

## MEGA MORPHOLOGIES OF 21ST CENTURY LANDSCAPES; THE CHARACTERISTICS OF AN INVERTED-EXTERIOR CITY FORM

Gerhard Bruyns, Associate Professor, The School of Design, The Hong Kong Polytechnic University, Hong Kong.

Darren Nel, Ph.D. Candidate, The School of Design, The Hong Kong Polytechnic University, Hong Kong.

Yixuan Peng, Ph.D. Candidate, The School of Design, The Hong Kong Polytechnic University, Hong Kong.

Christopher D Higgins, Department of Geography, University of Toronto, Canada.

---

### ABSTRACT

*Historically, the science of urban morphology has developed spatial and urban taxonomies to examine the relationships between buildings and the larger territory. In later streams, building-to-territory characteristics were equated to either temporal processes of building aggregate or functional division of plots.*

*In mega-cities of Asia, spatial evidence subverts conventional building-to-space relationships. The production of 'mega-mega' projects, some of which account for the world's seventh largest built complex, amalgamizes building aggregate and street functions, into new definitions. Megacities show evidence of other morphological streams, that include; the emergence of volumetric morphologies, redefining the exact scale of the mega-mega complexes, and a growing tendency which interiorizes external morphological elements as part of the interior project.*

*This paper will question 'how' the use of conventional typemorphological descriptors can remain valid in assessing mega-scale projects. By way of looking at the gaming complexes of Macau SAR, the work will develop a line of critique commencing from the traditional concepts of morphological analysis and its validity in the mega scale context, through material evidence of mega spaces and their eventual inversion of functions and space. Findings will conclude on the formative and spatial characteristics of new spatial types. The need for a hybrid approach in both spatial analysis as well as in its space- to-built-object conceptual positioning points towards new morphological domains - interior morphologies - whilst at the same time, underscoring the shift brought on by conditions of scale as a primary factor in analysis of the mega-region environment.*

---

### BACKGROUND

*Urban morphology is the scientific domain that questions the form and structure of the city. Morphological methods have become useful in defining the spatial characteristics of urban settings in several conceptualizations, focusing on the physical materiality of the city or, in other words, the artefacts of buildings and the spaces they produce (Moudon, 1994).*

*In practice, conventional methodologies assess the external characteristics of settlements, seeking to explore the relational qualities between a single building and aggregates of buildings in terms of their arrangements, hierarchies of components, building types, physical structures, open spaces, and in more recent approaches, infrastructure layout.*

*Several studies have progressed from elementary comparisons to explorations of more complex relationships. Progression from a 'building-to-space emphasis' that looks primarily at building aggregate and neighborhood fabric (Cannagia & Maffei, 2001) or functional parceling of the city*

(Conzen, 2004), has moved towards 'space-to-network' comparison, (Read, 1996), 'space-to-road network distribution' (Boeri, 1993; Bruyns, 2011), 'space-to-planning policy' relationships (Oswald et al., 2003) and spatial analysis driven by mathematical derivatives that integrate 'isovist' (single-line) planes (Hillier and Hanson, 1984; Hillier 1996; Hillier et al. 2007, 2012).

Still, configurative analysis remains challenged by the mega and radical development paradigm (Koolhaas and Chung, 2001; Mohammadzadeh, 2011). Spatial evidence in Asian mega cities subverts several of the conventional building-to-space relationships. The production of 'mega' scale projects, some of which claim positions with the list of ten largest spatial volumes, amalgamizes building aggregate and street functions, into new interior-exterior definitions. This has forced a revision to a spatial position in morphological terms; (a) by redefinition of the exact scale of the mega-mega complexes (Peng & Bruyns, 2019), (b) by moving away from the dependency of two-dimensional view of morphological analysis based on the predominant plan view, in what we term 'volumetric morphologies' (Bruyns Higgins Nel 2020), (c) and finally, a morphological question which interiorized external morphological elements (Bruyns, 2019).

