planning back to the actors involved.

Here, we will reflect on the workshop process, assessing what worked well and where improvements could have been made. During the workshop, it became clear that the extracted patterns, both formal and informal, were unrefined. The definitions for formal patterns, in particular, were too vague and provided only simplified explanations of the complex language found in policy documents. Additionally, some of the illustrations used to convey the patterns were too abstract, making them difficult to comprehend. The informal patterns, on the other hand, employed simpler imagery that was easier to comprehend. However, in some cases, the imagery did not accurately convey the pattern's description and oversimplified the patterns. These observations align with criticisms from opponents of the pattern language, who argue that the patterns can be overly simplistic and fail to capture the complexities of the subject matter. Context-specificness is another issue that critics have raised, making it challenging to transfer patterns to other

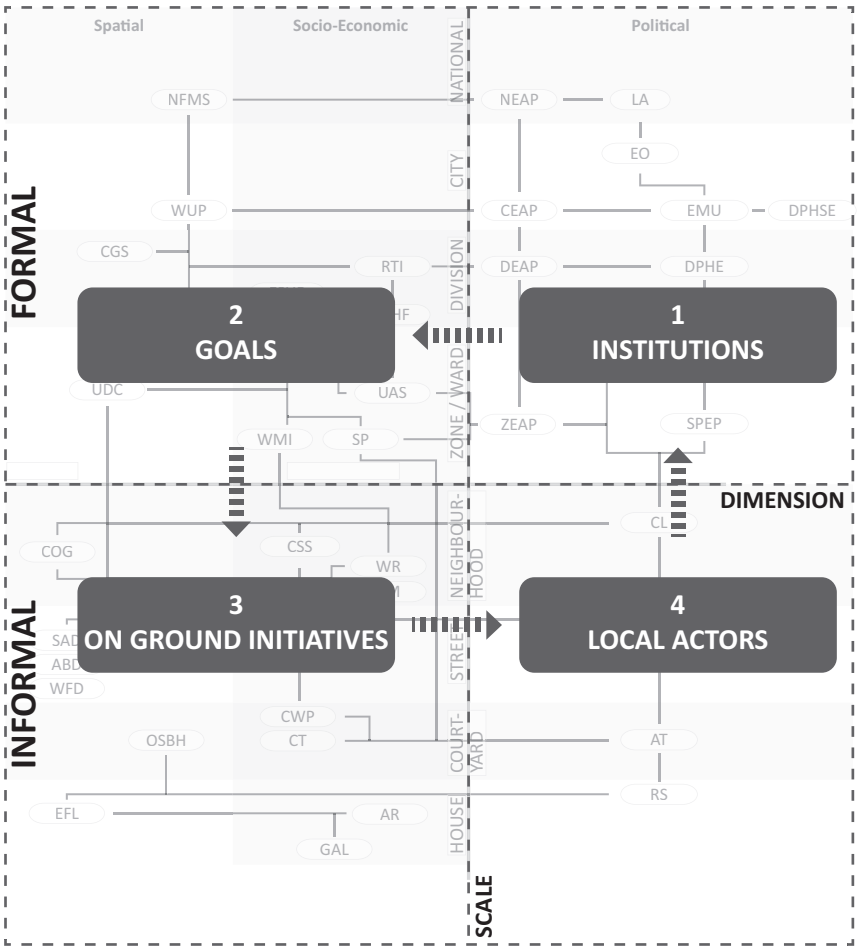

Figure 3. The quadrants of the pattern field. Source: Namwanje (2022, p. 112).

contexts. This is especially true for formal practices, which often rely on policy documents that can vary significantly from one location to another.

Upon reflection on our workshop experience, we have identified some actions that could have led to better results. Firstly, we realised that the initial session, which involved explaining the patterns to all participants before selecting them, was critical and should have been conducted separately in advance. It was necessary for participants from formal institutions to comprehend the informal practices and how they could align with existing planning policies. This would have enabled formal institution actors to understand their policies better, identify gaps, and reconcile them. Secondly, a comprehensive description of each pattern, translated into the local dialect, should have been provided to all participants before the workshop. This would have allowed them to familiarise themselves with the terms and descriptions, particularly for those from informal settlements who are not well-versed in technical terms and English. During the workshop, the patterns were not categorised, resulting in an unstructured prioritising process. Thus, we concluded that sorting the patterns into the predetermined categories of political, socio-economic, and spatial, and then deliberating them in order of scale, would be more structured and organised. This would allow for better connections between similar patterns and eliminate redundancies. In terms of pattern cards, we suggest using a combination of schematic diagrams and infographics for formal patterns and imagery and infographics for informal patterns. Moreover, the descriptions of formal patterns should be revised into simple and less technical terms, while those of some informal patterns should be elaborated.

In considering the pattern language approach, we previously discussed the concept of "formalisation" of informal practices and "informalisation" of formal practices, in order for both sets of practices to make a significant impact on Nakivubo wetland's urban development. The community workshop, which employed the pattern language approach, facilitated these necessary processes. In this research, "informalising" formal practices refers to simplifying them for better comprehension by the general public. However, during the workshop, it became clear that this was no easy task. In fact, it appeared that it would require multiple workshops to fully explain the formal patterns to the community members of Kasanvu. Nonetheless, despite these efforts, it is likely that the complexities of the urban planning process will still be difficult for a layperson to fully comprehend.

This is because there are numerous factors and decisions that are involved in the planning process which cannot be fully conveyed through a single pattern card. The pattern on UDC, for instance, is an extensive and complicated process involving multiple actors, which cannot be fully captured on the pattern card. The oversimplification of formal processes, while necessary, might also hinder the implementation process of the patterns since overlooked and unexplained aspects of the practice can pose challenges in the long run. As to whether informal practices can be "formalised," this proved to be more feasible. These practices are usually straightforward solutions to urban issues, and the necessary information to describe them is easily accessible. However, these practices arise from distinct socio-economic structures that regulate informal settlements, which must be comprehended and integrated into the pattern development process. To successfully incorporate the pattern language approach into urban planning, further workshops are necessary to refine the process and address the challenges identified in this section. These workshops will aid in finding effective solutions and enhance the approach's overall effectiveness.

7. Conclusion

In the context of urban planning in African cities, there is much to be gained from the pattern language approach. While critics may be correct in their assessment of the limitations of the pattern language, we agree with the proponents that this approach has much to offer. In urban areas like Kampala, formal and informal practices can often collide, creating a need for planners to seek out methodologies that can reconcile these opposing forces. One effective approach is to foster community involvement in the urban planning process. However, merely engaging citizens is insufficient for successful implementation if informal practices are not incorporated. To overcome this challenge, community workshops that bring together both residents and professionals are vital. The pattern language approach is valuable in this regard as it provides a means for the workshops to promote effective communication between professionals and laypeople. By deconstructing formal planning practices into comprehensible units of knowledge and informal practices into understandable formats, the pattern language approach can foster more meaningful community engagement during the workshops and help ensure that informal practices are considered in the planning process. While more research is necessary to fully realise the potential of the pattern language approach, this research illustrates its usefulness in linking formal and informal practices and facilitating meaningful community engagement. There is still much work to be done in utilising the pattern language approach in urban planning in Africa, but the potential benefits are clear.

Acknowledgments

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Conflict of Interests

The authors declare no conflict of interests.

References

Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I., & Angel, S. (1977). *A pattern language*. Oxford University Press.

Bhan, G. (2019). Notes on a Southern urban practice. *Environment and Urbanization*, *31*(2), 639–654. https://doi.org/10.1177/0956247818815792

Bhatt, R. (2010). Christopher Alexander's pattern language: An alternative exploration of space-making practices. *The Journal of Architecture*, *15*(6), 711–729. https://doi.org/10.1080/13602365.2011.533537

Cai, J. (2018). *Design with forms, as well as patterns*. TU Delft Open.

Das, A. (2015). Participatory slum upgrading: Lessons from post-decentralization India and Indonesia. *Journal of Indonesian Regional Development and Environment*, *1*, 15–34.

Dovey, K. (1990). The pattern language and its enemies. *Design Studies*, *11*(1), 3–9. https://doi.org/10.1016/0142-694x(90)90009-2

Eglin, R. (2020). Capturing a community's vision as a pattern language: Case study of the Mooiplaas community in Great Kei Municipality, South Africa. *Town and Regional Planning*, *76*, 29–41. https://doi.org/10.18820/2415-0495/trp76i1.3

Goodfellow, T. (2010). *"The bastard child of nobody"? Anti-planning and the institutional crisis in contemporary Kampala*. Crisis States Research Centre.

Goodfellow, T., & Titeca, K. (2012). Presidential intervention and the changing "politics of survival" in Kampala's informal economy. *Cities*, *29*(4), 264–270. https://doi.org/10.1016/j.cities.2012.02.004

Guma, P. K. (2016). The governance and politics of urban space in the postcolonial city: Kampala, Nairobi and Dar es Salaam. *Africa Review*, *8*(1), 31–43. https://doi.org/10.1080/09744053.2015.1089014

Hausleitner, B., Hill, A. V., Domenech, T., & Muñoz Sanz, V. (2022). Urban manufacturing for circularity: Three pathways to move from linear to circular cities. In L. Amenta, M. Russo, & A. van Timmeren (Eds.), *Regenerative territories* (pp. 89–103). Springer.

Healey, P. (1996). The communicative turn in planning theory and its implications for spatial strategy form-

ations. *Environment and Planning B: Planning and Design*, *23*(2), 217–234. https://doi.org/10.1068/b230217

Hill, A. V. (Ed.). (2020). *Foundries of the future: A guide to 21st century cities of making*. TU Delft Open.

Home, R. (2015). Colonial urban planning in Anglophone Africa. In C. N. Silva (Ed.), *Urban planning in Sub-Saharan Africa: Colonial and post-colonial planning cultures* (pp. 53–56). Routledge.

Kampala City Council Authority. (2012). *Kampala physical development plan*.

Kampala City Council Authority. (2014). *Kampala strategic plan*.

MacPherson, L. (2013). Participatory approaches to slum upgrading and poverty reduction in African cities. *Interdisciplinary Journal of Social Sciences*, *1*(1), 85–95.

McFarlane, C. (2012). Rethinking informality: Politics, crisis, and the city. *Planning Theory & Practice*, *13*(1), 89–108. https://doi.org/10.1080/14649357.2012.649951

Ministry of Water and Environment. (2019). *National environment act*. Uganda Printing and Publishing Corporation.

Nadin, V., & Stead, D. (2008). European spatial planning systems, social models and learning. *DisP–The Planning Review*, *44*(172), 35–47. https://doi.org/10.1080/02513625.2008.10557001

Namwanje, P. (2022). *The new (in)formal: Leveraging formal and informal practices towards the just, resilient and sustainable urban development of Kampala* [Unpublished Master's thesis]. Delft University of Technology.

National Environment Management Authority. (2000). *National environment (wetlands, riverbanks and lake shores management) regulations*.

Richmond, A., Myers, I., & Namuli, H. (2018). Urban informality and vulnerability: A case study in Kampala, Uganda. *Urban Science*, *2*(1), Article 22. https://doi.org/10.3390/urbansci2010022

Roy, A. (2011). Slumdog cities: Rethinking subaltern urbanism. *International Journal of Urban and Regional Research*, *35*(2), 223–238. https://doi.org/10.1111/j.1468-2427.2011.01051.x

Salingaros, N. A. (2000). The structure of pattern languages. *Architectural Research Quarterly*, *4*(2), 149–162. https://doi.org/10.1017/s1359135500002591

Steyn, G. (2006). A pattern language as a tool for studying African urbanism using Malindi, Kenya, as a case-study. *South African Journal of Art History*, *21*(10), 10–26.

van Dorst , M. (Ed.). (2013). *The pattern book—European masters in urbanism*. European Higher Education Consortium in Urbanism.

World Bank Group. (2015). *Promoting green development in African cities*. https://doi.org/10.1596/22941

Yiftachel, O. (2006). Essay: Re-engaging planning theory? Towards "South-Eastern" perspectives. *Planning Theory*, *5*(3), 211–222. https://doi.org/10.1177/1473095206068627

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Article

Social Sustainability and Alexander's Living Structure Through a New Kind of City Science

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Abstract
The disputed endorsement of inherited visceral and universal aesthetic preferences justifies the scientific validity of Alexander's living structure. Apart from implying a resource-efficient way to promote well-being through urban design, the premise favors a collective approach to human self-perception and social justice. To better understand the contributions of Alexander, this article explores current knowledge about visceral and universal aesthetic preferences for living structure and if and how the new kind of city science, a mathematical model describing living structure, can be used for further testing. It also elaborates on the social impact of living structure, including its premise, and the potential of the new kind of city science to support social sustainability. A literature synthesis on living structure, the new kind of city science, and the premise showed a positive link between well-being and exposure to living structure. Limitations in research design nevertheless precluded conclusions about the associated visceral and universal aesthetic preferences. The new kind of city science was found appropriate for further research by holistically representing living structure. Moreover, like the hypothesized biological origin, social learning and sociocultural transmission were found to theoretically support the premise of universality and a collective approach to human identity and social justice, with further societal implications. For the concept of living structure to support social sustainability, it must be coupled with the promotion of empowerment and community mobilization. Hence, the operationalization of the new kind of city science should align with Alexander's call for bottom-up approaches.

Keywords
Christopher Alexander; living structure; new kind of city science; social sustainability; urban design; urban planning

Issue
This article is part of the issue "Assessing the Complex Contributions of Christopher Alexander" edited by Michael W. Mehaffy (Sustasis Foundation) and Tigran Haas (KTH Royal Institute of Technology).

1. Introduction

Christopher Alexander's (2002a) claim of having captured the essence of beauty and unveiled secrets of good art, architecture, and design is controversial since value and aesthetic appreciation are commonly considered subjective and learned (Dawes & Ostwald, 2017). The organic worldview theoretically enables the idea of objective beauty, acknowledging humans as part of an interconnected whole inclusive of value and beauty (Alexander, 2004; Whitehead, 1929). In line with the biophilia hypothesis (Wilson, 1984), Alexander (2002a) assumes humans have a visceral and universal love for life, lifelike objects, and processes. By identifying and replicating the structural quality of living entities, i.e., "livingness," objective beauty can be captured and enhanced. Alexander (2002a) terms such structures as "living structure."

Despite identifying generic design principles, Alexander et al. (1977; see also Alexander, 2002a) think that holistic designs with high degrees of living structure can only emerge through a long-term process of inclusive, bottom-up agency (Alexander, 1979). Theoretically, this approach differs little from conventional planning and design since the assumption of subjective and learned design preferences is usually accompanied by an acknowledgment of the importance of participation and process (e.g., Dempsey et al., 2012). However, a purely subjective approach towards beauty aligns with a wear-and-tear society, continuously in need of renewal to provide for changing societal conditions. On the contrary, Alexander's claim of objective beauty implies that an aesthetically successful design is eternally good.

While pressure on urban space increases (Florida, 2017; UN-Habitat, 2016) along with increasing expectations of urban design to balance conflicting interests and ensure the maintenance of attractive, socially just, and health-promoting urban environments (Burton, 2000; Dempsey et al., 2012; Samuelsson et al., 2018; UN-Habitat, 2016), the assertion of living structure's permanence appears beneficial. Finding ways to imitate visceral and universal health-promoting qualities successfully would favor built investments in cities with long-term endurance and could increase urban dwellers' tolerance for densely built environments.

Densification and urbanization imply less space per capita and an increasing need for sharing. The importance of sharing is further stressed on a global scale by the breach of planetary boundaries along with increasing inequalities and risk of self-reinforcing feedback between the two (Millward-Hopkins, 2022; Rockström et al., 2009; United Nations Department of Economic and Social Affairs, 2020). Since taste in arts significantly takes part in identity formation (Fingerhut et al., 2021) and since ideas of "the self" are strongly linked to conceptions of social justice (Warren, 1990), a discursive displacement of beauty from "unique to the individual" to "inborn and universal" could have societal implications. The acknowledgment of objective beauty aligns with a collective approach to social justice based upon a strong link between identity and society, benefitting redistributive policies and sharing but potentially compromising individual autonomy, an essential protection against authoritarianism (Dawes & Ostwald, 2017; Heywood, 2021; Kymlicka, 2002).

The underlying assumptions of visceral and universal beauty are fundamental to assessing the contributions of Alexander. However, their validity is disputed both on a theoretical basis and due to the equivocal character of related empirical findings (Joye & De Block, 2011; Ulrich, 1993). The "new kind of city science" (NKCS), advocated by Jiang (2022a), proposes a mathematical model built on living structure and the organic view of space, facilitating the identification and assessment of a living structure. It comprises three fundamental issues about a city: how it looks, how it works, and what it ought to be. With the NKCS, degrees of living structure can be identified in pictures and landscapes (Jiang & de Rijke, 2023), enabling novel research about the universal and visceral appreciation for living structure and about the biophilia hypothesis as a common model of explanation (e.g., Jiang, 2022b; Mehaffy & Salingaros, 2015).

Through a literature synthesis, this article aims to explore current knowledge about the premise of universal and visceral aesthetic preferences for living structure and if and how the NKCS can be used for further testing. Furthermore, the article aims to elaborate on the impact of living structure, including its premise, on social justice and social sustainability, and, finally, on the potential of the NKCS to support social sustainability. In so doing, the article brings new insights about the NKCS's potential to uncover Alexander's contributions and subsequent implications for some of the most critical issues of our time.

After describing the method, the remainder of the article first describes the living structure of Alexander and the NKCS and how the NKCS builds upon living structure and the organic worldview. After that, we account for the organic worldview, biophilia, and associated findings concerning visceral and universal aesthetic preferences for living structure. This is followed by elaborations on how the NKCS can further test the premise of visceral and universal preferences for living structure, the subsequent implications for social justice and social sustainability, and the potential of the NKCS to support such values. Finally, the conclusions are presented.

2. Method

The synthesis was carried out in three steps. We started by reviewing Alexander's living structure. The review was performed on Alexander's main work with a conceptual bearing on urban form and design, here considered to be the following: *A City Is Not a Tree* (1965), *A Pattern Language* (1977), *The Timeless Way of Building* (1979), and *The Nature of Order: An Essay on the Art of Building and the Nature of the Universe* (2002–2005). This was followed by a review of the NKCS, including articles by Jiang (2022a), who conceived the NKCS. The included literature describes the mathematical model of the NKCS, its purpose, and how it builds upon the living structure of Alexander and the underlying worldview. The premise of visceral and universal aesthetic preferences was identified as fundamental to justify living structure as science in addition to art. Due to the controversial nature of the premise, it became the point of departure for the rest of the study.

To further understand the premise, a third review was performed on the organic worldview and the biophilia hypothesis, serving as the foundational conceptual and scientific frameworks for living structure and the NKCS (e.g., Alexander, 2002a, 2004; Jiang, 2022a, 2022b; Salingaros, 2015). We began by accounting for the organic worldview and the biophilia hypothesis by drawing from its creators, Whitehead (1929), respectively,

Wilson (1984), and Kellert and Wilson (1993). To understand the biophilia hypothesis from the perspective of living structure, we also included literature from living structure advocates such as Alexander (2002a), Jiang (2022a), Mehaffy (2017), and Salingaros (2015). Thereafter, a review of the scientific support for the biophilia hypothesis and the underlying premise of visceral and universal aesthetic preferences for living structure was performed. It included articles presenting empirical research on human responses to nature and features relating to living structure, either in literature reviews or original research.

