

centre. As in natural selection, it is a process that exerts its action in a continuous and prolonged way over time, resulting in an organized pattern.

The scope of this series of discoveries cannot be overstated. Bill Hillier's life's work represents a complete conceptual revolution in the way of approaching architectural space and its relationships with society. He has pushed architectural theory out of a purely speculative stage to that of an objective, logically sound, analytical system: 'a configurational theory of architecture' (Hillier, 1996). Above all, he endowed it with a truly scientific paradigm, quantitatively-led and falsifiable, but whose basic assumptions and predictions have shown to be fundamentally sound through a large body of empirical research.

I consider that the most important thing that Bill has bequeathed us is the possibility of pursuing a truly scientific path, as researchers of architecture and the city. In the same way that Darwin forever transformed the life sciences, Hillier has forever transformed the theory of architecture, providing it with the scientific foundations it lacked. There is a famous phrase by the biologist Theodosius Dobzhansky (1973): 'nothing in biology makes sense except in the light of evolution'. I would like to end by saying that, in my view, nothing in architecture makes sense – except in the light of the configurational theory that Bill Hillier left to us.

## Urban form and climate change planning: on the normative framework for urban design

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The need to connect research and practice in urban planning and urban design has been extensively discussed in the forums of the International Seminar on Urban Form, most recently by Samuels (2019). This requirement is especially relevant when it comes to applying theory to practice on the most urgent issues, such as planning for climate change mitigation and adaptation. However, the implementation of research-based evidence remains slow. As a result, on the one hand our interdisciplinary field generates a growing body of theoretical and

### Note

1. In Bill Hillier's own terms, such rules are the 'syntax for the morphic language of human spatial organization' (Hillier and Hanson, 1984, p. 51). This is the context whence the term 'space syntax' stems, which Bill coined and which was dear to him. I feel, however, that the term has lost part of its original content over time and is today too narrow to cover the whole extent of Bill's overall scientific contribution, hence its absence from this text. I trust that Bill would agree with this personal choice.

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highly-specialized research read by a limited audience. On the other hand, planning and design practitioners tend to rely on precedents in the form of best practice case studies as guidance for their project proposals (for example, a collection in Hanzl and O'Reilly, 2018, 2019). In a limited number of cases (for example, Tötzer *et al.*, 2018; Shrivastava *et al.*, 2019), researchers are invited to contribute their expertise to these projects.

At the same time, in today's circumstances of rapid urbanization combined with the challenges

of a changing climate, practitioners need a clear foundation from which to plan, design and manage future cities, and to educate the next generation in the built environment disciplines. This foundation requires a robust evidence base underpinned by relevant research. Another urgently-needed element is a common framework for the evaluation of projects and their outcomes. While there are manuals that address the governance and strategic aspects of transformations management for climate change adaptation (Barth *et al.*, 2014), they require practical implementation and critical reflection on the results.

Normative criteria on how to design urban forms that take into account climate resilience and the need for climate adaptivity are being developed and elaborated in many locations all over the world. Many draw on the experience of green/sustainable building rating systems such as the Building Research Establishment Environmental Assessment Method (BREEAM, UK); Leadership in Energy and Environmental Design (LEED, USA) and the Green Building Council of Australia's Green Star scheme. These rating systems have increasingly been scaled up to provide guidance at a scale between the building and the city, variously described as 'neighbourhood', 'precinct' or 'community'. Examples include the BREEAM and Green Star Communities tools and LEED for Neighborhood Development. Further, new rating schemes have emerged over the past 5 or 6 years that are specifically focused on the health and wellbeing of the occupants of built form – the WELL Building and Fitwel standards.

Just as building rating systems are built on the theoretical foundation of building physics, their extension to precinct scale (and guidance on climate-responsive urban design more generally) is to a greater or lesser degree grounded in *urban physics*, in particular the relationships between energy, geometry and materiality. There is a clear intersection here with the subject matter of urban morphology as exemplified by the three fundamental components of *form*, *resolution* and *time*, as articulated by Moudon (1997). While not necessarily converging *per se*, research in the fields of urban climatology and urban morphology is certainly drawing on a common set of building blocks (no pun intended). While we may debate how urban morphology should best be integrated into planning and urban design practice, climate change-conscious built environment professionals are (again, to a greater or lesser degree) applying basic urban morphological concepts in their

day-to-day work. Similarly, scientists seeking to focus their understanding of urban climatological phenomena to inform planning and design practice are employing ideas from urban morphology without necessarily being aware of it. Notable examples include the Local Climate Zone (LCZ) model developed by Stewart and Oke (2012) which comprises 17 standard 'regions of uniform surface cover, structure, material, and human activity that span hundreds of meters to several kilometres in horizontal scale' (Stewart and Oke, 2012, p. 1884). Stewart and Oke point out that while the system was designed primarily to support urban heat island research, it 'offers a basic package of urban climate principles for architects, planners, ecologists, and engineers' (2012, p. 1894).

With regard to climate change and local climate hazards, while there are no universal solutions that could be implemented globally, some situations repeat, at least referring to the similarities in climate change directions and their consequences. It is this perspective that informed the development of the LCZ model. In the practice of urban design and planning, we might notice the emulation of certain practices and solutions between various locations, often globally. This practice-led approach arguably dominates the discipline, as can be seen at conferences of urban planning professionals. Research follows practice rather than defines paths for the development of new, and redevelopment of existing urban form (Dhar and Khirfan, 2017). The most common way to explore the topic is to assess various implementation strategies and projects in the quest for the methods of assessment and criteria which might apply to the evaluation of future redevelopment. This kind of methodology is at the heart of the Intergovernmental Panel on Climate Change (IPCC) reports, which reviews research and implementation practices to define recommendations.