This paper aims to link the conceptual frameworks of space, physical objects and morphologies to the conditions of the mega in the Asian context. The work examines the challenges faced within configurative research by briefly discussing the conditions of space, territory and scales in relation to the material morphological artefacts. Thereafter, the paper uses the setting of Macau Special Administrative Region (SAR) and its material evidence of the gaming industry's as morphological context of mega-forms, underscoring four key factors that jointly influence the approach to what we term 'mega-morphologies'. Findings of the paper concludes on the challenges mega-entities provide, through the alignment of analytics tools as well as a need to rely on a hybridity of methods to assess double layer morphologies in mega region environments.

---

## NEW SPATIAL CONDITIONS, NEO-MORPHOLOGIES

In our view, three challenges can be defined in the context of mega regions and spatial analysis. First, territorial comprehension greatly influences configurative analysis and morphological enquiry. Christaller and Baskin's central-place theory (1966) linked the morphological domain to regional relationship. Read (1996; 2007) formulated a 'center theory' in a 'flat-city' scenario within Dutch cities, highlighting the presence of a 'supergrid', as the structural element that attracts economic functions (shops and commerce) based on speed and the intensity of movement. Hillier et al. (1993) and van Nes (2018) delivers a refined theory on natural movement economic process, relating spatial structures to commercial location patterns. Bruyns (2011), has shown the possibility of layers of spatial hierarchies, revisiting the link between typomorphological analysis of territories and 'central place theory'. Although all valuable in own right, these methods remain untested in mega regions, especially within the Greater Bay Area (GBA) of the Peral River Delta and its clusters of 11 mega cities. The underpinnings of contemporary 'place regions' and the challenges brought on by amalgamated territories requires new visions, in for example, what defines scale and polycentric structures within the morphological discourse as well the validity of naming protocols and the eventual description of such mega spatial characteristics.

Secondly, the material artefacts of the build landscape have signifyingly changed in the mega-city context. Mega-cities have beyond their horizons, become incredibly 'vertical' in orientation (Shelton, et al., 2010). Ireson and Barley (2000) suggest that vertical cities can be understood as the production of layered horizontal surfaces, from which the authors identified 'elevated territories' and the multi-layered nature of vertical space. For Rhowbotham (2000), vertical

urbanization is synonymous with the 'Lasagne City' with Yeang's (2002) discussion defining tower typologies as self-contained cities, mixing internalized land use and a vertical public realm to 'vertical' transportation. Lin and Gamez's (2018) definition of 'vertical urbanism' focused on multi-layered organisms driven by population density dependent on multidimensional spatial networks.

Thirdly, linked to the aforementioned, mega-city conditions definitively secures the correlation between density, verticality and morphology. Berghauer-Pont and Haupt's (2010a; 2010b) Spacematrix built on the work of Angenot (1954), Heimas (1965) and Rådberg (1988) and their respective takes on dwelling density, land-use intensity, building coverage and spaciousness advances the construction of analytical tools for assessing the formal properties of density in low- to medium-density cities. FARMAX: Excursions on Density (Maas et al., 1998) challenges density in the design context when faced with limited space and how functions replicate in vast numbers. Still, the majority of density related morphological modelling remains untested in the combined settings of high-density and the mega-city. The limitations of spatial analysis, transferred from a 'one-level city' to what we call the 'vertical clusters of commerce, business and dwelling', challenge how we understand (a) the planned inversion of cities (Lin, 2018), (b) the 'suspension' of public and private spaces away from the urban surface and (c) the implication of vertical centers in terms of neighborhoods and territories.

---

#### MEGA-MORPHOLOGIES, MACAU SAR

To explicate the discussion on the material evidence of the mega-regions and mega-scale artefacts with the challenges posed for morphological enquiries, the focus shifts to the gaming and hotel industry of the Special Administrative Region (SAR) of Macau, China.