With that as a basis, conclusions were made on how the NKCS can be operationalized to progress the testing of the premise of visceral and universal aesthetic preferences for living structure. We also concluded the implication of present knowledge about living structure and its premise for social justice and social sustainability, and finally, on the potential of the NKCS to maintain and promote such values.

3. Living Structure and the New Kind of City Science

Alexander (2002a) describes a living structure as an evolving structure, inclusive of space and pervasive, departing from the surface of the earth as the expression of completeness, to which all else relates recursively. The world is perceived as complex and non-linear, and the living structure as the structure of complex adaptive systems (CAS; Alexander, 2003). Complexity and non-linearity, regarding both CAS and living structure, depend on the interdependence of a system's different components and subsequent emergent properties (Alexander, 2003; Jiang, 2015; Walker & Salt, 2006). Complexity is explained to be captured by the semilattice structure, described as the structure of living things (Alexander, 1965). A semilattice is similar to a treelike structure, but instead of having parts connected only through one common medium, a semilattice is a pronounced network with direct connections between nodes. Natural cities—i.e., cities that have emerged slowly over time instead of being planned—are often characterized by a semilattice structure, demonstrated by Alexander (1965) to provide the complexity needed to promote life through comprehensive interconnections. Planned and modernistic cities—for example, Brasília—are, on the contrary, often characterized by a treelike structure and considered incapable of supporting a living city.

Complexity recurs throughout the rest of Alexander's work. It is further emphasized in the presentation of 253 aesthetically beneficial design patterns identified by Alexander et al. (1977), suggested as tools to enhance the livingness of, for example, regions, towns, neighborhoods, buildings, rooms, and construction details. The patterns are explained to form a language with nearly endless possible combinations where a singular pattern, on the smallest level of scale, receives its meaning from the interactions between patterns over and within each scale, hence from its context and "the whole." When Alexander (2002a) later generalized the patterns into 15 properties of good design, understood as expressions of the underlying characteristics of life, complexity is continuously underlined (see, for instance, the first and 15th properties; Table 1). Complexity also reappears in Alexander's (1979, 2002b) elaborate promotion of a slow and stepwise emergent urban design, departing from what already exists, from the actions and interactions of the people living and engaging in their environment. On the contrary, large-scale and top-down processes are considered incapable of generating good design (Alexander et al., 1977).

Jiang (2022a, p. 31), through the NKCS, describes the living structure as "the recurring notion (or inherent hierarchy) of far more small substructures than large ones." The NKCS captures the nonlinear thinking of CAS through a Paretian mindset, perceiving the world as unbalanced and heterogenous, contrasting the conventional Gaussian mindset and the perception of the world as predictable, linear, and simple (Jiang, 2015). The scaling law represents the Paretian mindset and endorses skewed distribution and an often-occurring absence of a well-defined mean (Jiang, 2015).

According to the scaling law, a living structure consists of a recursive hierarchy of a significantly higher number of small substructures than large substructures across all scales. The ratio between small and large substructures is closer to 80/20 in accordance with the Pareto distribution (Jiang, 2015, 2022a). Living structure is gradually valued, and the degree of living structure is to livingness what temperature is to warmth. The degree of living structure (L) is defined by the number of substructures (S) and their inherent hierarchy (H), that is, $L = S \times H$ (Jiang & de Rijke, 2023). More substructures and hierarchies, or a deeper recursiveness, imply more livingness. The scaling law describes a heavy-tailed distribution, i.e., a dataset with more data lower than the average (tail) than data higher than the average (head), caused by the interdependence of substructures. It captures the qualities of the semilattice (Jiang, 2015), physically manifest in the urban landscape as, for instance, high-connectivity streets in terms of the number of nodes connecting different spaces (Jiang, 2019).

Through the scaling law and the heavy-tailed distribution, it is possible to further understand the recursiveness of substructures (Jiang, 2022a). The divide between the head and the tail in the heavy-tailed distribution frames disparate substructures termed head/tail breaks (Jiang, 2013). The head of each break can be further divided into substructures if the substructure, i.e., the head, meets the conditions of a heavy tail distribution. The number of breaks represents the number of hierarchies and the recursiveness of the dataset. Many breaks are equal to a deep recursiveness.

Jiang (2022b) illustrates the hierarchical order of urban substructures in terms of street networks by comparing the city plans of London and Manhattan (Figure 1).

L(left) = (1 + 2 + 5 + 10 + 33 + 383) × 6 = 2604 L(right) = (1 + 41 + 163) × 3 = 615

Figure 1. The city plans of London (left) and Manhattan (right) as examples of living structure. Source: Jiang (2022b, p. 39).

Instead of a conventional static view, the city plans are viewed as dynamically evolved from a whole. For example, the City of London is understood as a step-by-step evolution or transformation (like a cell division process) from one to two to five to 10 to 33 and 383 substructures over six hierarchical levels (Jiang & Huang, 2021). By comparing the two city plans, the degree of livingness of the City of London appears more than four times greater than New York's, hence, the City of London has a higher degree of living structure than that of Manhattan (Jiang, 2022b).

Within the NKCS, the scaling law is considered dominant (Jiang, 2022a). However, the NKCS also encompasses Tobler's (1970) law and the Gaussian mindset. Tobler's law departs from a well-defined average with slight differences between substructures, acknowledging the interrelatedness of everything and the increasing interrelatedness with proximity. These two laws might seem contradictory, but with the scaling law working across scales, and Tobler's law within scales, they complement each other (Jiang & de Rijke, 2023). Furthermore, Jiang (2022a) explains that living structure is favored by the approximate, and both laws are statistical rather than exact.

While the scaling law and Tobler's (1970) law explain the appearance and function of cities and can be used to assess existing structural states and dynamics, two corresponding principles concerning what a city ought to be meet each law (Jiang, 2022a). The scaling law is met by the principle of differentiation, aiming to create far more small substructures than large ones. It indicates recursiveness and applicability over scales. Tobler's law is met by the principle of adaptation, intending to secure adaptation and relative similarity between substructures within the same level of scale.

The two fundamental laws (scaling law and Tobler's law) and the two principles (differentiation and adaptation) of the NKCS are distillates of Alexander's 15 properties of good design. According to Jiang (2019), by using both principles when designing a coherent whole is promoted, characterized by nested and recursively ordered substructures, well adapted to each other. The relationship between the 15 properties and the two principles (by extension, the two laws) of the NKCS is listed and explained below (Table 1).

4. The Organic World View and the Biophilia Hypothesis

The endorsement of the organic worldview, inclusive of the prevailing Cartesian and mechanical worldview, but

Table 1. Relationship between Alexander's 15 properties and the laws and principles of the NKCS.

Property	Description of property (Alexander, 2002a)	The linkage between property and principles (Jiang, 2019)
Levels of Scale	Substructures of different sizes and hierarchical order enhance each other. However, the size difference between substructures should be balanced.	Levels of Scale and the scaling law mirror each other. The property is therefore linked to the principle of differentiation by promoting deep recursiveness and far more small substructures than large ones.
Strong Centers (i.e., substructures)	A substructure is strong when the surrounding substructures, and the contained and containing substructures, are strong.	Strong Centers is linked to both principles. Surrounding centers on the same level of scale meet the principle of adaptation, and the recurring centers across levels of scales meet the principle of differentiation.
Thick Boundaries	Distinct boundaries intensify substructures and connect as much as separate substructures and space.	Thick Boundaries meets the principle of differentiation and adaptation since the differentiation of substructures and space takes place within and over levels of scales.

Table 1. (Cont.) Relationship between Alexander's 15 properties and the laws and principles of the NKCS.

Property	Description of property (Alexander, 2002a)	The linkage between property and principles (Jiang, 2019)
Alternating Repetition	Subtle variations enhance livingness by averting monotony. The structure becomes more living with only some minor alterations in each repetition.	Alternating Repetition meets the principle of adaptation because the alterations are usually similar in size.
Positive Space	Space is as essential as substructures. Substructures should expand outwards and include their surroundings, like corn kernels on a cob.	Positive Space applies within and across levels of scales and therefore meets the principle of differentiation and adaptation.
Good Shape	A good shape is a shape that recursively consists of other good shapes.	Good Shape meets the principle of differentiation since the property addresses substructures across levels of scales.
Local Symmetries	Symmetry on a local level benefits livingness but should not occur globally.	Local Symmetries meets the principle of adaptation. If symmetry occurs over levels of scales, the scaling law is contradicted.
Deep Interlock and Ambiguity	Substructures sometimes merge or consist of mutual substructures in a way that makes it difficult to distinguish substructure and space from each other.	Deep Interlock and Ambiguity meets the principle of adaptation because interlock tends to occur between similar substructures within the same level of scale.
Contrast	A distinction between substructures in terms of color, light, and structure can intensify aesthetic experiences.	Contrast meets the principle of adaptation because such distinction recurs between nearby and similar substructures.
Gradients	Variations should be gradual across space, imitating natural gradients that occur as responses to differences in the environment.	Gradients meets the principle of adaptation because of its field-like character, occurring between nearby substructures within the same level of scale.
Roughness	Like gradients, irregularities, for instance, in terms of texture, can occur in substructures as a cause of adaptation to surrounding irregularities.	Roughness meets both principles because it is related to fractals and occurs on the same level of scale and across levels of scales.
Echoes	Smaller substructures are similar to larger substructures, favoring coherence.	Echoes meets both principles because the property resembles the recursiveness of fractals across and within levels of scales.
The Void	A large and empty substructure can enhance the intensity of "the whole" and contribute to harmony and distinction.	The Void meets the principle of differentiation by taking place at the largest level of scale, surrounded by smaller substructures.
Simplicity and Inner Calm	This property occurs locally and represents a state of simplicity and calm by eliminating unnecessary substructures.	Simplicity and Inner Calm meets the principle of adaptation by only having local relevance. The application across levels of scales would result in minimalism.
Not-Separateness	Despite having individual characters, all substructures and space interact and must be holistically dealt with. The same applies to the 15 properties.	Not-Separateness has multiple meanings and can relate, for instance, to inseparable levels of scales or substructures of a whole.

not limited to it (Alexander, 2004; Whitehead, 1929), enables the existence of visceral and universal aesthetic preferences and, in extension, the justification of living structure and associated ideas as a science (Alexander, 2002a, 2004; Jiang, 2022a). According to Alexander (2004), the mechanical worldview, extended into modernist society, has until now hindered the appreciation and consideration of value and beauty in science since it perceives humans to be separate from the rest of the world, value to be subjective and arbitrary, and the quality of a system comprehensible through each systemic component separately. The organic worldview, conceived by Whitehead (1929), instead withholds humans and values as interdependent substructures of an organic, interconnected whole with emergent properties. The departure is scientifically approached through biophilic reasoning (Jiang, 2022b; Salingaros, 2015), sometimes with explicit references to complexity theory and CAS (Mehaffy, 2017; Mehaffy & Salingaros, 2015).

According to the biophilia hypothesis, humans are biologically predisposed to be attracted or repelled by certain environmental features through affective responses adapted to the environment where humans mainly evolved (Kellert & Wilson, 1993; Wilson, 1984). Salingaros (2015) describes two sources for biophilic instinct representing two parallel strands of conjecture. The first source relates to landscape characteristics of the savannah, encompassing the existence of, for instance, greenery, bodies of water, and a particular spatial organization. The second source, which Alexander and the NKCS relate to, regards the geometries of biology, i.e., living structure, which humans also have evolved to appreciate or detest depending on what has been functional. It concerns, for example, fractals, scaling, organized complexity, complex symmetries, and colors (Mehaffy & Salingaros, 2015; Salingaros, 2015). By identifying the seemingly beneficial quality in nature and living entities, the quality can be simulated and captured in non-living elements, such as paintings, artifacts, rooms, buildings, gardens, streets, and cities (Alexander, 2002a, 2005; Jiang & de Rijke, 2023).

Contemporary human habitats, industrialized and urbanized, are considered estranged from nature and devoid of living structure, thus, also inappropriate for human life (Kellert & Wilson, 1993; Wilson, 1984). This is particularly evident in modernist architecture and design adopting minimalistic ideals (Alexander, 1965, 2002b; Jiang, 2022b; Mehaffy, 2017). Worldwide use of living structure characteristics in architecture and art, seemingly over time until modern days, is used to argue for biophilia and the assumption of visceral and universal appreciation for living structure (Alexander, 2002a; Joye, 2007).

Reviews on biophilia confirm consistent reports of the aesthetic appreciation for nature and the health benefits of exposure to nature (Berto et al., 2023; Bratman et al., 2012; Gaekwad et al., 2022; Gullone, 2000). However, evidence of a predisposed aversion towards some natural features (i.e., biophobia) is often considered to provide the most salient support for the hypothesis. Advocates think that if functional fear of specificities, for instance, snakes and spiders, can be transferred over generations, reasonably so can appreciation (Kellert & Wilson, 1993; Ulrich, 1993; Wilson, 1984). Nevertheless, all do not accept the assumed symmetry between positive and negative responses toward natural elements and entities (Joye & De Block, 2011; Ulrich, 1993). Joye and De Block (2011) argue that such assumptions are neither supported by evolutionary reasoning nor empirical findings.

A lack of cross-cultural studies and an overall geographical bias towards Western countries in the biophilic/biophobic body of literature furthermore hinders conclusions about the universality of such results (Gaekwad et al., 2022; Gullone, 2000; Ulrich, 1993) and about a potential biological origin (Gullone, 2000). However, Ulrich (1993) argues that while affirmative cross-cultural studies on biophilic responses do not disprove biological inheritance, they fail to provide evidence. Support for universal preferences cannot exclude possibilities of widespread acquired preferences through learning. Moreover, Ulrich (1993) thinks that both genetics and learning most likely have an impact, but to an uncertain extent, and suggests behavioral genetics as one way to investigate such distinctions further. In that case, Ulrich (1993) proposes, for instance, to first determine positive biophilic responses with high individual variability and then compare responses of a large sample of twins to the same biophilic stimuli.

Studies about exposure to nature and nature representations, like those mentioned above (e.g., Berto et al., 2023; Bratman et al., 2012), are used to argue for living structure since the significance of for instance, fractals, scaling, and organized complexity is based on their prominent existence in nature (Friedenberg et al., 2022; Salingaros, 2012, 2015). However, research on living structure is also isolated from nature representations. For example, Berto et al. (2023) conclude evidence of preferences for, and restorative qualities of, façades characterized by organized complexity. Preferences for patterns of organized complexity are also observed by Aks and Sprott (1996), and several studies focusing on artificial fractals conclude positive responses (Hagerhall et al., 2004; Spehar et al., 2003; Viengkham & Spehar, 2018). However, while demonstrating robustness in fractal preferences, Viengkham and Spehar (2018) found no support for universality, and Stamps (2002) concluded preferences for non-fractals in urban landscapes.

A positive and significant relationship between human activity and a high degree of semilattice structure is demonstrated by a study on human activity in relation to varying degrees of semilattice structure in urban districts (Huang et al., 2022). Likewise, a topological perspective is proven accurate in predicting human traffic flow (Hillier, 1996; Hillier & Iida, 2005; Penn, 2003), and high connectivity (as in a semilattice) promotes

movement and spatial integration (Legeby, 2018). This might be explained by Penn's (2003) suggestion that the perception of space depends on topology rather than geometry, an idea shared by Jiang (2019) and the NKCS since the topological perspective captures the physical manifestation of the scaling law.

Like research concerning exposure to nature and nature representations, research on human responses when exposed to a living structure, demonstrates positive results (Aks & Sprott, 1996; Hagerhall et al., 2004; Hillier & Iida, 2005; Huang et al., 2022; Spehar et al., 2003). However, the evidence is not enough to support universality or biological inheritance. Apart from a scant selection of empirical research, most studies depart from small samples and investigate self-reported preferences and aesthetic ratings of images (e.g., Aks & Sprott, 1996; Huang et al., 2022; Spehar et al., 2003; Viengkham & Spehar, 2018). Literature is geographically biased, and cross-cultural studies, like research investigating the relationship between biological and learned causes for affective and cognitive responses, appear to be scarce.

5. Discussion

The NKCS captures the essence of the organic worldview, the theoretical enabler of visceral and universal aesthetic preferences, and the departure of Alexander's work on living structure. The organic worldview and its incorporation of the mechanical worldview are represented by combining the Paretian mindset and the scaling law with the Gaussian mindset and Tobler's law. The organic interdependence of substructures and "the whole" is reflected by the Paretian distribution and the scaling law. In contrast, the mechanical order is reflected by the Gaussian distribution and Tobler's law (Jiang, 2022a). This gives a good account of the complexity prominent in the work of Alexander (e.g., 1965, 1979, 2002a, 2004), further manifested by the heavy-tailed distribution of the scaling law, the hierarchical graph of head-tail breaks, and the topological perspective of cities, indicative of the suitability of the NKCS to analyze cities as complex networks (Jiang, 2015).

The design principles of differentiation and adaptation distill Alexander's (2002a) 15 properties of good design (Jiang, 2019). By promoting the enhancement of far more small substructures than large ones, the principle of differentiation captures the feature of deep recursiveness, a defining characteristic of several of Alexander's (2002a) 15 properties, i.e., Levels of Scales, Strong Centers, Good Shape, and Echoes. The principle of adaptation instead emphasizes the feature of coherence in the same or nearby scales, particularly evident in the properties of Local Symmetries, Deep Interlock and Ambiguity, Gradients, and Simplicity and Inner Calm (Jiang, 2019; Jiang & de Rijke, 2023). Hence, we conclude that the NKCS provides a tool to make holistic accounts of a living structure instead of focusing on singular living structure characteristics, for instance, fractals. The NKCS is therefore argued to be particularly appropriate to use in the continued research of living structure, for instance, regarding the underlying assumption of visceral and universal aesthetic preferences.

Empirical research supports a positive link between human well-being and nature and the characteristics of a living structure (e.g., Berto et al., 2023; Bratman et al., 2012; Gaekwad et al., 2022). However, empirical research testing the claims of universal and visceral aesthetic appreciation is scant, and evidence is inconclusive (Joye & De Block, 2011; Ulrich, 1993). Since the legitimacy of living structure as science, in addition to art, rests upon the existence of visceral and universal beauty, this knowledge gap is essential to understand the contribution of Alexander and how to proceed best when designing cities. However, it is a challenge to test these claims. Testing universal value demands extensive cross-cultural studies, and testing the biological inheritance of value demands a method capable of refuting learned responses (Gullone, 2000; Ulrich, 1993). Sometimes research showing physical responses is taken as evidence for heredity, but learned responses can also manifest physically, for instance, considering the placebo effect (Wager et al., 2004). Furthermore, the associated nature/nurture dichotomy is generally questioned for a more integrated approach (Creanza et al., 2017; Moore, 2002; Thompson et al., 2016). In agreement, Ulrich (1993) promotes biophilic research to recenter around the significance of biological factors in relation to learning rather than attempting to prove a binary existence. To argue for biophilic design on behalf of well-being, when conflicting with sociocultural norms and preferences, the genetic factor would have to prove dominant or at least of considerable significance for human well-being.