To improve the functioning of this methodology and encourage the dissemination and integration of urban morphological thinking with built environment practice, we propose the development of a framework that would enable the collection and comparison of biophysical, built form and land use planning parameters across different locations against the backdrop of their changing climate conditions. If we take into account both the social and economic situation and types of climate risk, a matrix that covers diverse circumstances can be developed. The application of such a framework would enable the exchange of good practices across disciplines. It could also contribute to the

definition of more direct and specific guidance for urban design and planning. Further, a framework which brings together urban form, biophysical parameters and socio-economic considerations could enable researchers in urban morphology, alongside disciplines such as ecology, water management, disaster management and the like, to collaborate and creatively contribute to the development of new strategies around climate change resilience and adaptation.

The most pertinent features addressed as part of the scheme include the typomorphology of transformations of the public realm, the quest for optimal densities (Berghauser Pont and Haupt, 2010) and the share of open space. Further, the role, placement and typology of green infrastructure necessitates a central place in contemporary research frameworks for urban design (Bartesaghi Koc *et al.*, 2017; Marcus *et al.*, 2019). Vegetation is considered to be a principal element of urban ecosystem services. Its city-wide influence goes beyond the reduction of the urban heat island. Not only does the urban forest (defined as ‘the sum of all woody and associated vegetation in and around dense human settlements’ by Miller *et al.*, 2015, p. 4) provide shade and reflect solar radiation, but it also lowers temperature through evapotranspiration and, when well designed, channels cooling breezes while blocking hot winds. At the same time, urban vegetation absorbs air pollutants, increases biodiversity, supports pollinators and contributes to water management. Parks, gardens and street greenery reduce noise levels. Moreover, they offer cultural services: space for physical activities and social life of citizens and help improve mental wellbeing and encourage relaxation (Marselle *et al.*, 2019). There is also a provisioning role in the form of urban agriculture (Russo *et al.*, 2017), and other resources obtained from urban vegetation, such as fibre or medicine components. Not only is green infrastructure useful to humans and positively influence our health (Hartig *et al.*, 2014) but it is critical to urban ecosystem conditions. A further significant field of research and practice addresses the role of ‘blue’ (water) infrastructure and water management, both in circumstances of drought and urban flooding.

Another principal area of research refers to the continuation and creative re-use of traditional construction solutions, known from vernacular architecture and informal settlements. The latter refers not just to built structures, but also infrastructure and more general development patterns. This traditionally recognised theme in urban morphological

studies offers the potential to enrich the catalogue of contemporary construction solutions significantly. This approach could extend and elaborate on examples from traditional built cultures. It might re-introduce the solutions used for centuries and forgotten as an outcome of globalisation and unification of building technology.

All in all, the collection of topics addressed above presents a challenge which could be addressed by researchers in urban morphology in collaboration with other disciplines. Each single case study of climate adaptation planning might contribute to this collection, as each represents a different set of circumstances and dangers. Nevertheless, the resemblances yield the chance of comparisons and learning by experience.

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## Designing for sustainability: retrieving a systemic role for urban form

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Approaching the study of urban form from a sustainability perspective has generated encouraging responses (Maretto, 2018; Sioen *et al.*, 2016). The implications are, however, twofold. On the one hand, the growing number of studies has taken two particular scales of approach – the city and the building. At the city scale there are the 1990s theories about sustainable urban form (Jenks *et al.*, 1996; Rogers, 1997), the formation of new urban movements advocating principles of how cities should be built (Duany and Plater-Zyberk, 1991; Congress for the New Urbanism, 1999) and the arrival of new scientific journals dedicated to the study of urban form, such as *Urban Morphology*. Notwithstanding the lack of consensus about the most preferable urban forms, debate on the efficiency of the urban environment rapidly emerged, echoed in various disciplines: in particular, in fields of study that aimed to explore the metabolic outcome from an environmental or socio-ecological perspective (Fischer-Kowalski, 1997), or through an efficiency perspective, mostly focused on resources and energy (Banister *et al.*, 1997; Thomson and Newman, 2017). The impacts of these on planning and industry were fast and obvious, in particular through the transportation, construction and material sectors. Sustainability, however, would emerge as a convincing argument

for the promotion of new technological applications (for example, new building materials, photovoltaic panels, energy-efficient light bulbs and electric vehicles), as a way to restore and maintain resources and energy necessary to guarantee that patterns of flows could continue operating within the natural system.

However, on the other hand, the acknowledgement of urban form itself as a contributor to sustainability somehow went unnoticed by the wider audience. Design solutions for improved urban form progressed, but were conditioned to arbitrary perceptions of sustainability and taste values. The linking of form and sustainability to how the city works, or should work, has always remained a challenge in the absence of actual evidence of urban performance and further data, contributing to the city being labelled a 'black box' by urban metabolic studies. This is not an isolated opinion. As a teacher of urban projects for architecture students, who are keen to design and create solutions for which urban form considerations are important, I have witnessed their concern about the sustainability appraisal of urban form, in particular at the city scale.

Yet advances made in new forms of data, especially those related to environmental performance, are challenging urban design to go beyond current