The Macau SAR is one of the 11 cities situated in the north western part of the Greater Bay Area of Southern China. Macau covers 33 km<sup>2</sup>, with roughly 667400 inhabitants (Bayarea, 2020). Spatially it is part of the Peral River Delta estuary's, with direct links with Hong Kong and Zhuhai, and indirect corridors to Guangzhou and Shenzhen. Spread across a series of interconnected peninsula and island, three main regions define its footprint; the Macao Peninsula, Taipa and outlying Coloane (Ni Sheng et.al. 2017, p 201). More importantly it attributes its unique trading and economic status to it being the only city that allows gambling within China. For 2017 alone, the city accounted 49.1% of its general 2017 industrial structure to the two economic pillars of Gambling and junket activities (Bayarea, 2020).

Table 1



Plot No	Total Building Area (m <sup>2</sup> )	Plot Area (m <sup>2</sup> )	Building-Plot Area Ratio	Number of Hotel Rooms	Casino Area (m <sup>2</sup> )	Retail Area (m <sup>2</sup> )
1	554394	333193	1.66	1500	37 000	100 000
<b>2 (CASE A)</b>	<b>389650</b>	<b>565252</b>	<b>0.69</b>	<b>12 000 +</b>	<b>60 896 (Worlds largest)</b>	<b>124 700</b>
3	82559	162137	0.51	1600	46 451	35 000
4	158060	124646	1.27	4451	39 019	16 300
5	105997	211434	0.50	1706	39 000	18 580
6	64415	77763	0.83	600	9 290	37 160
7	120281	74897	1.61	2000	27 000	53 000

<https://www.worldcasinodirectory.com/casino/lisboa-palace>

**Figure 1: An overview of all gaming related spatial indices. Data compilation draws from a series of sources that show income, spatial footprints, and quantifiable indicators related to gaming in Macau. Source: Authors, 2020.**

From its pre-colonial and Portuguese influence, to its current one-country-two-system status, Macau’s spatial landscape is a mixture of pre-colonial spatial types, off-set with post-colonial expansion and regional connectivity between the Chinese Mainland and Hong Kong (Ni Sheng et.al. 2017). Each of its three main sections has individual characteristics, either derived from colonial settlements (Macau peninsula), industrial expansions - airport and ferry services (Taipa Island) - with newly reclaimed swamp areas thanks to an aggressive land reclamation policy aimed at increasing housing and gaming (Colane Island).

Our discussion here focuses on the morphological artefacts produced by the gaming industry, in both their urban settings as well as their spatial configurations. More specifically we view this

unique state of morphological assemblage, in both a contextual and scalar paradigm, in what we define as *mega-morphologies*.

To date, Macau has six consigned gambling concessions. Each concession grants holders the possibilities of casinos and hotels (Gaming Inspection and Coordination Bureau, 2020). Our research examined casino and hotel complexes of each consignment, ultimately choosing one particular example. The motivation for limiting the discussion to one complex is based on the mere complexity of individual mega complexes, coupled with publicly available information. In addition, the research limited the focus to compounds located on Taipa. These complexes were substantially larger in scale, due to hotel, casino, entertainment and retail spaces forming single, comprehensive complexes.

The methodology to explicate mega-morphologies rely on the ongoing findings of Peng’s (2020) analysis. First, to establish contextual settings, the research documented building-footprint-to-urban-block-relationships, using GIS software. Secondly, a factual compilation of actual floor area and square meter coverages of each casino complex delivered a broad comparison. This included casino areas, hotel rooms, retail and dining spaces. Third, a detailed tracing of interior configurations and functional layout based on freely available maps provided internal layout and configuration patterns. Fourth, photographic documentation of interior spaces provided insight into the scale and properties of mega-interiors.

The mega-morphology of Case A consists out of gaming, retail functions and six hotels (Sands Investor Report, 2018). Case A's land concession, leased for a period of 25 years, claims five parcels on Cotai (ibid). Concretely, the sample covers, 60 896 square meters of casino (Ibid). One of its hotels features 2,841 standard hotel suites and 64 suites across 39-floors. In addition, the retail component alone claims 124 700 square meters. Approximately 111 483 square meters covers the convention and conference functions. As it stands the Case A claims to be one of the largest floor area structures globally – ranked seventh (ibid).