The NKCS cannot distinguish the origin of human responses by itself, but it can make holistic representations of a living structure devoid of other stimuli. It can also holistically account for the living structure in existing environments. As demonstrated by Giusti and Samuelsson (2023), new technologies such as smartwatches, tracking people's movements and health, can be used for large-scale, spatially explicit, public participatory research to collect people's self-reported experiences and spatially explicit data on heart rate variability, an important indicator for stress. The capacity of the NKCS to assess and map the living structure in urban landscapes, in combination with new opportunities for health-related data collection, enables cross-cultural and large-scale investigations of the relationship between degrees of living structure and well-being. It can help promote knowledge about the extent of conformity, perhaps universality, of aesthetic preferences for living structure. Another way to go forward with the same purpose could be to assess the degree of living structure in a large artwork sample from several divergent cultures. To research the biological influence on perceptions of beauty, the twin study suggested by Ulrich (1993) or

other suitable research designs could be performed with NKCS-generated representations of a living structure as biophilic stimuli.

Conclusive evidence for a significant biological component of aesthetic preferences would increase the scientific validity of living structure and associated ideas and make a strong case for human sameness and connectedness. However, so can conclusive evidence for the universality of preferences and even broad conformity explained by sociocultural evolution through social learning and a long-spun cultural transmission (Creanza et al., 2017; Thompson et al., 2016). Preferences acquired through rooted intercultural knowledge may not be fixed and eternal but suggest inertness (Thompson et al., 2016) and, therefore, also have the potential to legitimize living structure as a science. Moreover, while sociocultural evolution usually appears as a slow process of production and reproduction, some degree of plasticity enables sociocultural expressions deviant from learned and genetic bias, and sociocultural heterogeneity enables reform (Klüver, 2008; Thompson et al., 2016). The premise of living structure is controversial and exemplifies sociocultural heterogeneity. Despite so, it is possible that preferences for nature and living structure also represent a genetic bias. Continued scientific support for extensive preferences for living structure, regardless of preferential origin, could displace the discourse of beauty and reinforce the significance of a potential genetic bias. Moreover, it could increase the societal significance of Alexander's living structure and associated ideas, impacting urban design, resource use, well-being, and the sociocultural reform needed to manage increasing inequality and the breach of planetary boundaries.

The favoring of collective identity and conceptions of social justice is arguably justified to promote collaborative behavior and sharing. However, it stresses the importance of individual autonomy to maintain and promote democratic values and practices and avoid benefitting oppressive regimes. Alexander's (1979) promotion of inclusive, bottom-up agency to enhance living structure endorses individual uniqueness as necessary to build collective value. Moreover, theories on community work, particularly relevant within the context of urban social sustainability (Rothman, 1995; Sjöberg et al., 2015; Stepney & Popple, 2008), use collective identity to promote activation, inclusive participation, and democratic influence in decision-making processes (Adams, 2008; Popple, 2015). A long-term process promoting joint capacity, resource building, and collective empowerment encourages communities to mobilize and drive socially sustainable development themselves (Adams, 2008; Popple, 2015), for instance, through place-related planning since local construction projects engage people (Brusman & Turunen, 2018).

By enabling computer-generated design solutions with high living structure, the NKCS could challenge Alexander's (1979) faith in bottom-up agency for the emergence of holistic and aesthetically appreciated design. However, it cannot replace the empowering lessons of participation and joint effort engagements in the local environment. Hence, we stress space, place, and design as means of democracy, social justice, and social sustainability and the importance of using techniques like the NKCS to facilitate and encourage inclusive, participatory processes to empower people and local communities. The NKCS could, for instance, be incorporated into a participatory digital tool, allowing people to design their proposals for local construction projects and promote participation in negotiations. However, while encompassing Alexander's 15 properties, the NKCS is presently more general. To concretize something abstract, a participatory tool departing from living structure and the NKCS might benefit from combining the principle of differentiation and adaptation with Alexander's 15 properties or even the 253 design patterns.

6. Conclusion

Research demonstrates the health benefits of exposure to nature and living structure characteristics. Nevertheless, further testing of the assumption of visceral and universal aesthetic preferences for living structure is necessary to learn more about the validity of living structure as science in addition to art and the contributions of Alexander. Research capable of distinguishing the origin of preferences appears challenging to design and perform, especially since universal preferences do not equate with visceral preferences. Universality could equally be explained by social learning and widespread cultural transmission. Therefore, a potential confirmation of universal preferences for living structure would still require a refutation of the impact of learning to confirm the hypothesized biological origin. However, we argue that it is unnecessary to prove a biological origin of aesthetic preferences to support the validity of the premise of living structure. Universal preferences, or even broad conformity, acquired through social learning and long-spun cultural transmission may not be fixed and eternal but indicate an inertness that grants similar conclusions.

Considering the increasing critique of the nature/nurture dichotomy, a genetic component of aesthetic preferences is likely. In agreement with Ulrich (1993), further research is suggested to recenter around the significance of biological factors in relation to learning rather than attempting to prove a binary existence. With that in mind, the positive link between well-being and exposure to nature and living structure could be an expression of genetic bias while, at the same time, through its controversy, also representing sociocultural heterogeneity. If continued research successfully confirms preferences for living structure, inherited or not, living structure and associated ideas could engage in a self-reinforcing process and increase their significance in urban design, resource use, well-being, and the sociocultural reform needed to manage increasing inequality and the breach of planetary boundaries.

Due to the unique capacity of the NKCS to holistically represent Alexander's living structure and the organic worldview, the mathematical model is considered appropriate for continued research on, for instance, the visceral and universal nature of living structure preferences. Apart from justifying living structure as science with design implications, conclusive evidence for universal aesthetic preferences, or at least widespread conformity, would likely favor a more collective approach to human self-identity and social justice. To benefit a socially just and health-promoting development within the planet's boundaries, individual autonomy, as a cornerstone of democracy and social justice, must be maintained and enhanced. We, therefore, stress the importance of space, place, and design as means of democracy. The NKCS should, in accordance with Alexander's call for bottom-up design processes, encourage and facilitate inclusive participation in the design and construction of local environments to empower and mobilize people and communities.

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Conflict of Interests

The authors declare no conflict of interests.

References

Adams, R. (2008). *Empowerment, participation and social work* (4th ed.). Palgrave Macmillan.

Aks, D. J., & Sprott, J. C. (1996). Quantifying aesthetic preference for chaotic patterns. *Empirical Studies of the Arts*, *14*(1), 1–16.

Alexander, C. (1965). A city is not a tree. *Architectural Forum*, *122*(1/2), 58–62.

Alexander, C. (1979). *The timeless way of building*. Oxford University Press.

Alexander, C. (2002a). *The nature of order: The phenomenon of life: An essay on the art of building and the nature of the universe* (Vol. 1). Center for Environmental Structure.

Alexander, C. (2002b). *The nature of order: The process of creating life: An essay on the art of building and the nature of the universe* (Vol. 2). Center for Environmental Structure.

Alexander, C. (2003). New concepts in complexity theory arising from studies in the field of architecture: A response by Christopher Alexander. *Katarxis*, *3*, 1–24.

Alexander, C. (2004). *The nature of order: The luminous ground: An essay on the art of building and the nature of the universe* (Vol. 4). Center for Environmental Structure.

Alexander, C. (2005). *The nature of order: A vision of a living world: An essay on the art of building and the nature of the universe* (Vol. 3). Center for Environmental Structure.

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A pattern language: Towns, buildings, construction*. Oxford University Press.

Berto, R., Barbiero, G., & Salingaros, N. A. (2023). Biophilic design of building façades from an evolutionary psychology framework: Visual attention software compared to perceived restorativeness. *Visions for Sustainability*, *2023*(19), 91–124.

Bratman, G. N., Hamilton, J. P., & Daily, G. C. (2012). The impacts of nature experience on human cognitive function and mental health: Nature experience, cognitive function, and mental health. *Annals of the New York Academy of Sciences*, *1249*(1), 118–136.

Brusman, M., & Turunen, P. (2018). Socialt hållbar samhällsplanering [Socially sustainable social planning]. In S. Sjöberg & P. Turunen (Eds.), *Samhällsarbete: Aktörer, arenor och perspektiv* [Community work: Actors, arenas and perspectives] (pp. 117–138). Studentlitteratur.

Burton, E. (2000). The compact city: Just or just compact? A preliminary analysis. *Urban Studies*, *37*(11), 1969–2006.

Creanza, N., Kolodny, O., & Feldman, M. W. (2017). Cultural evolutionary theory: How culture evolves and why it matters. *Proceedings of the National Academy of Sciences*, *114*(30), 7782–7789.

Dawes, M. J., & Ostwald, M. J. (2017). Christopher Alexander's a pattern language: Analysing, mapping and classifying the critical response. *City, Territory and Architecture*, *4*(1), Article 17.

Dempsey, N., Brown, C., & Bramley, G. (2012). The key to sustainable urban development in UK cities? The influence of density on social sustainability. *Progress in Planning*, *77*(3), 89–141.

Fingerhut, J., Gomez-Lavin, J., Winklmayr, C., & Prinz, J. J. (2021). The aesthetic self: The importance of aesthetic taste in music and art for our perceived identity. *Frontiers in Psychology*, *11*, Article 577703.

Florida, R. (2017). *The new urban crisis*. Oneworld Publications.

Friedenberg, J., Martin, P., Uy, N., & Kvapil, M. (2022). Judged beauty of fractal symmetries. *Empirical Studies of the Arts*, *40*(1), 100–120.

Gaekwad, J. S., Sal Moslehian, A., Roös, P. B., & Walker, A. (2022). A meta-analysis of emotional evidence for the biophilia hypothesis and implications for biophilic design. *Frontiers in Psychology*, *13*, Article 750245.

Giusti, M., & Samuelsson, K. (2023). Evaluation of a smartphone-based methodology that integrates

long-term tracking of mobility, place experiences, heart rate variability, and subjective well-being. *Heliyon*, *9*(5), Article e15751.

Gullone, E. (2000). The biophilia hypothesis and life in the 21st century: Increasing mental health or increasing pathology? *Journal of Happiness Studies*, *1*(3), 293–322.

Hagerhall, C. M., Purcell, T., & Taylor, R. (2004). Fractal dimension of landscape silhouette outlines as a predictor of landscape preference. *Journal of Environmental Psychology*, *24*(2), 247–255.

Heywood, A. (2021). *Political ideologies: An introduction*. Bloomsbury Publishing.

Hillier, B. (1996). *Space is the machine: A configurational theory of architecture*. Press Syndicate of the University of Cambridge.

Hillier, B., & Iida, S. (2005). Network and psychological effects in urban movement. In A. G. Cohn & D. M. Mark (Eds.), *Spatial information theory: International conference, COSIT 2005, Ellicottville, NY, USA, September 14–18, 2005, Proceedings* (Vol. 3693, pp. 475–490). Springer.

Huang, J., Cui, Y., Chang, H., Obracht-Prondzyńska, H., Kamrowska-Zaluska, D., & Li, L. (2022). A city is not a tree: A multi-city study on street network and urban life. *Landscape and Urban Planning*, *226*, Article 104469.

Jiang, B. (2013). Head/tail breaks: A new classification scheme for data with a heavy-tailed distribution. *The Professional Geographer*, *65*(3), 482–494.

Jiang, B. (2015). Geospatial analysis requires a different way of thinking: The problem of spatial heterogeneity. *GeoJournal*, *80*(1), 1–13.

Jiang, B. (2019). Alexander's wholeness as the scientific foundation of sustainable urban design and planning. *New Design Ideas*, *3*(2), 81–98.

Jiang, B. (2022a). A new kind of city science built on living structure and on the third view of space. *Coordinates*, *18*(2), 31–40.

Jiang, B. (2022b). Geography as a science of the earth's surface founded on the third view of space. *Annals of GIS*, *28*(1), 31–43.

Jiang, B., & de Rijke, C. (2023). Living images: A recursive approach to computing the structural beauty of images or the livingness of space. *Annals of the American Association of Geographers*, *113*(6), 1329–1347. https://doi.org/10.1080/24694452.2023.2178376

Jiang, B., & Huang, J.-T. (2021). A new approach to detecting and designing living structure of urban environments. *Computers, Environment and Urban Systems*, *88*, Article 101646.

Joye, Y. (2007). Fractal architecture could be good for you. *Nexus Network Journal*, *9*(2), 311–320.

Joye, Y., & De Block, A. (2011). "Nature and I are two": A critical examination of the biophilia hypothesis. *Environmental Values*, *20*(2), 189–215.

Kellert, S., & Wilson, E. O. (1993). *The biophilia hypothesis*. Island Press.

Klüver, J. (2008). The socio-cultural evolution of our species: The history and possible future of human societies and civilizations. *EMBO Reports*, *9*(S1), S55–S58.

Kymlicka, W. (2002). *Contemporary political philosophy: An introduction* (2nd ed.). Oxford University Press.

Legeby, A. (2018). Everyday urban life at neighbourhood centers: Urban design and co-presence. In P. A. E. Toft & M. Rönn (Eds.), *The production of knowledge in architecture by PhD research in the Nordic countries* (pp. 73–100). Nordic Academic Press of Architectural Research.

Mehaffy, M. (2017). *Cities alive: Jane Jacobs, Christopher Alexander and the roots of the new urban renaissance*. Sustasis Press.

Mehaffy, M., & Salingaros, N. (2015). *Design for a living planet*. Sustasis Press.

Millward-Hopkins, J. (2022). Why the impacts of climate change may make us less likely to reduce emissions. *Global Sustainability*, *5*, Article e21.

Moore, D. S. (2002). *The dependent gene: The fallacy of "nature vs. nurture"* (2nd ed.). Macmillan.

Penn, A. (2003). Space syntax and spatial cognition: Or, why the axial line? *Environment and Behavior*, *35*(1), 30–65.

Popple, K. (2015). *Analysing community work: Theory and practice*. Open University Press.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., de Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., . . . Foley, J. A. (2009). A safe operating space for humanity. *Nature*, *461*(7263), 472–475.

Rothman, J. (1995). Approaches to community intervention. In J. Rothman, J. L. Erlich, & J. E. Tropman (Eds.), *Strategies of community intervention* (pp. 26–63). F. E. Peacock Publishers.

Salingaros, N. A. (2012). Fractal art and architecture reduce physiological stress. *Journal of Biourbanism*, *2*(12), 11–27.

Salingaros, N. A. (2015). *Biophilia and healing environments: Healthy principles for designing the built world*. Terrapin Bright Green.

Samuelsson, K., Giusti, M., Peterson, G. D., Legeby, A., Brandt, S. A., & Barthel, S. (2018). Impact of environment on people's everyday experiences in Stockholm. *Landscape and Urban Planning*, *171*, 7–17.

Sjöberg, S., Rambaree, K., & Jojo, B. (2015). Collective empowerment: A comparative study of community work in Mumbai and Stockholm. *International Journal of Social Welfare*, *24*(4), 364–375.

Spehar, B., Clifford, C. W. G., Newell, B. R., & Taylor, R. P. (2003). Universal aesthetic of fractals. *Computers & Graphics*, *27*(5), 813–820.

Stamps, A. E. (2002). Fractals, skylines, nature and beauty. *Landscape and Urban Planning*, *60*(3), 163–184.

Stepney, P., & Popple, K. (2008). *Social work and the*

community: A critical context for practice. Palgrave Macmillan.

Thompson, B., Kirby, S., & Smith, K. (2016). Culture shapes the evolution of cognition. *Proceedings of the National Academy of Sciences*, *113*(16), 4530–4535.

Tobler, W. (1970). A computer movie simulating urban growth in the Detroit region. *Economic Geography*, *46*(2), 234–240.

Ulrich, R. S. (1993). Biophilia, biophobia, and natural Landscapes. In S. R. Kellert & E. O. Wilson (Eds.), *The biophilia hypothesis* (pp. 73–137). Island Press.

UN-Habitat. (2016). *World cities report 2016—Urbanization and development: Emerging futures*. https://unhabitat.org/sites/default/files/download-manager-files/WCR-2016-WEB.pdf

United Nations Department of Economic and Social Affairs. (2020). *Inequality in a rapidly changing world* (World Social Report No. ST/ESA/372). https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2020/02/World-Social-Report2020-FullReport.pdf

Viengkham, C., & Spehar, B. (2018). Preference for fractal-scaling properties across synthetic noise images and artworks. *Frontiers in Psychology*, *9*, Article 1439.

Wager, T. D., Rilling, J. K., Smith, E. E., Sokolik, A., Casey, K. L., Davidson, R. J., Kosslyn, S. M., Rose, R. M., & Cohen, J. D. (2004). Placebo-induced changes in fMRI in the anticipation and experience of pain. *Science*, *303*(5661), 1162–1167.

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

Warren, M. (1990). Ideology and the self. *Theory and Society*, *19*(5), 599–634.

Whitehead, A. N. (1929). *Process and reality: An essay in cosmology*. The Free Press.

Wilson, E. O. (1984). *Biophilia*. Harvard University Press.

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Article

Patterns of Growth: Operationalizing Alexander's "Web Way of Thinking"

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Abstract
Christopher Alexander was often characterized—and sometimes seemed to characterize himself—as "sui generis," a radical and perhaps even eccentric thinker on architecture, technology, culture, and nature. That perception in turn has led many to dismiss Alexander's work as too idiosyncratic to be operationalized in the pragmatic world of planning and building. Here we show, however, that Alexander's core ideas have strong parallels in contemporary network science, mathematics, physics, and philosophy, and in the pragmatic world of technological design (including computer software). We highlight a remaining gap in translating Alexander's work into practical tools and strategies for implementation—a gap that is tantalizingly near to being bridged.

Keywords
Christopher Alexander; design patterns; network science; pattern language; wiki

Issue
This article is part of the issue "Assessing the Complex Contributions of Christopher Alexander" edited by Michael W. Mehaffy (Sustasis Foundation) and Tigran Haas (KTH Royal Institute of Technology).

1. Introduction

There can be little dispute that Christopher Alexander, who died in 2022, was one of the most influential architecture and design theorists of the late 20th and early 21st centuries (Wania, 2015). At this writing, Google Scholar reports 24,800 scientific papers that include his name, as well as 36,900 that include the term "pattern language"—his seminal design methodology introduced in the 1977 book *A Pattern Language: Towns, Buildings, Construction* (Alexander et al., 1977).

It is also clear from the record that Alexander's legacy was a controversial one, with many researchers and critics finding fault with his work. One can find numerous examples such as the scathing essay by Alexander's Berkeley colleague Jean-Pierre Protzen (1978) titled "The poverty of the pattern language." Professor Kim Dovey (1990) documents a number of other hostile criticisms in his paper "The pattern language and its enemies." One can also find many papers that refer to Alexander's contentious reputation, such as that by Jones and Wong (2008, p. 1), in the first sentence of its abstract (it begins "Christopher Alexander is a controversial architect who…"). A 2003 profile in *The New York Times* takes a similar view, describing Alexander as "something of a prophet without honor in his own profession" (Miller, 2003).

Alexander himself provided evidence for this perception—and may have fueled it—by providing his own harsh criticisms of conventional architectural and planning practice, and offering (by his own description) radical alternatives. In the cover text of *A Pattern Language*, he and his co-authors stated that they intended to offer "an entirely new approach to architecture, building and planning, which will we hope replace existing ideas and practices entirely" (Alexander et al., 1977). Even more directly, Alexander described himself and his allies as being in a "Battle for the Life and Beauty of the Earth" and in "A Struggle Between Two World-Systems," in his last published book with that title and subtitle, respectively (Alexander et al., 2012).

Even those who admired Alexander's work often expressed skepticism about his ability to implement his ideas at a large scale in the real world of contemporary building. Andrés Duany, co-founder of the Congress for the New Urbanism and a noted campaigner for urban reform, pointed out that:

> Chris' methodologies do not wish to lower themselves to the required level of communication with the existing protocols. They create their own much smarter ones. But I don't think that we have time to break the existing ones down, nor to build up comprehensive new ones….And the problem isn't just financial. As I have said, it is the interlocked system which is so comprehensive that one has to grant it an awesome beauty, like that of a vast, smoothly functioning empire. (Duany, 2004)

For UCL professors Mike Batty and Stephen Marshall, the problem was compounded by what they saw as Alexander's eccentric theories of nature:

> Part of the problem of trying to apply Alexander's ideas is the extent they are bound up with his own very specific unorthodox view of how nature (and the universe) works. This is a particular problem for what some regard as his magnum opus *The Nature of Order*, a work that across four volumes runs to thousands of pages (without an index), whereby it is rather difficult to pin down precise definitions of concepts or trace their relation to mainstream science. (Batty & Marshall, 2017, p. 8)

Judging from the record, Batty's and Marshall's is a prevalent view in the fields of architecture and urban planning. Indeed, as these findings suggest, it is common to see Alexander's ideas referred to as "unorthodox" and not ready for the real world, and other words to that effect (often less politely stated).

Yet there are other fields where Alexander's ideas—even his deeper philosophical ones—have found a much warmer reception, and even a greater degree of practical application. Perhaps surprisingly, one of those is the eminently practical world of computer science and software design.

2. Alexander's Influence in the Software World

The methodologies of computer software designers produce outcomes far more rapidly than do the methodologies of environmental designers. A computer's software will often either run properly, or, in many cases, quickly manifest "bugs"—strange results, unintended consequences, or even the malfunction of the computer, i.e., a software "crash." For obvious reasons, there must be a premium on the efficacy of implementation.

For that reason, it may be rather surprising that software designers took inspiration from an architect—and one with something of a reputation as a mystic, no less—to develop one of their most ubiquitous design methodologies. In this case it was Alexander's pattern language, whose common usage in the software world is indicated by a simple Internet search of the term. Google's search engine returns 412,000 hits for "'pattern language' architecture," but 851,000 hits for "'pattern language' software"—more than twice as many hits. The term "design pattern"—the equivalent term used by software designers—returns 21 *million* hits.

The Wikipedia entry for "pattern language" begins to offer clues about the utility of patterns in software. Rather than describing problems that are peculiar to the built environment, the entry makes a broader summary: "A pattern language is an organized and coherent set of patterns, each of which describes a problem and the core of a solution that can be used in many ways within a specific field of expertise" (Wikipedia, 2023a). The "field of expertise" under this definition could vary enormously, and could indeed include software.

Similarly, the Wikipedia entry for "design pattern" suggests its broader utility: "A design pattern is the re-usable form of a solution to a design problem. The idea was introduced by the architect Christopher Alexander and has been adapted for various other disciplines, particularly software engineering" (Wikipedia, 2023b).

The widespread adoption of pattern language methodology in software began when a small group of engineers, among them Ward Cunningham and Kent Beck, received copies of Alexander's book *The Timeless Way of Building*, the companion volume to *A Pattern Language: Towns, Buildings, Construction*. Cunningham and Beck were struggling to find a reliable methodology to clarify a particular software design using the object-oriented Smalltalk software language. Cunningham and Beck saw a promising opportunity to try out Alexander's ideas, particularly those involving user participation. As an experiment, they gave two user representatives, a trainer and a field engineer, a series of rudimentary patterns of their own creation, and directed the user representatives to finish the design. They "were amazed at the (admittedly spartan) elegance of the interface their users designed" (Cunningham, 2011).

Other software designers had begun to converge on similar applications of Alexander's ideas, and, following several software conferences and workshops where Cunningham and Beck had presented their results, a larger group gathered at a mountain retreat in Colorado to develop the foundations of software patterns and to launch a new organization, the Hillside Group, and a new conference series, Pattern Languages of Programming, or PLoP for short. As Cunningham recalls:

> We agreed that we were ready to build on Erich Gamma's foundation work studying object-oriented patterns, to use patterns in a generative way in the sense that Christopher Alexander uses patterns for urban planning and building architecture. We then used the term generative to mean creational…. (Cunningham, 2011)

Many of the participants in the early pattern language work went on to play outsize roles in other pioneering software development, including Agile Methodology,

Extreme Programming, Scrum, and wiki, the basis of Wikipedia and many other websites. Design patterns are themselves ubiquitous in software design today, including most games, many operating systems, and many other systems. Far from being impractical and esoteric, pattern languages of programming have proven themselves eminently practical and even robust.

The development of wiki is particularly revealing. As Cunningham makes clear, wikis were invented as a means to exchange patterns among users, and moreover, the structure of a wiki itself follows that of a pattern (Cunningham & Mehaffy, 2013). As with the structure of a pattern, each wiki page identifies a topic with a name, a description of a problem or issue, a section analyzing the problem, and then a conclusion that provides a configurational solution. Moreover, there are hyperlinks from higher-level topics at the top, and lower-level topics at the bottom, which allow the wiki page (or pattern) to be linked in a web relationship with many other patterns (the structure of Wikipedia is even closer to Alexander's pattern structure, often with an iconic photo, and ubiquitous hyperlinks, although the topic of each wiki page is not a "problem" per se but a broader topic of knowledge, e.g., the wiki page "pattern language" itself.)

Wikipedia has even become a powerful resource in the development of artificial intelligence. Most text-based AI systems, like IBM's Watson and OpenAI's GPT3, draw on the Wikipedia dataset (Wikipedia, 2023c). This is not a coincidence, since large language models and pattern languages share a similar hyperlinked or web-networked structure. Indeed, the salient feature of many complex systems is their highly interconnected network patterns, or "deep nets." Since the pattern language methodology is open-ended, like language itself, in principle, pattern languages could be vastly complex, and intricately customizable to a wide range of modeling projects.

One such modeling project is a collaboration between the author and Ward Cunningham to develop a pattern language-based urban design tool, known as a "scenario-modeling tool." The research, conducted at Delft University of Technology in the Netherlands, drew on Bayesian methodology, neural networks and other capabilities, to construct a wiki-based set of patterns, that could be adapted to calculate "externalities," e.g., greenhouse gas emissions, or other impacts of various urban design scenarios. The prototype or "alpha test version," developed as proof of concept, employed four of Alexander's patterns, rewritten more precisely to allow quantitative measurement. Designers using the tool could vary the parameters of each of the patterns, resulting in variations of the predictive outputs of the "externality" metrics. This could be highly beneficial in, for example, evaluating the benefits of various design changes so as to improve public good, and thereby to "monetize" those benefits to encourage the change in scenarios.

The model is known as WikiPLACE, an acronym for "Wiki-based Pattern Language Adaptive Calculator of Externalities." The tool is a calculator for use by urban designers, allowing them to make usefully reliable predictions about the various choices of urban design parameters they might make (density, distribution of destinations, etc.) The model uses patterns to adapt to the various scenarios, and, using real-world data to generalize the impacts of these variables, it makes an evidence-based model output of the predictive value of one or more "externalities"—in this case, greenhouse gases per capita, although in principle it could be used for any externality for which there is reliable modeling data (or indeed, any calculation that is not an economic externality as well, so long as data is available to develop the model).

In the initial test, the prototype or "alpha test version," shown in Figure 1 (author's screenshot), was applied to three scenarios, each of which was then compared to a known dataset for the equivalent real-world scenario. For one dataset (emissions per capita of cities in comparison to their countries) the correlation of prediction to known values was within 17%. For the second dataset (different cities within the USA) the correlation of prediction to known values was within 5.32%. For the third dataset, a comparison of neighborhoods within Austin, Texas, the correlation of prediction to known values was within 8.2%.

This research demonstrates that Alexander's work with pattern languages—and its translation into wiki, and other software applications—does indeed have great potential for practical application. It is noteworthy, however, that it took a departure into the domain of computer science in order to demonstrate this usefulness.

3. Alexander's Influence in Other Fields

There are also other remarkable applications of pattern languages in a wide range of other fields. A Google Scholar search of the term "pattern language" produces over 39,000 hits in a dizzying number of topics, including "a pattern language for learning management systems" (education), "a pattern language for security models" (cryptography), "a pattern language for communication revolution" (sociology), "contract as pattern language'' (law), "an ontology pattern language for service modeling" (business), "towards a pattern language for quantum algorithms (quantum physics and computing), "a pattern language for costumes in films" (film), "a pattern language for composing film music" (music), dynamical patterning modules, a "pattern language" for development and evolution of multicellular form (molecular biology), and seemingly endless others.

It is worth noting that many of these are documenting eminently practical applications, not only in functional software design, but in engineering, business, law, music and the arts, and many other disciplines. One paper even documents "A pattern language for writing patterns" (Meszaros & Doble, 1998)!

The last item, "a 'pattern language' for development and evolution of multicellular form," is perhaps more theoretical than most, but also particularly instructive.

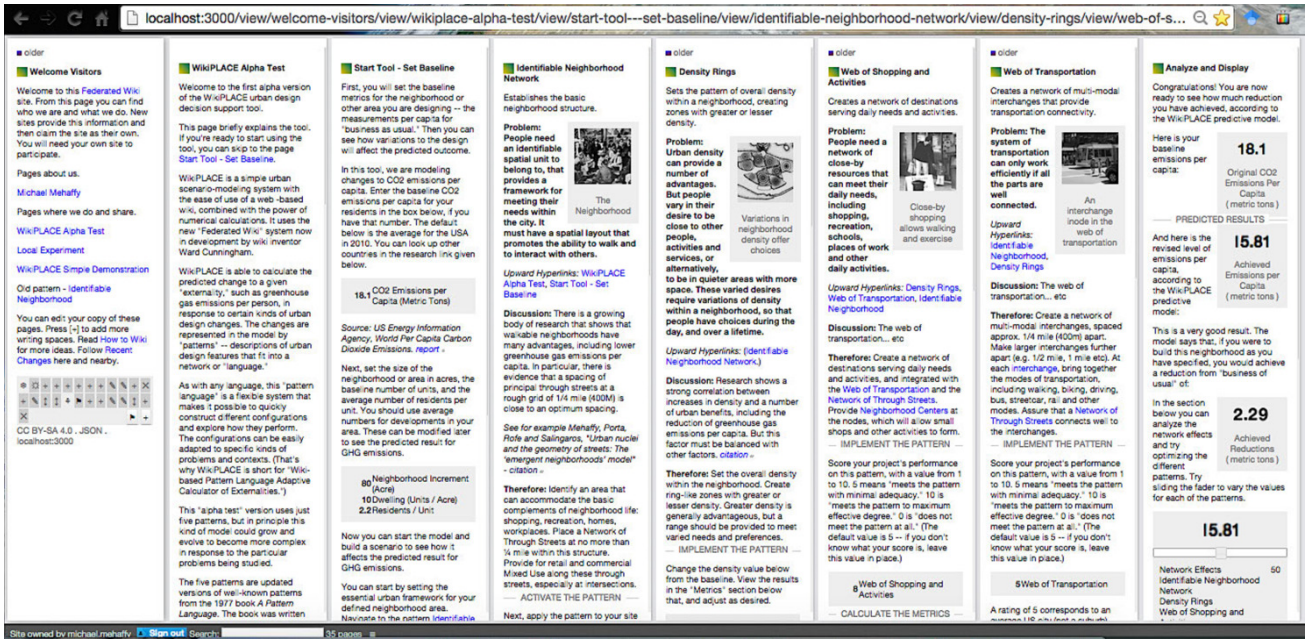

Figure 1. The complete structure of the WikiPLACE urban design scenario-modeling tool, as it appears in a screenshot of its maximum zoom out on a desktop, showing all the patterns used in the alpha test version. From left to right, the introduction and startup page, the Start Tool—Set Baseline page, the four patterns, and the final display page. Users can adjust the values of the patterns, or change the order or number of patterns. Following the protocol of a wiki, users can also edit the patterns as they desire, or even write new ones on their own local copy, which can be shared with others, if desired, through the federated network.

The paper, by molecular biologists Stuart Newman and Ramray Bhat of New York Medical College, considers the mystery of the origins of multi-cellular organisms around the time of the so-called Cambrian Explosion, approximately 550 million years ago. They propose that something analogous to a pattern language structure occurred in the genetic code. As they explain in the abstract:

> We propose that DPMs, acting singly and in combination with each other, constitute a "pattern language" capable of generating all metazoan body plans and organ forms. This concept implies that the multicellular organisms of the late Precambrian-early Cambrian were phenotypically plastic, fluently exploring morphospace in a fashion decoupled from both function-based selection and genotypic change. The relatively stable developmental trajectories and morphological phenotypes of modern organisms, then, are considered to be products of stabilizing selection. This perspective solves the apparent "molecular homology-analogy paradox," whereby widely divergent modern animal types utilize the same molecular toolkit during development. (Newman & Bhat, 2009, p. 693)

In other words, the model of a pattern language helps to explain the enormous generative possibilities of multicellular life, while the local adaptation and natural selection produce the particular forms that exist in a given environment.

Newman and Bhat's paper attracted considerable attention, with over 225 citations on Google Scholar as of this writing. Bhat went on to explore the pattern language model even farther, exploring a more direct analogy between pattern languages in biological systems and in human architectures. After further research in the Life Sciences Division at Lawrence Berkeley National Laboratory, he published a paper, "Understanding complexity through pattern languages in biological and man-made architectures." Bhat describes the aims of the paper in the abstract:

> The advances in the theory of complexity have come not just from biologists, but also from architects and urban theorists. In this essay, I discuss how theorists from both life and architectonic sciences have come to a similar conclusion: that patterned and organized form ensures proper function and, ultimately, life. I show how deviation from this principle in biology leads to cancer and death; in architecture, the deviation allows the takeover of mechanical and imagery-based building ideologies leading to dysfunctional and "lifeless" building and public spaces. (Bhat, 2014, p. 8)

In so doing, Bhat clearly implies that Alexander deserves credit (as an architect) for contributions to the theory of complexity, and furthermore, Bhat, and his colleague Newman find highly useful explanatory benefits from Alexander's pattern language, even perhaps helping to explain the origins of multi-cellular life, and even the nature of cancers. This is, of course, in addition to the practical applications of pattern language methodology

in a seemingly endless number of fields, far beyond its already prodigious contribution to software.

4. Problems in the Architecture Field

We now face a puzzling question: Why, then, has the pattern language methodology not been more successful in the very domain for which it was originally developed, architecture and the built environment, yet had such remarkable success in other fields? Three related reasons seem apparent.

First, the original 1977 book became a victim of its own success. Instead of serving, as stated in the introduction, as only the start of a vastly larger open-source collaboration producing "countless thousands of other languages," the original collection of 253 patterns became a classic—but also the "final word" on what patterns could be. This outcome was in stark contrast to what the book actually said:

> We hope, of course, that many of the people who read, and use this language, will try to improve these patterns….You see then that the patterns are very much alive and evolving. In fact, if you like, each pattern may be looked upon as a hypothesis like one of the hypotheses of science. In this sense, each pattern represents our current best guess as to what arrangement of the physical environment will work….But of course, no matter what the asterisks say, the patterns are still hypotheses, all 253 of them—and are therefore all tentative, all free to evolve under the impact of new experience and observation….The fact is, that we have written this book as a first step in the society-wide process by which people will gradually become conscious of their own pattern languages, and work to improve them…it is possible that each person may once again embark on the construction and development of his own language—perhaps taking the language printed in this book, as a point of departure. (Alexander et al., 1977, pages xv–xvii)

The problem is further complicated by the copyright of the original book, still held by Oxford University Press and the estate of Christopher Alexander. In effect this means that no future pattern language can contain any of the original 253 patterns in the book—in spite of the fact that many of the patterns are archetypal, as Alexander and his coauthors themselves observed: "We doubt whether anyone could construct a valid pattern language" without many of the patterns in the book (Alexander et al., 1977, p. xvii). This amounts to a fatal handicap: no other pattern language could be valid, unless it violated the copyright of the original book.

This situation had the effect of "freezing" the original 253 patterns in an unalterable, inflexible, bible-like volume, forever frozen in the language of 1977. That was in stark contrast to the world of software, where tens of thousands of patterns could be freely exchanged, altered, added to, discarded, and otherwise adapted to fit varying needs and changing circumstances (one egregious example of an inflexible pattern that posed just such a problem was "South Facing Outdoors," a pattern that is only valid in the Global North, and literally invalid on half of the planet).

But there is a second apparent reason that the pattern language methodology did not find a warm reception in the world of architecture and the built environment: its critical and even hostile position toward the architecture profession, an attitude that was apparently reciprocated by that profession. The book's authors expressed their intention to "replace existing ideas and practices entirely" (Alexander et al., 1977, cover) and to remedy the problem "that the [pattern] languages which people have today are so brutal, and so fragmented, that most people no longer have any language to speak of at all—and what they do have is not based on any human, or natural considerations" (Alexander et al., 1977, p. xiv).

As described by Dovey (1990) et al., the response from many architects was overtly hostile (e.g., "the pattern language and its enemies"; "the poverty of the pattern language" and others). Many architects are also known to dislike restrictions in their design freedom, including design codes, formulae, etc., which are seen as too prescriptive. For many of them, as Dovey makes clear, the pattern language was far too prescriptive. For Protzen (1978), it failed to embrace the open-ended nature of good design, and the frequent need to innovate beyond what any code or regulation might specify.

But this sensibility failed to understand what the sciences had been increasingly recognizing in the late 20th century: that generative systems *do* use rules and constraints, and indeed, that is the basis of their complexity. The process of morphogenesis does not abandon the genome and proteome and construct willfully creative forms. As Newman and Bhat argued, it uses something very much like a pattern language to guide what is certainly a vastly complex and interactive process.

This brings us to the third factor that may account for the failure of pattern language methodology in the built environment: The failure of the architecture and planning professions to understand or embrace what Jane Jacobs (1961, p. 429) referred to as "organized complexity," or the dawning sciences of complex adaptive systems. For Jacobs (1961, p. 429), these insights revealed to us "the kind of problem a city is"—a problem in which the variables are interactive in complex ways, but they are not random. Indeed, they form a web-network, of exactly the kind described by pattern languages. Jacobs (2000, p. 26) herself argues that it was essential that we must begin to operationalize this "web way of thinking," as she referred to it.

It is also not a coincidence that Alexander had earlier and famously criticized "tree-like" cities, whose variables were neatly segregated into hierarchical relationships, in his landmark 1965 paper "A city is not a tree."

The remedy for tree-like hierarchies was nothing other than the web-like structure seen in pattern languages.