Based on the material evidence we summarize four key characteristics of mega-morphologies. First, Mega morphologies embody a **three-dimensional amalgamation of spatial typologies** and built form. The fusion of several morphological types radically expands on the urban footprint of each mega block. The spatial dimensions, bulkiness of individual complexes and mere volumes of spaces claimed by the 'mega' emphasis, ultimately shifts the mega-morphology away from the pure architectural artefact towards and urban domain and grand city project. The combination of hotels types, malls, bridge connections, external and internal streets, covered avenues and piazzas linked to vast entertainment complexes remain all-encompassing and, unidentifiable to a particular human scale or recognizable typology. For example, a conventional single dwelling or house and its definitive interior divisions and rooms, in the mega context, become exaggerated in scale and in their use. The conformity of a living room and bedroom as individual spatial types, in the setting of a hotel suite, replaces dwelling typologies. Reconfigured into 'thin' and linear arrangement of passageway and the adjacent string of bedrooms, the new 'dwelling' uses multiple and sometime interconnected rooms to define its unitary form. Within rooms, other household functions become dispersed, whilst still maintaining the category of 'room'. The pizza coffee bar, a typology extracted from the Italian village or town, becomes an exaggerated function attracting thousands, forming a link between a public thoroughfare and other commercial entities, while being linked to vertical circulation elements as escalators and elevators.

Second, as a consequence, the mega scale **disassociates its formal properties from any external functions** of the city's setting. Whereas the traditional functionality of the city becomes associated with the spatial characteristic or architectural type, the mega morphologies mechanize new process of operation beyond the specific features of neighborhood, industrial quarters, or Central Business District. Mega-morphologies therefore mechanize scales to amplify conventional planning and design, not to mirror new town principles as self-sustaining mini cities, but as enclaves that independently operate based on; (i) a massive immigrant labor force (IOM, 2016), (ii) on a self-directed transportation systems, (iii) on highly scripted security protocols, and (iv) economic ecologies on which governments GDP's become dependent on (The World Bank, 2020).

Figure Set 1: CASINO MAPS

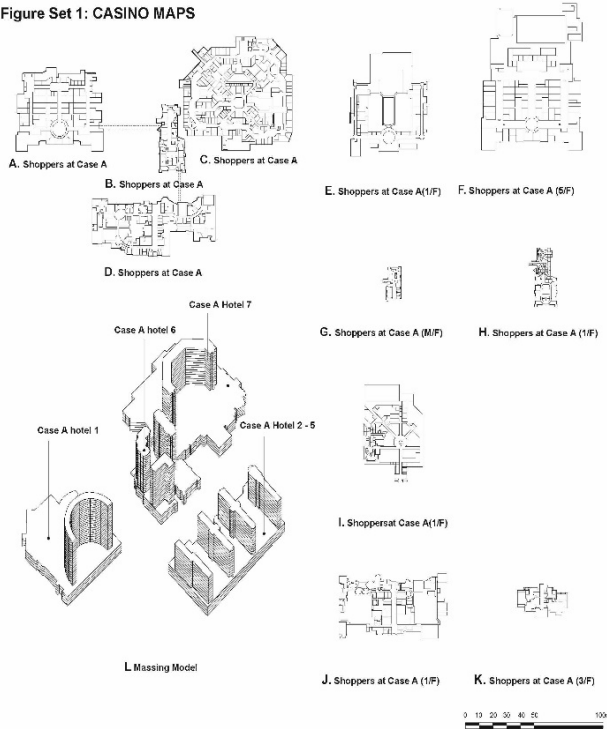


Figure set 1: The images shown here demonstrate the size, layout and scale of Case A, in Macau's mega-morphologies. The compilation is the overview of the various levels and three-dimensional properties. Source: Authors, 2020.

rely on the scale of urban design for articulation. The shift from household, to urban and yet again to the monumental, changes conventional interiority to oversized spatial mazes, linked with lanes, extensive passages and vastly widened corridors.