5. The Problem of Geometry (and Symmetry)

There was yet another problem with the pattern language, and one that Alexander himself identified. The methodology did not yet deal sufficiently with the problem of geometry and form. The elements dealt with in the pattern language did not guide users to actually shape places, or to shape them in sufficient detail, to produce results that were profound, or ultimately satisfying. This realization set him on a 25-year project to describe "The Nature of Order," or as the subtitle calls it, "An Essay on the Art of Building and the Nature of the Universe." As Alexander explained it:

> So what is *The Nature of Order* all about? Took 25 years to write, four big fat books, or big thick books, unfortunately a little expensive, about 60 dollars a book, thousands of lovely colored pictures—anyway, what's it all about? When I finished the pattern language, I thought that I had come close to solving the problem of making good human environments. And that if people went to work and used all those patterns, something very beautiful and good would follow, in the hands of ordinary people, and just from the use of that pattern language. That turned out to be not true.....I think people did things that were very very helpful to them and some of them are quite lovely, just in the sense of being informal and being about that person or this person or that place, and so forth. But.... the buildings, and the groups of buildings and so forth, were not really beautiful, to put it quite simply. They weren't. Luckily, I was at that time still relatively early in my professional life. And so I had time to think about this. And what *The Nature of Order* is about is, what does it take to make the things beautiful—really and truly beautiful, in the old-fashioned meaning of the word, um so that it touches you in your heart? And what these books attempt to do is to describe what is involved in thinking about that, what's involved in doing it, what's involved from a practical point of view, in terms of construction contracting and so forth, what's involved from a spiritual point of view, so that you as the maker, whoever that is, are in a sufficiently harmonious state to be able to make a beautiful thing. So, it's really the gamut of all of that, is what these books are about. And um, I certainly got closer, in those books than I did in the pattern language. A *lot* closer. (Alexander in Sustasis Collaborative, 2021; emphasis added)

Once again, Alexander seemed to be veering off into esoteric topics, including spirituality, beauty, harmony, and the like. This was the problem that Batty and Marshall alluded to when they described "his own very specific unorthodox view of how nature (and the universe) works," and noted that "it is rather difficult to pin down precise definitions of concepts or trace their relation to mainstream science" (Batty & Marshall, 2017, p. 8)

However, a careful analysis shows that Alexander's ideas do in fact track very closely with mainstream science, particularly the evolving field described as a "science of cities." Mehaffy (2019) analyzed *The Nature of Order*, and described a number of contributions it made to the emerging science of cities:

- Adaptive morphogenesis and the growth of form;
- Building process as the interaction of multiple distributed agents;
- City evolution as a comprehensible (and modifiable) emergent outcome of complex adaptive systems;
- Aesthetics as a non-trivial indicator of life-supporting order in cities;
- A more human-centered application of data and metrics.

Mehaffy concluded the analysis by noting:

> We see, then, that in spite of Alexander's heretical reputation within the architecture profession, his idiosyncratic formats and mistakes, and his own disinterest in drawing parallels, the actual work was always situated deeply within recognizable and often ancient topics of science and philosophy, from his early work on the synthesis of form to his late-career work on "the art of building and the nature of the universe." Topics of mereology (part-whole relations), hylomorphism (the transformations of matter), ethics (what is good architecture, and what is good practice), ontology (the nature of reality), and other perennial human concerns, can be seen throughout his work. (Mehaffy, 2019, p. 15)

Another parallel between Alexander and the work of others (past and present) can be drawn in the domain of symmetry theory—a moribund topic in the field of architecture, where it is often dismissed as simplistic mirror symmetry, but a rich topic in physics and mathematics (and it is also a richer topic than is often recognized within the history of architecture). Alexander (2003) reported in *The Nature of Order* that he could describe "fifteen fundamental properties" that are common to many beautiful structures, and in turn they are generated by fifteen fundamental transformations. These properties can also be described as forms of symmetry (e.g., scaling symmetry, mirror symmetry, rotational symmetry, translational symmetry, information symmetry, and various combinations; Mehaffy & Salingaros, 2021).

The scheme is shown below, with Alexander's property on the left, and the equivalent form of symmetry on the right:

1. "Levels of Scale" (scaling symmetries);
2. "Strong Centers" (rotational, reflectional symmetries);

3. “Boundaries” (rotational, reflectional symmetries);
4. “Alternating Repetition” (compound symmetries);
5. “Positive Space” (net convex symmetrical spaces);
6. “Good Shape” (coherent symmetrical shapes);
7. “Local Symmetries” (reflectional symmetries within symmetry breaking);
8. “Deep Interlock and Ambiguity” (translational symmetries);
9. “Contrast” (reflectional symmetries);
10. “Gradients” (translational symmetries);
11. “Roughness” (translational symmetries);
12. “Echoes” (information symmetries);
13. “The Void” (symmetry void);
14. “Simplicity and Inner Calm” (symmetry simplicity ratio);
15. “Not-separateness” (ultimate symmetry, with symmetry breaking, of all things).

Thus, in spite of the apparent esoteric sound of some of these properties, they can all be accounted for by well-established concepts of symmetry in mathematics and physics. Their contribution is in how they are applied to specific problems of design, and, as Alexander describes in great detail, the specific configurations necessary for good design.

As with Alexander’s other work, although he was disinterested in drawing parallels to others in architecture, the sciences and philosophy, the many parallels are evident. There is also a unique and notable contribution, which may offer practical benefits on the level of Alexander’s previous pattern language work. This is certainly a tantalizing prospect.

6. Reforming the “Operating System for Growth”

We are, however, left with the question: How can Alexander’s insights, with their parallels to network science and others, their demonstrated efficacy in software and other fields, and their apparent relevance to urgent issues of quality and sustainability in the built environment, actually be operationalized, beyond what has occurred only minimally to date? What are the remaining barriers, and how must they be tackled?

At the heart of Alexander’s critique of contemporary methods is an analysis of our “modern” technological systems, and their tendency toward excessive abstraction, fragmentation, oversimplification, and, in a word, crudeness. This was the precise problem that software engineers identified and tackled, embracing Alexander’s generative and web-like approach, and his methodology not for the composition of elements, but rather, for what we might call the “genesis of wholes” (Mehaffy, 2007). This was manifested not only in their embrace of pattern languages, but in their “Agile” methodology, their generative methods, and their open-source, networked approach to collaborative design.

Alexander describes a historic transition, occurring as part of the Industrial Revolution, to what he termed “System B”—a system that relies too much upon mechanical and linear methods of composition, instead of the more organic and web-like methods of biological systems, and indeed of an earlier stage of technology—what he termed “System A” (Alexander et al., 2012, pp. 43–62). We assumed that we were more advanced by adopting the more rational methods of System B, he notes—but we threw out the baby with the bathwater, so to speak. The challenge now is not to go back to the world of System A—that is probably impossible, and likely ill-advised—but rather to reform System B to incorporate more of the powerful and sophisticated (if overlooked) capacities of System A, perhaps a kind of “third stage” of technology, one that has learned from previous failures, and found its way to a more resilient, more life-supporting kind of technology.

It seems that parts of our technological society are more advanced in dealing with this challenge (like software and the biological sciences) while other parts are relatively backward (like architecture and urban development). There are particular obstacles when it comes to the built environment, comprising what we might think of as the “operating system for growth.” These are the processes that govern real estate development, finance, planning, design, engineering, entitlement, construction, etc. They include all the codes, standards, laws, regulations, models, incentives and disincentives, that govern what can be built, what will generate profit or loss, and what can even be conceived or executed.

This “operating system for growth” functions as a kind of “massive multiplayer game,” in which rules and interactions generate activities and results, and feedback influences the results. If there is insufficient feedback—for example, economic feedback from so-called “externality” impacts, like greenhouse gas emissions, or health benefits, or other negative or positive outcomes—then the system is less likely to be responsive to the need to manage those results for greater human benefit.

Jane Jacobs wrote perceptively about this challenge, and particularly its economic dimensions. In *The Death and Life of Great American Cities*, she noted that “in creating city success, we humans have created marvels, but we left out feedback. What can we do with cities to make up for this omission?” (Jacobs, 1961, p. 252). It is indeed feedback that we need, of exactly the kind that biological systems use to achieve complex results—complex, adaptive, networked.

This is precisely the technological challenge that the software innovators have used in developing pattern language technology, and later Agile, wiki, and other adaptations. Perhaps we must now take a lesson from their success?

7. Horizons of Pattern Languages

Christopher Alexander was once asked by this author whether he considered adapting the pattern language methodology to be able to incorporate more of the

geometric and transformational insights of *The Nature of Order*. "Yes, I did," he reported, "but I chickened out" (personal communication, 2008).

Alexander himself was always interested in the next question and the next challenge, and quick to move on from previous work. That approach served him well over a prodigious and remarkably influential career. Perhaps, however, the remaining challenge is to ask how some of these achievements could be brought together into a more effective "operating system," taking lessons from the successes of the software world.

One such project is the book and companion wiki titled *A New Pattern Language for Growing Regions* (Mehaffy et al., 2020). This project takes the guidance of Alexander's foreword as inspiration, "that each person may once again embark on the construction and development of his own language—perhaps taking the language printed in this book, as a point of departure" (Alexander et al., 1977, p. xvii). The book is a collection of 80 new patterns, addressing new challenges not covered by the original book.

As the book's summary states:

> This new collection emerged in part from a five-year collaboration with UN-Habitat to address new urban challenges, including rapid urbanization, slum upgrading, sustainable urbanism, emerging technologies, and new tools and strategies to meet these and other challenges. However, there remains an urgent need to develop and share tools and strategies grounded in research evidence, and subject to revision, addition, and refinement, with new findings from new collaborators. (Mehaffy et al., 2020, back cover)

Importantly, the book was simultaneously published open-access as a PDF, a printed text (available for sale to cover the cost of printing) and a companion wiki, created by wiki inventor Ward Cunningham (also one of the pioneers of pattern languages of programming). It is available on the web to anyone at npl.wiki (Figures 2, 3, and 4).

The new pattern language incorporates a number of topics and issues not present in the original volume, including "patterns of process":

- *Geometric patterns*: echoing Alexander's 15 properties, there are patterns for "Local Symmetry," "Fractal Pattern," and "Framing."
- *Project economics patterns:* There are financial tools like "Tax-Increment Finance" and "Land

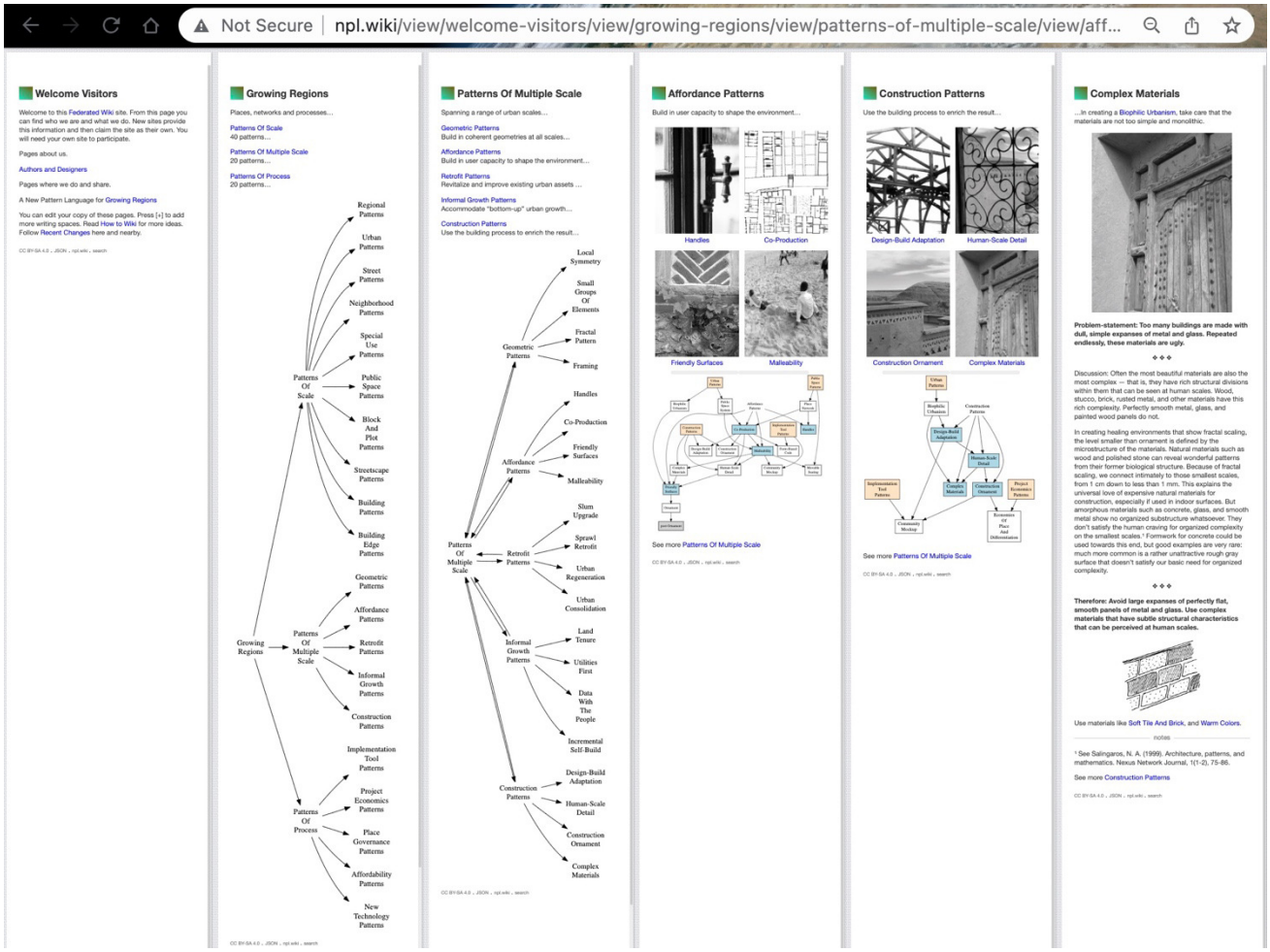

Figure 2. The wiki version of *A New Pattern Language for Growing Regions*. Source: Mehaffy et al. (2020).

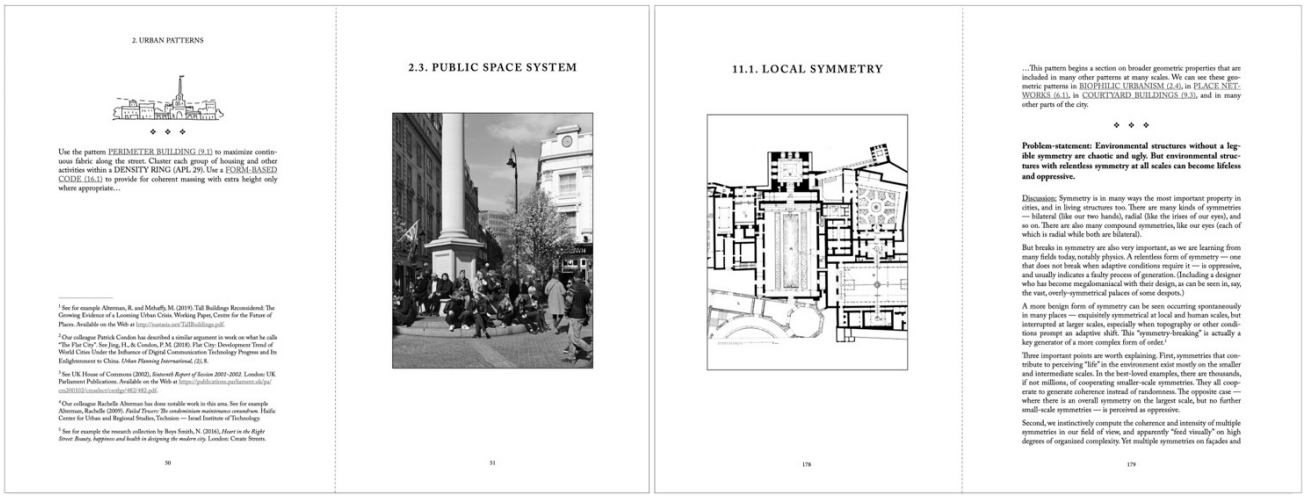

Figure 3. Pages from *A New Pattern Language for Growing Regions,* showing new kinds of patterns, like geometric patterns, and those relating to the New Urban Agenda, like public space patterns. Source: Mehaffy et al. (2020).

Value Capture," as well as broader patterns of "Externality Valuation" and "Economies of Place and Differentiation"—meant to balance current lopsided economies of scale and standardization.

- *Informal growth patterns:* Many of the patterns are aimed at the current challenge of rapid urbanization, including patterns in this category: methods of securing "Land Tenure" for residents of informal settlements, "Utilities First" to provide basic infrastructure, "Data With the People" to provide basic information like addresses, and "Incremental Self-Build" to provide a pathway to homes for all.
- *Retrofit patterns:* Strategies for transforming existing places to better-quality human habitat, including "Slum Upgrade," "Sprawl Retrofit," and "Urban Regeneration."
- *Affordance patterns:* These are patterns that empower people to change their own environments, including "Co-production," "Handles," and "Malleability."
- *New technology patterns:* Empowerment of citizens with neighborhood-based technology, including "Citizen Data," "Augmented Reality Design," and "Responsive Transportation Network Company."
- *Implementation tool patterns:* These patterns are most closely aimed at the challenge of implementation, and they include patterns meant to replace or supplant existing elements of the "operating system for growth." They include "Form-Based Code," "Neighborhood Planning Center," and "Entitlement Streamlining"—a kind of "plug and play" approach to approving plans that have already been developed with and supported by the community.

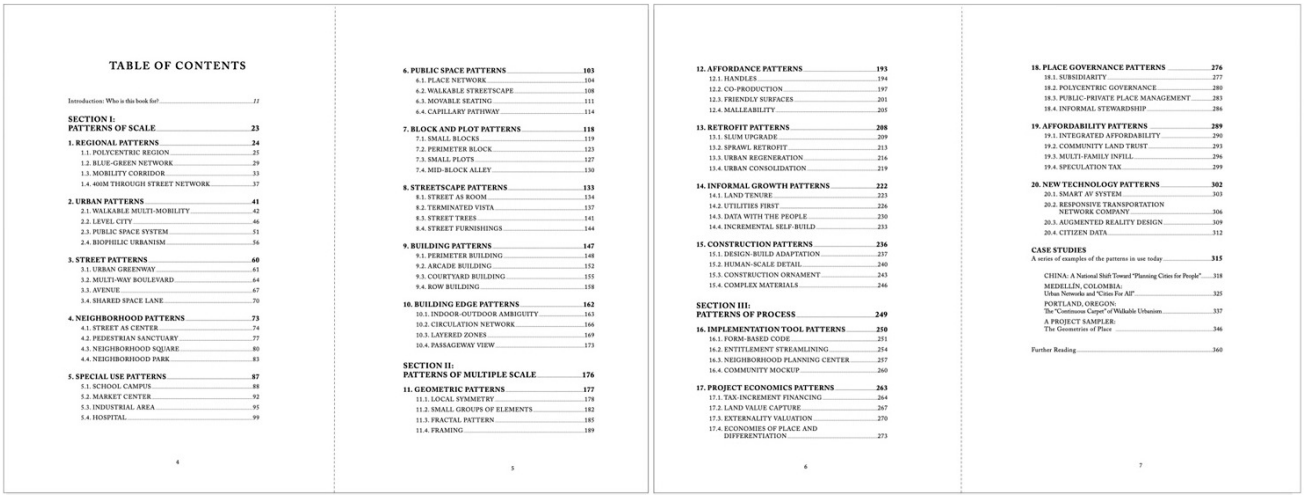

Figure 4. The table of contents of *A New Pattern Language for Growing Regions,* showing the many different kinds of new patterns. Source: Mehaffy et al. (2020).

8. Conclusion

The aim of *A New Pattern Language for Growing Regions* was not to provide an exhaustive collection of patterns, but to break open the restrictions and show what is possible, offering "proof of concept" for many different kinds of patterns (geometric, financial, process, etc). All of these patterns, along with the original 253, as well as others developed in custom contexts, are now being used in a number of consulting projects internationally, with encouraging results. They are indeed serving to bridge the gap to implementation, and operationalizing a "web way of thinking" (and acting) that addresses our profound contemporary challenges. This reported project is only one of many projects that a number of collaborators are developing. It does suggest, however, that Alexander's isolation within the built environment professions may be coming to an end, as the methods so successful in other fields—and among some in the built environment, like the New Urbanists—begin to bear fruit.

In this context, it is important to close by noting a historic event, and its relation to this work. In December 2016, all 193 member states of the United Nations adopted by acclamation the New Urban Agenda, the outcome document of the Habitat III conference in October of that year. That document contains many of the elements that are under discussion in this paper: addressing rapid urbanization, finding more joined-up approaches, using new economic and process tools, and new technologies (including open data and peer-to-peer sharing). The document's focus on public space networks is notable, as is the inclusion of other elements covered in *A New Pattern Language for Growing Regions.* That the book emerged in part from a five-year collaboration with UN-Habitat is evidence of the growing valuation of Alexander's potential contributions to our challenges.

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Conflict of Interests

The author declares no conflict of interests.

References

Alexander, C. (2003). *The nature of order: An essay on the art of building and the nature of the universe, Book 1.* Center for Environmental Structure.

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A pattern language: Towns, buildings, construction*. Oxford University Press.

Alexander, C., Neis, H. J., & Alexander, M. M. (2012). *The battle for the life and beauty of the Earth: A struggle between two world-systems*. Oxford University Press.

Batty, M., & Marshall, S. (2017). Thinking organic, acting civic: The paradox of planning for cities in evolution. *Landscape and Urban Planning*, *166*, 4–14.

Bhat, R. (2014). Understanding complexity through pattern languages in biological and man-made architectures. *ArchNet-IJAR*, *8*(2), 8–19.

Cunningham, W. (2011). *History of patterns*. c2. https://wiki.c2.com/?HistoryOfPatterns

Cunningham, W., & Mehaffy, M. W. (2013). Wiki as pattern language. In *PLoP '13: Proceedings of the 20th Conference on Pattern Languages of Programs* (Article 23). The Hillside Group.

Dovey, K. (1990). The pattern language and its enemies. *Design Studies*, *11*(1), 3–9.

Duany, A. (2004). *A conversation with Andrés Duany (Interview by M. Mehaffy)*. Katarxis 3. http://katarxis3.com/Duany.htm

Jacobs, J. (1961). *The death and life of great American cities*. Random House.

Jacobs, J. (2000). *The nature of economies*. Vintage Books.

Jones, B., & Wong, Y. (2008). Virtual and physical: Architect Christopher Alexander on living spaces. In *VALA: Libraries, Technology and the Future 2008 Conference* (pp. 1–10). VALA.

Mehaffy, M. W. (2007). Notes on the genesis of wholes: Christopher Alexander and his continuing influence. *Urban Design International*, *12*(1), 41–49.

Mehaffy, M. W. (2019). Assessing Alexander's later contributions to a science of cities. *Urban Science*, *3*(2), 59.

Mehaffy, M. W., Kryazheva, Y., Rudd, A., Salingaros, N., & Gren, A. (2020). *A new pattern language for growing regions: Places, networks, processes*. Sustasis Press.

Mehaffy, M. W., & Salingaros, N. A. (2021). Symmetry in architecture: Toward an overdue reassessment. *Symmetry: Culture and Science*, *32*(3), 311–343.

Meszaros, G., & Doble, J. (1998). A pattern language for pattern writing. In R. Martin, D. Riehle, & F. Buschmann (Eds.), *Pattern languages of program design 3* (pp. 529–574). Addison-Wesley Publishing.

Miller, L. (2003, July 27). Pattern recognition. *The New York Times*. https://www.nytimes.com/2003/07/27/books/the-last-word-pattern-recognition.html

Newman, S. A., & Bhat, R. (2009). Dynamical patterning modules: A "pattern language" for development and evolution of multicellular form. *International Journal of Developmental Biology*, *53*(5/6), 693–705.

Protzen, J. P. (1978). The poverty of the pattern language. *Design Methods and Theories*, *12*(3/4), 191–194.

Sustasis Collaborative. (2021, December 21). *Christopher Alexander: Life in buildings (Full)* [Video]. YouTube. https://www.youtube.com/watch?v=oKO3vYjZbcs&t=663s

Wania, C. E. (2015). Investigating an author's influ-

ence using citation analyses: Christopher Alexander (1964–2014). *Proceedings of the Association for Information Science and Technology*, *52*(1), 1–10.
Wikipedia. (2023a). *Pattern language*. https://en.wikipedia.org/wiki/Pattern_language
Wikipedia. (2023b). *Design pattern*. https://en.wikipedia.org/wiki/Design_pattern
Wikipedia. (2023c). *GPT-3*. https://en.wikipedia.org/wiki/GPT-3

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Article

A Quanti-Qualitative Approach to Alexander's Harmony-Seeking Computations

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Abstract
Harmony-seeking computations, as proposed by Christopher Alexander, offer a way to tackle complexity. Smart, free agents, facing uncertainty, look for order in a context powered by fifteen attractors, or patterns. Harmony-seeking would then be a relatively guided path across those idealized patterns, towards wholeness and beauty. However, individuals acting to change the city must combine circumstances imposed by external and inner urban forces with personal interpretations of one or more of those patterns that could change all the time. Moreover, each action is intertwined with others, in an unpredictable outcome. This article explores the possibility of bringing together urban inner and outer forces and ingenious individuals' actions of city change by hypothesizing: (a) wholeness as a structural attribute defined as spatial centrality; (b) beauty as meaning attached to places, evolving either from historic accumulation or individual assignment; (c) order as every meaningful approximation between them; (d) a disaggregated description of the urban organism, based on multi-layered graphs, in which would be possible to record both morphological and territorial characteristics (form, transport, infrastructure) and semantic attributes (land uses, public image, remote associations, symbolic relationships); and (e) a set of spatial differentiation measures, mostly based on centrality, potentially able to depict wholeness (by measuring the effect of each component on all others) and beauty (by measuring urban robustness derived from any selected set of components). A multilayer graph-based approach to spatial differentiation algorithms provides a framework for the description, analysis, and performance evaluation of every component, as well as the whole system, both through quantitative and qualitative representation.

Keywords
graph representation; harmony-seeking; multilayer networks; spatial differentiation; urban planning and design; wholeness

Issue
This article is part of the issue "Assessing the Complex Contributions of Christopher Alexander" edited by Michael W. Mehaffy (Sustasis Foundation) and Tigran Haas (KTH Royal Institute of Technology).

1. Introduction

Harmony-seeking (HS) computations is where Alexander (2009) takes on complexity, in his own terms: (a) there is order in nature (as well as in artificial organisms such as buildings and cities); (b) order is expressed by wholeness, that is, by an intensely intertwined system in which nothing is superfluous and everything is related to everything else in a meaningful way; (c) there is a sense of order, that is, wholeness operates as an attractor to which new parts and relationships tend to; and (d) wholeness can be broken down into particular properties, making the presence and intensity of each one in an organism result in more or less order. This is not essentially different from his previous theories, particularly from pattern language (Alexander et al., 1977), which too proposes immanent qualities to which objects and parts of objects should tend, except for here in HS things are much more

far-reaching, in the sense that the focus is not on isolated objects but nature in general, that is, large natural as well as artificial systems.

Alexander's everlasting search for patterns (Alexander, 2002, 2009) acquires an expanded meaning, involving urban/architectural forms of operators (very many of them) trying to simultaneously understand existing underlying patterns in existing organisms, and acting towards generating their own order within such complex, uncontrolled environment—then, opposed to the Oregon experiment, where the whole group of agents is known and present at all interactions. Patterns would work like attractors, harmonious states to which forms should converge and, as in artificial systems forms do not evolve by themselves, human agents would seek for. However, patterns neither are unique nor individual's paths toward them are free from interferences, misunderstandings, or second thoughts, nevertheless, agents are many, independent, not present at all interactions, and unknown to each other. In this sense, an HS behaviour theory that does not consider human relative free will, learning skills and, above all, a context of thousands of independent and simultaneous actions interfering with each other, leading to unexpected results is missing something.

Our understanding, to this moment, is that:

1. There is an unresolved inconsistency between two important components of the theory, one dealing with patterns, taken as immanent qualities of form, and the other dealing with HS itself, the latter suggesting some sort of reasoning. In natural organisms, HS is, in fact, a passive process of form production led by cosmic forces, volcanic activity, tectonic plaques' movement, gravity, Brownian interaction, cell partition, and so on. In artificial organisms HS involves thinking, comparing, expecting, learning, mistaking, and evaluating, all of that practised by a great number of operators supposedly cooperating with each other (although not all with all) over space and time.

2. There is also an unresolved inconsistency between the very concept of wholeness, a sort of synthetic quality, obtained through a sufficient presence of virtuous patterns, and the HS process itself. Conscious actions of HS carried out by a specific operator could not only undermine similar actions taken by other operators on the same organism, destroying their carefully crafted patterns, but also failing to achieve its own objective by being undermined by others.

3. There is a lack of definition about what the actual 15 properties of wholeness are, as well as a complete lack of relationship between them and the HS process. Alexander believes that these properties (levels of scale, strong centres, boundaries, alternating repetition, positive space, good shape, local symmetries, deep interlock and ambiguity, contrast, gradients, roughness, echoes, the void, simplicity and inner calm, and not-separateness) are crucial in making the wholeness of a system. However, Seamon (2016, p. 61) argues that the 15 properties "may cast an incomplete understanding when one attempts to apply them to the larger-scale environment," mainly because of the largely localist nature of most of them (e.g., local symmetries, good shape, and contrast). According to Seamon, the global scale is largely unaddressed by the properties, although wholeness is claimed to be a global character of configurations. The comprehensive character of Alexander's concepts, which deals with all scales, from rooms and buildings to neighbourhoods and whole cities, hampers their clear understanding. While the 15 properties can be useful to analyse simple artefacts like architectural facades, as suggested by Salingaros (1997), they may not be adequate for analysing large and complex artefacts such as cities, given the multidimensional and wicked nature of planning and urban design.

There is no intention here to fill the gaps and link the dots between Alexander's high theories, however, we could not avoid thinking about what he came up with, and, following his advice, try to explore alternative approaches to the problem. We start with the relation between properties (patterns) and values (immanent qualities), which has been indeed discussed before (Alexander & Poyner, 1984; March, 1976; Rittel & Webber, 1973). The latter authors did make the case for the wicked nature of the urban realm, a planning landscape full of ill-defined problems, ambiguous goals and objectives, uncertainty, and unclear alternatives, suggesting a fragmented framework for pattern and value recognition. March (1976) goes in the same direction, arguing the immanent qualities and defending that values are fundamentally social, or socioeconomic, something that can change according to different circumstances, people involved, resources available, priorities, etc. Such vision seems more compatible with the idea of a complex organism being built over time by many agents acting independently from each other. Each individual HS action can be contradicted or undermined by others right on the same spot and at the same time. In this sense, everybody is looking for something (beauty, wholeness) but hardly getting exactly what they envisioned.

Alexander himself, together with Poyner, in their article "The Atoms of Environmental Structure," seems to offer a view over the conflicting nature of environment evolution. They say that:

> The environment requires a specific geometry only to resolve a conflict between two tendencies [tendencies is the word they use to express "needs"], and once a conflict between two tendencies is clearly stated, it would be possible to define the geometrical relation required to prevent the conflict. (Alexander & Poyner, 1984, p. 124)

Additionally, "the environment needs no geometrical organization beyond that which it gets from combination or relations so defined" (Alexander & Poyner, 1984, p. 124). In our own words, this is understood as, first, a conflict in the process, second, conflicts are prompted by two (or many) agents acting simultaneously on the same spot, generating conflict, third, agents act according to each own needs (meaning values) and fourth, urban form emerges from a proper articulation between two (or many) needs.

In order to progress, we have derived some assumptions, which follow:

1. Wholeness can be represented by centrality, which is a well-known property of urban systems and can be measured in different ways. Centrality, perhaps, is not enough to encompass Alexander's concept of wholeness, although it is certainly as close as one can get to it in qualitative and quantitative terms.

2. Wholeness properties are taken as needs, or tendencies, i.e., sociotechnical components of a city that are represented by physical devices as well as socioeconomic values and can develop an individual's centrality effects, as well as act in combinatorial ways to generate complex centralities.

3. Centrality descriptions are manifest in terms of configurations rather than geometries so that different scales of urban can be explored. Configurations are meant to be relations between two tendencies that can prevent conflict, not excluding eventual geometrical derivations.

Relying on the above assumptions, this article aims to propose a graph-based approach as an alternative to operationalize the HS process. The scale addressed is the neighbourhood or the whole city scale, namely the urban planning/design scale.

In the next section, we detail the framework suggested to describe, analyse, and evaluate each component of the urban spatial system in relation to the others. We explain the descriptive system adopted and the spatial differentiation measures used to compose the proposed framework. Then, we present some exploratory studies, which illustrate how the suggested approach could work in an empirical context. Finally, we discuss the main drawbacks, challenges, and potential for future development.

2. Proposed Methodological Framework

An outstanding aspect of Alexander's trajectory is the focus on the design as a question of the relationship between parts and wholes (Mehaffy, 2019; Seamon, 2016). The 15 properties were his last attempt to identify the precise mathematical structure of that relationship, in the sense that the properties are structural features which describe 15 kinds of relationships among centres. Centres are the primary entities of which wholeness structure is composed and can be a wall, a building, an open space, or an entire city. Indeed, Alexander could not find a mathematical language to represent this, so the key step in this debate is to define how to describe urban components and their relationship to each other and the whole.

In that regard, Alexander's ideas (2002, 2009) are very suggestive of a network approach, as already have been explored by some authors (Jiang, 2015, 2016). Here we propose a step further: a multilayer network approach (Aleta & Moreno, 2019; Kivelä et al., 2014; Nicosia et al., 2013). Bearing in mind the notion of centres (Alexander, 2002) as entities that represent some bit of geometry/space we attempt to schematize it into a graph language and describe their relationships by graph-based measures, like centrality measures.

Graph-based approaches are widely used in urban studies and provide formal representation and a mathematically manageable language to handle the urban components. There are several street network models within graph-based urban studies, from axial lines to road intersections (Marshall et al., 2018), but most of them focus on the representation solely of the street network, as a simple graph, while other components of the urban system such as built forms, land use, transport infrastructure and symbolic relationship receive less attention.

Some authors (Aleta & Moreno, 2019; Kivelä et al., 2014) suggest that simple graphs can be an obstacle to the representation of some phenomena because they focus on one type of relationship at a time. Nicosia et al. (2013) argue that a complex network is rarely isolated, and often some of its nodes could be part of several graphs at the same time. Thus, there is a growing interest among network scientists in a perspective of multilayer graphs, which tends to be a more realistic representation of complex systems, when considering multiple types of elements and relationships (Kivelä et al., 2014; Nicosia et al., 2013). Such a perspective is especially useful to handle urban systems since a city can be thought of as a large system composed of subsystems, which, in turn, are also composed of subsystems (Johnson, 2012). This refers to the vision presented, decades ago, by Alexander (2015) in "A City Is Not a Tree" (originally published in 1965) which emphasizes the overlapping subsystems observed in cities. In that sense, an approach based on multilayer graphs, in which vertices and edges represent elements and relationships of various types, opens the possibility of operationalizing the representation of the different networks and structures that overlap in the city.

Some authors have already explored a multilayered graph perspective to handle multimodal networks of transport (Gil, 2014) while others have explored some way of including built forms or land use in graph-based representations (Krafta, 1994, 1996; Krüger, 1979; Sevtsuk & Mekonnen, 2012) and cognitive structure

(Faria, 2010; Faria & Krafta, 2003, 2013). But there is still no unified framework to represent multiple kinds of urban features. Thus, the main advantage of the descriptive system suggested here is to provide a disaggregated description of the urban organism embracing several kinds of urban components, both qualitative and quantitative. Such a descriptive system can tackle multiple dimensions of urban design, such as physical attributes, activities, and conceptions (Montgomery, 1998).

The next sections detail the descriptive system and the spatial differentiation measures adopted in this article.

2.1. Description of the Urban Organism

We propose a descriptive system based on two key ideas: (a) Alexander centres as the nodes of a graph; and (b) the urban spatial system as a multi-layered graph. The first step for developing such an approach is to define what are the nodes (vertices) and the links (edges) of each layer in the graph. Then it must be defined how each layer becomes part of the graph, that is, which elements can be represented as vertices and what types of connections must be considered. This also involves thinking about how different layers interact with each other.

A general scheme of the urban system can be seen in Figure 1, with its systems and subsystems categorized into three groups: urban spatial structure, functional structure, and cognitive structure. The urban spatial or morphological structure refers to the physical–spatial dimension, encompassing elements such as public spaces, built forms and infrastructure, each of which consists of its own subsystems. The functional structure, characterized by the different networks of actors—individuals, groups, and institutions—concerns the socioeconomic dimension of the urban spatial system. It comprises a system of interactions, which is strongly influenced by elements geographically located and distributed in the urban space, such as land use, activities, densities, and transportation facilities. Lastly, the cognitive structure, which refers to the mental representation of the environment, consists of various elements that individuals or communities utilize to organize their mental image into meaningful information units.

A multidimensional framework was designed for this study, including specific representation strategies for each type of urban element, as shown in Table 1. Representation strategies refer to the rules or mechanisms for constructing the graph and can vary according to the adopted perspective. For instance, built forms can be viewed as individual objects represented by nodes added to the graph, or from a functional perspective where other representation strategies can be employed, such as adding land use information and weights to the vertices. The representation of the street network as a graph already has a vast literature (Marshall et al., 2018). Other elements, however, lack a greater definition of how to describe them through graphs. Therefore, the strategies outlined here help provide a unified framework for multi-layer graph representation.