Figure Set 2: COMPARISON

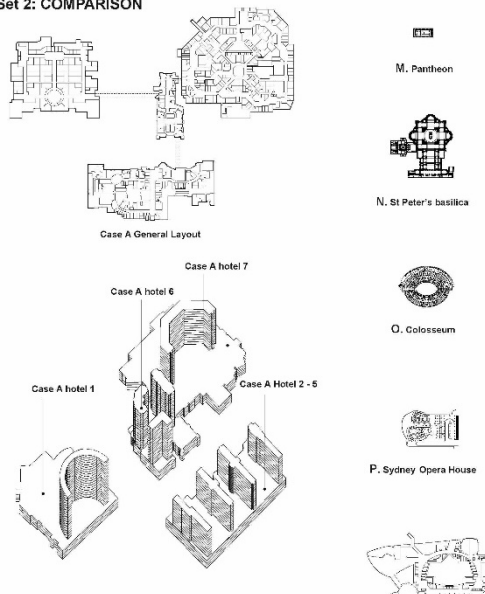


Figure set 2: A to scale comparison of the investigated mega morphologies to other building. Source: Authors, 2020.

Thirdly, **mega morphologies conclusively demonstrate the tendency to invert all lived space.** Linked to the aforementioned characteristic of functional disassociation from the city, the relationships of the mega-form to urban edge produce unsympathetic transitions between building envelope, the city and the human dimension. The presence of blind facades and inaccessible walking dimensions, further exacerbated by gaming security and climate, facilitates the inwardness of the public, and a negation of the external space. To this effect, the broad range of mega conditions deliver morphologies-within-morphologies. Although similar in traits to those spatial settings of the commercial mall, mega morphologies are the scaled-up version of exterior envelopes, engulfing all forms, types and configurations of space. Malls, piazzas, urban squares, city forums, leisure areas and porticos are in both the layout and experiences, inverted conditions which

Finally, and possibly a question that could drive countless future research, is the methods for **analyzing configurative properties of mega-morphologies and their valance with existing analytical tools.** At both the territorial, building and interiorized levels, the analytical question of applying any one specific method to this formal type remains inconclusive. For analysis of mega-complex settings, GIS could be a valuable instrument, comparing footprints, plot usage, user density, movement or linkages to space, data and ecological factors. The combinations of GIS with Space Syntax itself, can elude to question of connectivity and spatial integration, in both the city as well as the interfaces between mega-city morphology, and mega-interiors. However, for the



Figure Set 3: IMAGES

EXTERIOR



INTERIOR



Figure set 3: A collection of exterior as well as interior images of the mega-morphologies. The series of views illustrate the spatial characteristics of the mega-morphologies. Source: G Bruyns, 2020.

analysis of the internal settings of mega-complexes, the appropriation of a single tool remains short-sighted. First, we foresee the descriptive protocols of the more traditional morphological schools – the Italian, English, French methods – as a means to assess internalized typologies of spaces. Possible outcomes here could address the spatial reticulation of built-to-void relationships. Linking the outcomes back to Space Syntax methods may prove useful to demonstrate integration and choice relationships, in either the conditions of both urban spaces and interiors layouts. Finally, we further problematize the two-dimensional orientation of analysis when applied to mega-morphologies. A viable addition to the 2D analytical framework would be the inclusion of a three-dimensional, and more volumetric, approach. As documented in the work of Bruyns, Higgins and Nel (2020), this would require the volumetric assessment of each interior void. Determining the spatial attributes of (i) overall building height, (ii) individual floors height (floor to floor) and

(iii) floor height for a series of linked buildings is a first step. Using the ‘sliced’ approach, each floor will be represented a ‘slice’ in the overall volume, adding data and other variables to the larger question of properties and mega scale spaces. Although tested on dense settings as Hong Kong, the possibility of the approaches discussed here remain untested, due to the sensitive nature of the gaming mega-morphologies.

---

## CONCLUSIONS

In conclusion, the discussion here on mega-forms is a first step in the larger line of enquiry linking the morphology discourse to the mega and oversized contexts. No definitive outcomes are shown other than the existence of the required material evidence that points towards the first descriptions of defining mega-morphologies’. This is done whilst seeking out mega-morphology complexity through five spatial characterizes and the challenges that arise in the analysis of such conditions.

We remain certain that 21<sup>st</sup> century progress will further fuel the morphogenetic conditions for large and amalgamated configurations of built space. This brings to light possible links between the nature of the environment and the material artefacts of the city, which in turn, influence scientific protocols through which analysis occurs. Beyond the co-influence of scale and data as key indicators of mega-morphologies formal properties, the analysis of mega-structures should heed calls to embrace compounded methods to fuel other streams of morphological research. This would further align previously marginalized discourses into the morphological debate, acknowledging all

scales through which mega-conditions materialize, as for example the possibility of including interior settings part and parcel of a mega-morphology landscapes. Moreover, as an eventual outcome, the spatial nomenclatures of double embedded morphologies (morphologies-within-morphologies) will forever alter the traditional naming of regions, cities, buildings and spaces for the continuously unfolding mega-territories of tomorrow

---

#### ACKNOWLEDGMENT:

We would like to thank Mr. CHAN Ka Cheong for his assistance with drawing and data collection.

---

#### REFERENCES

- Berghauser-Pont, M. Y., & Haupt, P. (2010). *Spacematrix: space, density and urban form*. Rotterdam: NAI Publishers.
- Boeri, S., Metropolitan, A. I., Lanzani, A., & Marini, E. (1993). *Il territorio che cambia: ambienti, paesaggi e immagini della regione milanese*. Milan: Abitare Segesta.
- Bruyns, G. J. B. (2011). *Urban Dispositif: An Atlas of Spatial Mechanisms and the Contemporary Urban Landscape: A Reading of Movement as an Interpretive Device and Mechanism of Urban Form*. PhD Thesis. Delft University of Technology, Delft: The Netherlands.
- Bruyns, G., Higgins, C.D., Nel, D., (in print). *Urban Volumetrics: From Vertical to Volumetric Urbanisation and its Extensions to Empirical Morphological Analysis*. *Urban Studies Journal*.
- Conzen, M. R. (2004). *Thinking about urban form: papers on urban morphology, 1932-1998*. Bern: Peter Lang.
- Christaller, W. (1966). *Central Places in Southern Germany*. London: Prentice Hall.
- Gaming Inspection and Coordination Bureau. (2020). *Monthly Gross Revenue from Games of Fortune*. Retrieved July 09, 2020, from [http://www.dicj.gov.mo/web/en/information/DadosEstat\\_mensal/2020/index.html](http://www.dicj.gov.mo/web/en/information/DadosEstat_mensal/2020/index.html).
- Grand Lisboa Palace Review. (n.d.). Retrieved July 09, 2020, from <https://www.worldcasinodirectory.com/casino/lisboa-palace>.
- Gianfranco, C., Maffei, G. L., (2001). *Interpreting Basic Building*. Architecture. Firenze: Alinea Editrice.
- Hong Kong SAR Government. (n.d.). *Great Bay Area Map*. Retrieved July 09, 2020, from <http://www.bayarea.gov.hk/en/about/the-cities.html>.
- Hillier, B., & Hanson, J. (1989). *The Social Logic of Space*. Cambridge: Cambridge University Press.
- Hillier, B. (2007). *Space Is the Machine: A Configurational Theory of Architecture*. 2nd ed. Cambridge: Cambridge : Cambridge University Press.
- Hillier, B. (1996). *Cities as movement economies*. *Urban Design International* 1(1). 1: 41–60.



Hillier, W. R. G., Yang, T., & Turner, A. (2012). Normalising least angle choice in Depthmap-and how it opens up new perspectives on the global and local analysis of city space. *Journal of Space Syntax*, 3(2), pp. 155 - 193.

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>.

IOM. (2016). IOM Conference on Migrants and Cities. Retrieved July 09, 2020, from <https://www.iom.int/iscm/conference-migrants-and-cities>.