For the functional dimension weighted graphs, directed graphs, and remote connections are the main strategies suggested. Weighted graphs mean assigning attributes to the nodes that give some loading effect to the graph so that it no longer deals only with spatial configuration. Such attributes can refer to urban densities or land value, for example, which are usually unevenly distributed in the urban system. It is also possible to use directed graphs, in other words, to specify pairs of complementary activities, such as supply and demand or origin and destination so that functional dependency relationships between pairs of specific nodes are characterized. Such representation strategy enables running specific graph analysis considering only selected pairs

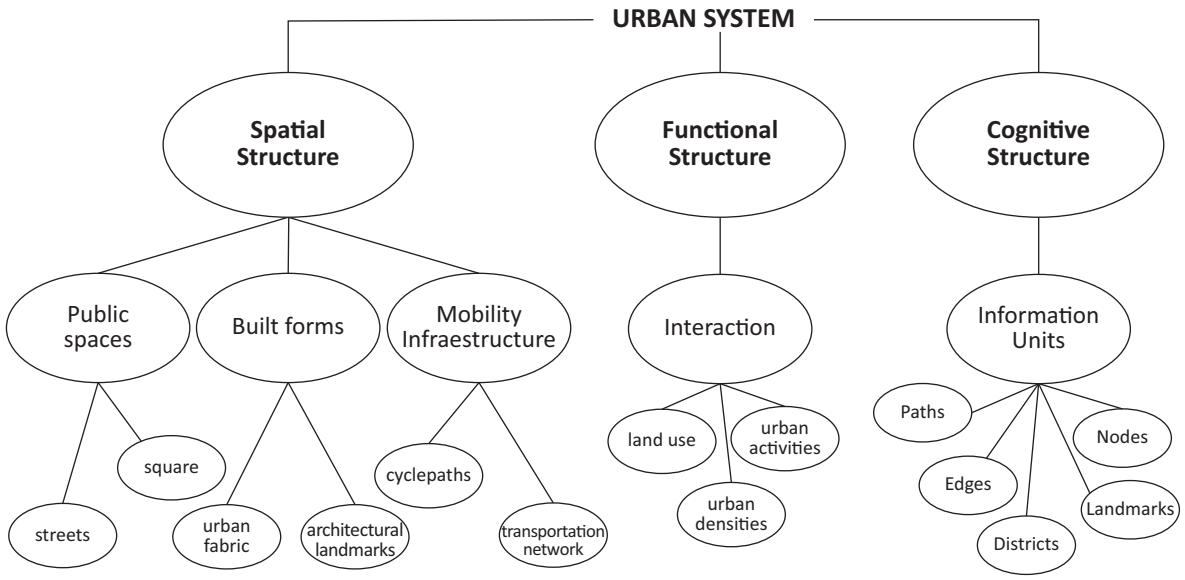

Figure 1. Examples of elements that comprise the urban system's representation.

Table 1. A multidimensional framework for multi-layer graph representation.

	Urban elements	Representation strategies
SPATIAL/MORPHOLOGICAL DIMENSION	Public spaces, street network; built forms; building typologies; parcels, mobility infrastructure	(a) Simple graphs (b) Multilayered graphs (c) Use of impedance values on edges
FUNCTIONAL DIMENSION	Land use; urban activities; urban densities; transport	(a) Weighted graphs (b) Directed graphs between complementary pairs of activities (c) Remote connections between elements
COGNITIVE DIMENSION	Public image; symbolic relationships	(a) Aggregation of elements (b) Distinction of elements (c) Remote connections between elements with some cognitive or symbolic relationship

of nodes and not the "all-to-all" analysis (e.g., Krafta, 1996), as commonly used in the spatial configurational analysis. Using remote connections, which means not being by physical adjacency, is another strategy for representing functional aspects of cities, such as transportation. Remote connections between public transport stop, for example, can be characterized by edges that apply a shortcut effect to the graph (e.g., Gil, 2014). It can also be used to directly associate urban activities connections.

For the cognitive dimension, the representation must schematize the mental representations of the environment. Mental representation concerns the cognitive structure that each person or community has on the environment, in other words, it consists of environmental information cognitively structured in the human mind (Faria & Krafta, 2003). This type of description is practically unexplored as graph-based models, except for Faria and Krafta (2003, 2013) and Faria (2010). According to these authors, there are two main criteria used by individuals in the process of identifying environmental elements, such as Lynch's five elements. The first is information aggregation, which is detecting continuities in the environment to define useful grouping of information, such as districts and paths. The second is information distinction or segregation, which means recognizing "significantly different or strategically located information, in order to create environmental elements for orientation and reference, such as nodes and landmarks" (Faria & Krafta, 2003, p. 5). Based on these mechanisms, it is possible to define strategies to represent the information units, such as (a) aggregation of the vertices that compose it into a single vertex, (b) multiple connections between the vertices that make up the same information unit, and (c) insertion of a new vertex to represent a distinguishable element. Besides being selected or grouped, environmental elements tend to have their relationship altered and distance distorted in the process of environmental cognition, so using edges that characterize remote connections between elements with some symbolic relationship can also be a valuable representation strategy.

Figure 2 provides some examples of how each layer becomes part of the graph. Street networks, when taken from a purely spatial perspective, can be represented by simple graphs, and there is a plurality of approaches to network modelling (Marshall et al., 2018). In this article, we adopt a base graph representation where street segments are the vertices, and the junctions are the edges (Figure 2a). Marshall et al. (2018) refer to this as the "street-segment graph." This representation enables the description of not only the linear elements of the street network but any element of the urban system, regardless of its geometry. As a result, it is possible to encompass all the heterogeneity of the urban environment. Such disaggregated representation allows not only inserting new layers of elements more easily but also making flexible the inclusion of edges that correspond to different types of relations, without necessarily being by physical adjacency.

Several layers can be added to the base graph, as shown in Figure 2. This way, two or more layers can be combined in a unified representation scheme, always having the street network as the base graph. In the present study, parks and squares are represented as nodes connected to the adjacent streets (Figure 2b). Each route of public transportation is represented as a vertex, which does not physically exist, but represents the abstract idea of a public transport route. Such representation assumes that this route can take people directly to any stop point (Figure 2c). Residential use is assigned to the nodes by disaggregation of information from census data, while non-residential activities such as urban facilities, retail and urban equipment are assigned to the vertex corresponding to the adjacent street (Figure 2d). Information units of environmental cognition are represented by vertices connected to corresponding adjacent streets (Figure 2e). It is important to emphasize the possibilities of representation are not limited to these layers or these criteria.

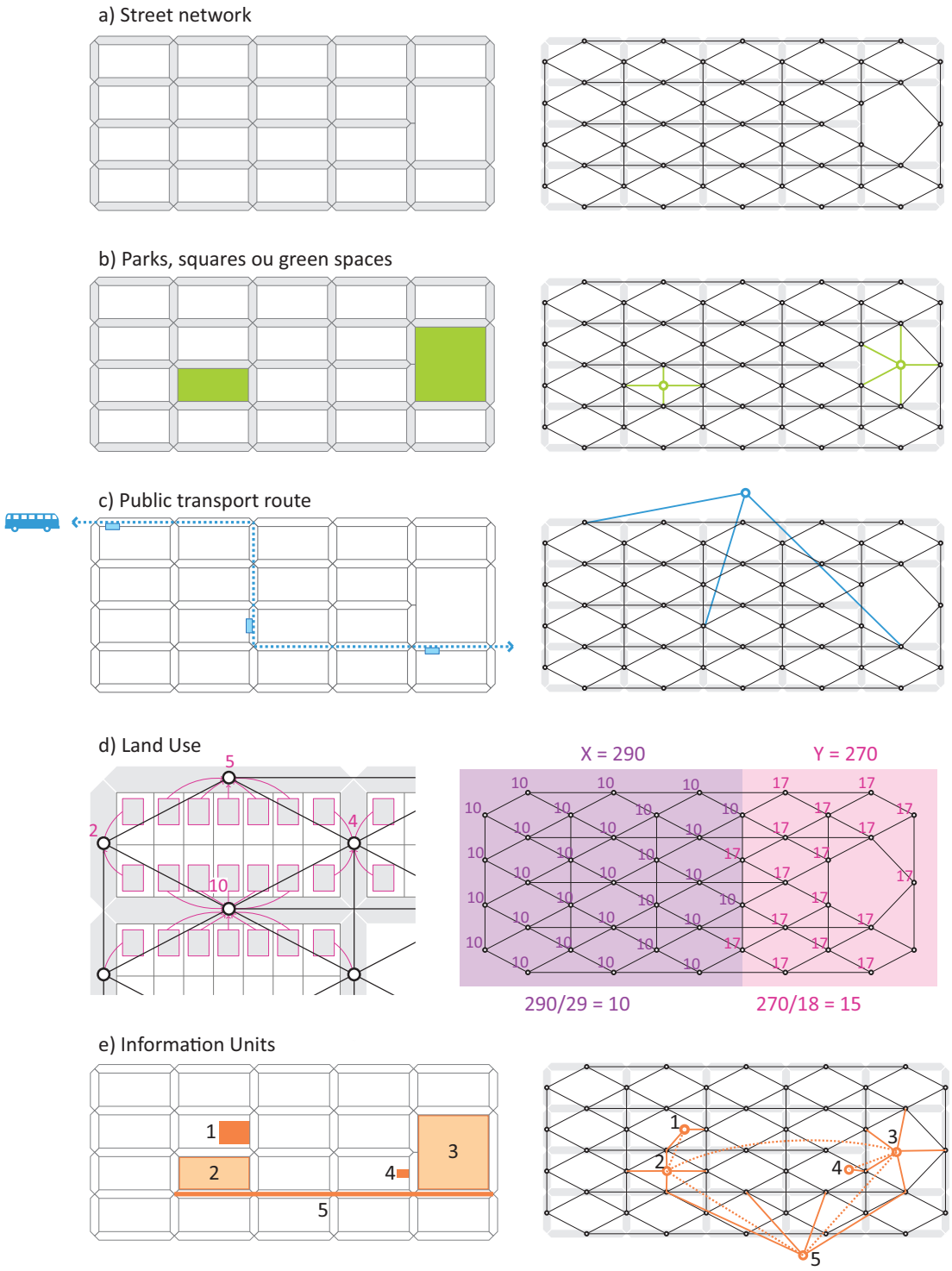

Figure 2. Examples of graph representation for each kind of urban component.

2.2. Spatial Differentiation Measures and Urban Properties

After outlining a representational framework, it is necessary to define methods of spatial differentiation for the graph's elements. Here we define a set of spatial differentiation measures proper to identify hierarchical relationships between entities, in other words, to describe the degree of wholeness, by measuring the effect of each component on all others. There are several graph-based algorithms proposed in the literature to depict network properties, firstly applied to social networks (Freeman, 1977) and afterwards to spatial networks (Crucitti et al., 2006; Hillier & Hanson, 1984; Krafta, 1994, 1996; Sevtsuk, 2010).

Graph-based measures capture the global characteristics of the configuration and allow for hierarchising the parts of the system, thus being useful to describe

wholeness. Besides, network properties are mathematically manageable and can be related to urban properties, being useful to planning and urban design since several dimensions of interest in urban design are included.

According to Crucitti et al. (2006), a spatial analysis grounded on a set of different centrality measures rather than a single one increases the ability to characterize the city structure. For urban design purposes and aiming at a more holistic understanding, it seems logical to use a set of measures which highlight multiple kinds of hierarchies of the urban system. Combining different graph-based measures with different graph representations can lead to a set of several schemes to depict spatial differentiation, that can be associated with urban properties, like urban intensity (Krafta, 1994; Sevtsuk, 2010) or natural movement (Hillier et al., 1993).

Since the layers are independent of each other, many combinations are possible, always keeping the base layer of street networks which articulates the others. Through the insertion of different representation layers in the graph and attributes, it can reveal several urban properties, many of which have already been explored in literature. Since the layers are independent of each other, many combinations are possible, always keeping the base layer of street networks which articulates the others. Not necessarily all layers need to be involved in all measurements. Therefore, combining different graph-based measures with different graph representations can lead to a set of several schemes to grasp urban properties. The idea of having multiple representations of attributes and measurements of properties of the urban spatial structure meets the purpose of providing each operator (urban designer) with the possibility of associating properties of the urban spatial system with values and design objectives.

Several studies have found consistent correlations between centrality measures and empirical urban properties such as urban intensity (Krafta, 1994; Sevtsuk, 2010), co-presence patterns (Hillier & Hanson, 1984; Maciel & Zampieri, 2021), vehicle and pedestrian movement patterns (Hillier et al., 1993; Kirkley et al., 2018), land use patterns (Lima et al., 2017; Porta et al., 2009, 2012; Sevtsuk & Kalvo, 2018; Wang et al., 2011), land value patterns (Spinelli & Krafta, 1998), cognitive patterns (Faria, 2010) and stability of the urban structure (Kirkley et al., 2018; Strano et al., 2012), among others. Although still lacking further empirical evidence, the hierarchy captured by centrality measures reveals at least a latent potential of urban phenomena and socioeconomic behaviours. These indicatives, even provisionally, can be used as a proxy of urban properties to decision support in urban design.

In the next section, exploratory studies based on an empirical case are presented to illustrate the use of the proposed model, far from intending to exhaust all the possibilities based on the idea outlined here. The experiments carried out are not intended to validate the proposed model, however, they serve to discuss the potential and difficulties in operationalizing the design process with the procedures provided here, as well as to complement and detail its definition.

3. Experiments

The experiments presented here aim to deepen and complement some methodological aspects that seem particularly pertinent, such as the representation through multilayer graphs and the visualization of the results. Since there is no established method of doing this in the literature, these experiments precisely aim to explore possibilities of representation by examining the effects of the insertion of new layers in the graph. Each representation layer added to the graph produces effects, changing the hierarchy of the results. There are two important questions here: What kind of impacts are produced by inserting new layers, and how can they be visualized? Such explorations are made through an empirical case, the central region of the municipality of Lajeado (Brazil). In general terms, the study comprises a comparison of the insertion of different layers to the simple graph, which represents only the street network. We assume that other layers are always anchored to the street network, which works as a kind of base layer—indispensable—to the others. Then, the effects of the insertion of different layers in the graph are verified: parks and squares, bus lines, land use, and cognitive structure. By effect, we mean changes in the results of the different measures of spatial differentiation so that the elements gain or lose relevance in the ranking.

The tests carried out consist of the following steps: (a) provide descriptions through multilayer graphs; (b) process spatial differentiation measures; and (c) compare, through advanced visualization techniques, the insertion of different layers of representation, one by one, with the simple graph—only of the street network, observing how each layer deforms the results.

The multilayer graphs were constructed from empirical data (Figure 3), adopting the representation strategies outlined in the previous section, such as weighted graphs and remote connections. Closeness centrality and Freeman-Krafta centrality (F-K centrality) were used to analyse the network properties of the graphs, firstly applied to the simple graph, and then to the four multilayer graphs presented in Figure 3.

Closeness centrality (Crucitti et al., 2006; Freeman, 1979) is a distance-based measure since it illustrates the idea of accessibility, showing how close each location is to all other locations. This metric is defined as the inverse of the total distance required by a node to reach all the others.

F-K centrality (Krafta, 1994) is adapted from betweenness centrality (Freeman, 1977, 1979), which is one of the most used in urban network studies. Betweenness centrality measures the capability of a node to be in the path of the others. In other words, the nodes that are most often part of the shortest path between all the

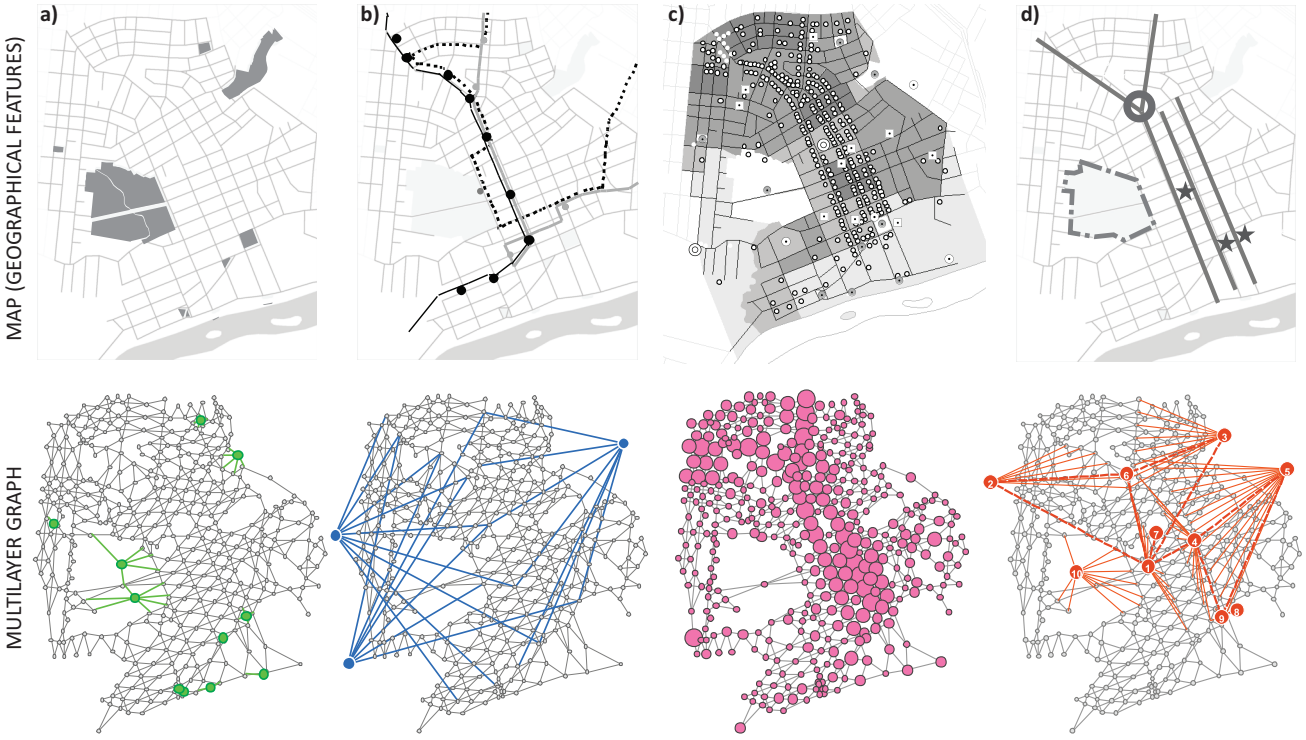

Figure 3. Map description and the corresponding multilayer graph of (a) parks and squares; (b) public transport routes; (c) land use—residential density, retail, and urban equipment; and (d) information units—paths, districts, nodes, and landmarks.

others are the most central in the graph. F-K centrality (Krafta, 1994) adopts the same calculation logic as betweenness centrality; however, it considers the distances between pairs of nodes and can compute node weights. F-K centrality was chosen because it describes more accurately the idea of urban spatial differentiation produced by geographic distances and uneven distribution of built forms or densities. Freeman's original measure computes the same value for all nodes that are in the path, no matter how long the path is, while F-K centrality considers that there is a tension between each pair of nodes, and this tension is dissipated along the path so that in pairs with more distant nodes the tension is diluted along the path. Since betweenness centrality was developed to analyse social networks, which are non-spatial, it does not consider these geographical and morphological aspects. Therefore, F-K centrality seems to be the most interesting for the analysis of urban networks.

All the measurements cited above analyse pairs of entities connected by a shortest path, that is, they are separated by a certain distance. In this study, distances are measured in the number of topological steps, since we use remote connections which are impossible to measure in metric distances.

To facilitate visualization and comparison, the results obtained for the graph nodes were converted into a raster surface using an interpolation technique. and the resulting surface was then normalized to a range from 0 to, as shown in Figure 4. One advantage of this visualization method, compared to visualization by discrete units directly on the graph nodes (as shown in Figure 4a) is the possibility to compare spatial patterns obtained from graphs of different sizes. These colour images clearly show hierarchical spatial patterns, revealing where the peaks of higher values are. They also show how the decay of these values occurs and how the values decay and distribute to the regions with lower values. With such images, it is easy to understand the role of each node in the global structure or, in other words, to understand its hierarchical position.