Ireson, A., & Barley, N. (Eds.). (2000). *City levels*. Basel: Birkhauser.

Koolhaas, R., Leong, S. T., Chung, C. J., & Inaba, J. (Eds.). (2001). *Great leap forward*. Cologne: Taschen.

Lin, Z., (2018). Vertical Urbanism: Re-conceptualizing the compact city, in: Lin, Z., Gamez, J.L. (Eds.), *Vertical Urbanism: Designing Compact Cities in China, China Perspectives*. Routledge, London ; New York, pp. 3–18.

Mohammadzadeh, M. (2011). Urban Morphology in the 21 Century; an Agglomeration of Mega Urban Projects. In proceedings of *18th International Seminar on Urban Form*. Montreal, Canada.

Moudon, A.V. (1994). Getting to Know the Built Landscape: Typemorphology. In *Ordering Space: Types in Architecture and Design*, ed. Karen Frank and Lynda Schneekloth. New York: Van Nostrand Reinhold. 289 - 314.

Maas, W., van Rijs, J., & Koek, R. (Eds.). (2006). *FARMAX: Excursions on Density*. Rotterdam: Nai Uitgevers Publishers.

Oswald, F., Baccini, P., & Michaeli, M. (2003). *Netzstadt. Designing the Urban*. Basel: Birkhauser.

Peng, Y., (Forthcoming). *Chinese Megablock Urbanism: An enquiry into the conceptualization and interpretation of urbanization practice in China*. PhD thesis. The Hong Kong Polytechnic University.

Peng, Y., Bruyns, G., (2019). Chinese Megablock Urbanism: a Tool of limitless Urbanization in an Unprecedented Speed and Scale. In: *ISOCARP World Planning Congress* (eds M Juvara and S Ledwon), Jakarta and Bogor, Indonesia, 9 September 2019, pp. 279–291.

Rhowbotham, K., (2000). Lasagne City, in: Ireson, A., Barley, N. (Eds.), *City Levels*. Basel: Birkhäuser.

Read, S.A., Bruyns, G., (2007). The Form of the Metropolitan Territory. The Case of Amsterdam and its Periphery. Proceedings of the *6th Space Syntax Symposium (6SSS)*, Istanbul, Turkiye, June 12-15, 2007.

Read, S.A., (1996). *Function of Urban Pattern: Pattern of Urban Function*. PhD Thesis. Delft University of Technology, Delft, The Netherlands. Retrieved July 09, 2020 from <http://resolver.tudelft.nl/uuid:8cd48195-4f27-42f0-a78d-885506c33e85>.

Shelton, B., Karakiewicz, J., and Kvan, T. (2010). *The Making of Hong Kong: From Vertical to Volumetric*. Oxfordshire: Routledge.

Sheng, N., Tang, U. W., & Grydehøj, A. (2017). Urban morphology and urban fragmentation in Macau, China: island city development in the Pearl River Delta megacity region. *Island Studies Journal*, 12(2), 199-212.

Sands. (2018). Sands Investor Report. Retrieved July 09, 2020, from <https://investor.sandschina.com/static-files/48953df6-4e83-4b76-be92-fed0621a1916>.

The World Bank. (n.d.). *GDP per capita, PPP (current international \$) - Macao SAR, China, China, Hong Kong SAR, China*. Retrieved July 09, 2020, from <https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD?locations=MO-CN-HK>.

Van Nes, A. (2018). The explanatory power of Space Syntax and Urban Morphology. In ISUF 2018: 25th International Conference on Urban Form. Krasnoyarsk, Serbia.

Yeang, K. (2002). *Reinventing the skyscraper: a vertical theory of urban design*. Chichester: Wiley-Academy, 2002.

---

#### CORRESPONDING AUTHOR

Gerhard Bruyns, Associate Professor, The School of Design, The Hong Kong Polytechnic University, Hung Hom, Kowloon. [gerhard.bruyns@polyu.edu.hk](mailto:gerhard.bruyns@polyu.edu.hk)