In this work, only visual comparisons were made. Thus, difference maps obtained through map algebra were also produced to facilitate the analysis and to help in comparing two raster surfaces (Figure 5). Difference maps were used to compare the results of each multilayer graph with the results of the simple graph, as they highlight areas with increased values (represented by warm colours) or decreased values (represented by cold colours) in comparison to the simple graph.

4. Results

Finally, Figure 5 summarizes the results obtained for closeness and F-K centrality measures in different combinations of layers in the graph in a raster surface ranging from 0 to 1 and its corresponding difference map. Through the difference maps, it is easy to see how the values obtained for the centrality measures change their hierarchy, with some regions showing an increase in

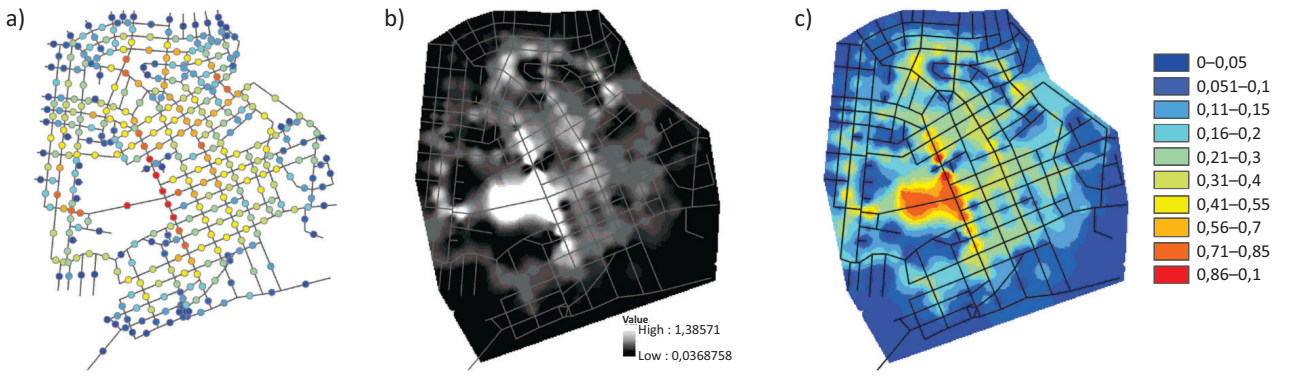

Figure 4. Geoprocessing process to obtain better visualization of results: (a) absolute results obtained for each node after running some centrality measure, (b) raster surface obtained by interpolation (inverse distance weighted technique) of the results from each node, and (c) normalized results from 0 to 1 range.

values and others showing a decrease. We can observe spatial pattern differences among the different centrality measures used and among the different representation layers.

Closeness centrality tends to concentrate higher values in the most central region of the graph, decreasing towards the edges, as it is a distance-based measure. Thus, representing only the street network does not offer great analytical potential. However, the insertion of other layers offers new perspectives for the use of this measure.

F-K centrality, as expected, presents results with an exponential statistical pattern, distinct from closeness centrality, and with quite distinct spatial patterns. In general, it can be said that it produces higher differences in the results than closeness centrality. Some layers produce more significant changes than others, depending on the representation strategy used. As we can see, the representation strategies that, in some way, generate a "shortcut" effect in the graph are the ones that produce the most significant impact on the results, as is the case of public transport and cognitive representation. Similar results can be found when adding weights to the nodes of the graph. In other words, such a representation strategy generates a "loading" effect, which deforms the hierarchy towards spaces with greater weights. Such results could be related to urban intensity. It is worth noting that closeness centrality does not consider the weights of the nodes so when we add land use weights to the graph, the result is the same as for the street network graph.

On the other hand, some representation strategies produce results with little difference compared to the simple graph, like just adding nodes in the graph. In the case of squares and parks, for example, the impact on the results depends on the position in the graph—more central or more peripheral—and the number of connections to the inserted node. In the case of the experiments performed here, only the biggest park of the study area led to great changes in the hierarchy.

The exploratory studies presented here are a small sample of the possibilities that can be explored through a multilayer network perspective. The same methodology used in the experiments to compare different graphs with different layers can be used in a design context, to compare and evaluate design hypotheses, verifying changes in the urban structure.

5. Discussion

The methodological framework proposed in this article has been designed to handle Alexander's HS computations and it can be thought of as an HS model of urban design. By assuming that design hypotheses contain values that are not always universal, we reject Alexander's vision of intrinsic quality of form grounded in the 15 properties. The harmony sought in a design context depends on the objectives and wills of the different agents. In other words, it varies according to the situation.

HS is reinterpreted here as a search for a design intention accomplishment. Therefore, we propose that the harmony sought in urban design could be given by a set of spatial differentiation measures, i.e., centrality measures that represent desirable urban properties. The disaggregated description of the urban system in the form of multilayer graph nodes could be a possible way to represent Alexander's centres, i.e., the entities of which the wholeness structure is composed. The graph-based approach outlined here and illustrated through exploratory studies provides a framework to deal with the whole and the role of the parts. Thus, it can be one possible way to answer Alexander's claims, at least for large-scale environments, since it enables description, analysis, and performance evaluation of each component, as well as the whole system, both through quantitative and qualitative representation.

The main contribution of the present work is precisely the discussion of Alexander's ideas focused on the scale of planning and urban design. The proposed framework seems to be a reasonable way to operationalize the HS process in a design context since it allows the depiction of various global patterns related to different aspects of urban design.

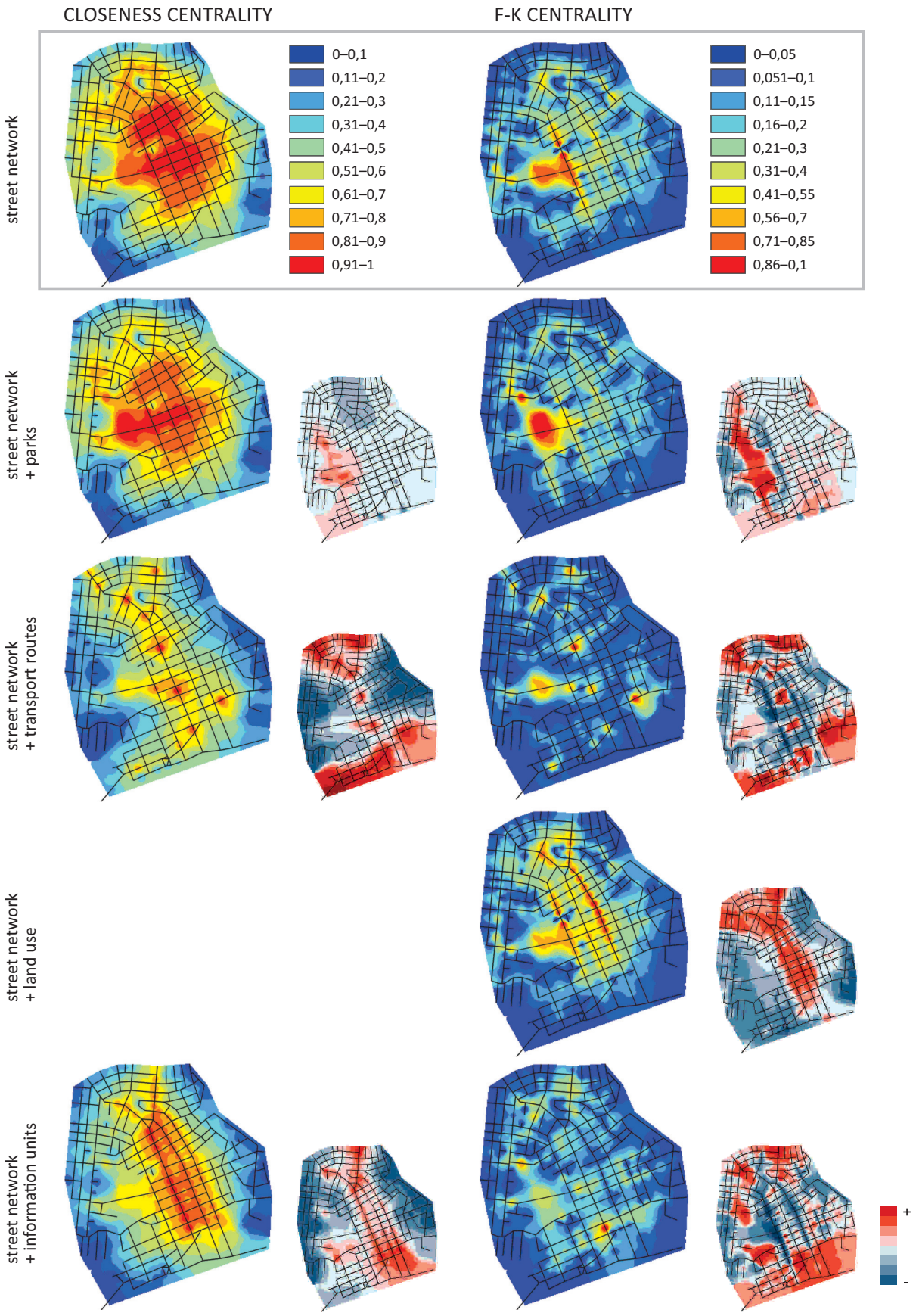

Figure 5. Results for closeness and F-K centrality measures in different combinations of layers in the graph and its corresponding difference map.

Given the number of possible measures that could be used, it would be up to the model operator (urban designer) to choose which variables would best represent the values sought in the project, in other words, the harmony sought in the project. Thus, the proposed model can be calibrated, through the insertion of different representation layers in the graph and attributes, allowing the operator to assign a relative value to any of its elements so that the concept of harmony fits the intended values and principles.

Mainstream urban configurational models focus on the description and analysis of the public spaces or street network. However, as seen throughout this article, there is still underexplored potential in representing other fundamental elements of urban design, such as built forms, urban infrastructure, cognitive aspects, and many others. The possibilities of representation and measuring are not restricted to those suggested here. In this sense, this work provides a starting point for further studies. Other centrality measures could be used, as well as other representation strategies could be explored. For instance, transport routes could be represented in different ways, like the representation used by Gil (2014). The representation of the cognitive structure is particularly challenging, having in mind the high degree of uncertainty regarding this topic and the reduced number of works that use graph-based approaches to describe the information units. Thus, the representation of the subjective dimension should be elaborated in future research. For example, different representation criteria could be thought of for the cognitive structure, considering different social groups. Additionally, complementary representation strategies also can be thought such as the definition of radii for processing measurements, and the definition of impedance values for the edges, which favour or disfavour certain paths, such as distance, travel time, road hierarchy, or slopes.

One of the main challenges for using a model with the proposed characteristics is translating requirements that are important to urban design to the possibilities of graph-based analysis results. In other words, more empirical works are needed to verify the correlation between graph-based measures and real phenomena.

A limitation of the proposed approach, based on data and modelling, is the very dynamic character of the city, which means that the simulation of city changes, that is, the design hypothesis, will always be out of step with what the city is at that moment. At the very moment that a project proposal is being developed and discussed, several aspects of reality are already changing, given that the process of urban changes is continuous.

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Conflict of Interests

The authors declare no conflict of interests.

References

Aleta, A., & Moreno, Y. (2019). Multilayer networks in a nutshell. *Annual Review of Condensed Matter Physics*, *10*(1), 45–62. https://doi.org/10.1146/annurev-conmatphys-031218-013259

Alexander, C. (2002). *The nature of order: An essay on the art of building and the nature of the universe* (Book one: The phenomenon of life). Center for Environmental Structure.

Alexander, C. (2009). *Harmony-seeking computations: A science of non-classical dynamics based on the progressive evolution of the larger whole*. Unpublished manuscript. https://www.livingneighborhoods.org/library/harmony-seeking-computations-v29.pdf

Alexander, C. (2015). A city is not a tree. In M. Mehaffy (Ed.), A *city is not a tree: 50th anniversary edition*. Sustasis Press.

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A pattern language: Towns, buildings, construction*. Oxford University Press.

Alexander, C., & Poyner, B. (1984). The atoms of environmental structure. In N. Cross (Ed.), *Developments in design methodology* (pp. 123–133). John Wiley & Sons.

Crucitti, P., Latora, V., & Porta, S. (2006). Centrality in networks of urban streets. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, *16*(1), Article 015113. https://doi.org/10.1063/1.2150162

Faria, A. N., & Krafta, R. (2013). Cognitive structure: Urban symbolic order and landmark detection. In N. Palma (Ed.), *Sistemas urbanos e regionais* [Urban and regional systems] (pp. 27–35). EDUNISC. https://repositorio.unisc.br/jspui/handle/11624/1810

Faria, A. P. (2010). *Análise configuracional da forma urbana e sua estrutura cognitiva* [Configurational analysis of urban form and its cognitive structure] [Unpublished doctoral dissertation]. Universidade Federal do Rio Grande do Sul. https://lume.ufrgs.br/handle/10183/29133

Faria, A. P., & Krafta, R. (2003, June 17–19). *Representing urban cognitive structure through spatial differentiation* [Paper presentation]. 4th International Space Syntax Symposium, London, UK. https://www.spacesyntax.net/symposia/4th-international-space-syntax-symposium

Freeman, L. (1979). Centrality in social networks conceptual clarification. *Social Networks*, *1*, 215–239.

Freeman, L. C. (1977). A set of measures of centrality based on betweenness. *Sociometry*, *40*(1), 35–41. https://doi.org/10.2307/3033543

Gil, J. (2014). Analyzing the configuration of multimodal urban networks. *Geographical Analysis*, *46*(4), 368–391.

Hillier, B., & Hanson, J. (1984). *The social logic of space*. Cambridge University Press.

Hillier, B., Penn, A., Hanson, J., Grajewski, T., & Xu, J. (1993). Natural movement: Or, configuration and attraction in urban pedestrian movement. *Environment and Planning B: Planning and Design*, *20*(1), 29–66. https://doi.org/10.1068/b200029

Jiang, B. (2015). Wholeness as a hierarchical graph to capture the nature of space. *Annals of the Association of American Geographers*, *29*(9), 1632–1648.

Jiang, B. (2016). A complex-network perspective on Alexander's wholeness. *Physica A: Statistical Mechanics and Its Applications*, *463*, 475–484.

Johnson, J. (2012). Cities: Systems of systems of systems. In E. Stolk, E. Tan, J. Portugali, & H. Meyer (Eds.), *Complexity theories of cities have come of age: An overview with implications to urban planning and design* (pp. 153–172). Springer.

Kirkley, A., Barbosa, H., Barthelemy, M., & Ghoshal, G. (2018). From the betweenness centrality in street networks to structural invariants in random planar graphs. *Nature Communications*, *9*(1), Article 2501. https://doi.org/10.1038/s41467-018-04978-z

Kivelä, M., Arenas, A., Barthelemy, M., Gleeson, J. P., Moreno, Y., & Porter, M. A. (2014). Multilayer networks. *Journal of Complex Networks*, *2*(3), 203–271. https://doi.org/10.1093/comnet/cnu016

Krafta, R. (1994). Modelling intraurban configurational development. *Environment and Planning B: Planning and Design*, *21*(1), 67–82. https://doi.org/10.1068/b210067

Krafta, R. (1996). Urban convergence: Morphology and attraction. *Environment and Planning B: Planning and Design*, *23*(1), 37–48. https://doi.org/10.1068/b230037

Krüger, M. (1979). An approach to built form connectivity at an urban scale: System description and its representation. *Environment and Planning B: Planning and Design*, *6*(1), 67–88.

Lima, L., Krafta, R., & Ribeiro, B. M. G. (2017). A distância como variável em modelos configuracionais no estudo da distribuição de atividades econômicas urbanas [Distance as a variable of configurational models for understanding the distribution of urban economic activities]. *urbe, Revista Brasileira de Gestão Urbana*, *9*(2), 354–370. https://doi.org/10.1590/2175-3369.009.002.AO14

Maciel, F. B., & Zampieri, F. L. (2021). Co-presence patterns in dispersed residential neighbourhoods of Brazilian medium-sized cities. *Environment and Planning B: Urban Analytics and City Science*, *48*(7), 1943–1954.

March, L. (1976). The logic of design and the question of value. In L. March (Ed.), *The architecture of form* (pp. 1–40). Cambridge University Press.

Marshall, S., Gil, J., Kropf, K., Tomko, M., & Figueiredo, L. (2018). Street network studies: From networks to models and their representations. *Networks and Spatial Economics*, *18*, 735–749. https://doi.org/10.1007/s11067-018-9427-9

Mehaffy, M. W. (2019). Assessing Alexander's later contributions to a science of cities. *Urban Science*, *3*(2), Article 59. https://doi.org/10.3390/urbansci3020059

Montgomery, J. (1998). Making a city: Urbanity, vitality and urban design. *Journal of Urban Design*, *3*(1), 93–116.

Nicosia, V., Bianconi, G., Latora, V., & Barthelemy, M. (2013). Growing multiplex networks. *Physical Review Letters*, *111*, Article 058701. https://doi.org/10.1103/physrevlett.111.058701

Porta, S., Latora, V., Wang, F., Rueda, S., Strano, E., Scellato, S., Cardillo, A., Belli, E., Càrdenas, F., Cormenzana, B., & Latora, L. (2012). Street centrality and the location of economic activities in Barcelona. *Urban Studies*, *49*(7), 1471–1488. https://doi.org/10.1177/0042098011422570

Porta, S., Strano, E., Iacoviello, V., Messora, R., Latora, V., Cardillo, A., Wang, F., & Scellato, S. (2009). Street centrality and densities of retail and services in Bologna, Italy. *Environment and Planning B: Planning and Design*, *36*(3), 450–465. https://doi.org/10.1068/b34098

Rittel, H., & Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, *4*, 155–169.

Salingaros, N. A. (1997). Life and complexity in architecture from a thermodynamic analogy. *Physics Essays*, *10*, 165–173.

Seamon, D. (2016). Christopher Alexander and a phenomenology of wholeness. In K. Pontikis & Y. Rofe (Eds.), *Pursuit of a living architecture: Continuing Christopher Alexander's quest for a humane and sustainable building culture* (pp. 50–66). Common Ground Publishing.

Sevtsuk, A. (2010). *Path and place: A study of urban geometry and retail activity in Cambridge and Somerville, MA* [Unpublished doctoral dissertation]. MIT. https://dspace.mit.edu/handle/1721.1/62034

Sevtsuk, A., & Kalvo, R. (2018). Patronage of urban commercial clusters: A network-based extension of the Huff model for balancing location and size. *Environment and Planning B: Urban Analytics and City Science*, *45*(3), 508–528.

Sevtsuk, A., & Mekonnen, M. (2012). Urban network analysis. *Revue internationale de géomatique*, *22*(2), 287–305.

Spinelli, J., & Krafta, R. (1998). Configuração espacial e distribuição do valor do solo urbano [Spatial configuration and distribution of urban land value]. *Cadernos IPPUR*, *12*(2), 83–104.

Strano, E., Nicosia, V., Latora, V., Porta, S., & Barthélemy, M. (2012). Elementary processes governing the evolution of road networks. *Scientific Reports*, *2*(1), 1–8.

Wang, F., Antipova, A., & Porta, S. (2011). Street centrality and land use intensity in Baton Rouge, Louisiana. *Journal of Transport Geography*, *19*(2), 285–293. https://doi.org/10.1016/j.jtrangeo.2010.01.004

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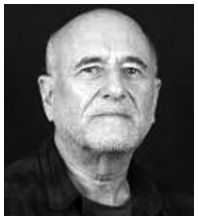

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