International Journal of High-Rise Buildings
March 2019, Vol 8, No 1, 57-69
https://doi.org/10.21022/IJHRB.2019.8.1.57

International Journal of
High-Rise Buildings
www.ctbuh-korea.org/ijhrb/index.php

Tall Buildings as Urban Habitats: A Quantitative Approach for Measuring Positive Social Impacts of Tall Buildings' Lower Public Space

Xihui Zhou, Yu Ye†, and Zhendong Wang

Department of Architecture, College of Architecture and Urban Planning, Tongji University

Abstract

After decades of high-speed development, designing tall buildings as critical components of urban habitat, rather than simply standing aloof from their environments, has become an important concern in many Asian cities. Nevertheless, the lack of quantitative understanding cannot support efficient architectural design or urban renewal that targets better place-making. This study attempts to fill the gap by providing a typological approach for measuring the social impact of tall buildings' ground conditions: that is, public space, podiums, and interfaces. The central business districts (CBD) of three Asian cities, Shanghai, Hong Kong, and Singapore, were selected as cases. Typical patterns and categories of lower-level public spaces among the three CBDs were abstracted via typological analyses and field study. The following evaluation is achieved through the analytic hierarchy process (AHP). This quantified approach helps to provide a visualization of high or low positive social impacts of tall buildings' lower-level public spaces among the three cases. This study also helps to suggest a design code for tall buildings aimed at a more human-oriented urban habitat.

Keywords: Lower public space, Social impact, CBD, Tall buildings

1. Introduction

The rapid urbanization of Asia over the past few decades has brought to bear high pressure to create lively urban habitats. In 1950, only 17% of the population in Asia lived in urban areas. The data show a rise to 40% in 2005, and it is estimated that over 55% of the Asian population will be urban by 2030 (World Urbanization Prospects, 2018). The large demands of economic and demographic growth have led to an efficient urbanization paradigm, focusing on a high-density built environment. In this context, new-build central business districts (CBDs), fully occupied by tall buildings, have become common. Although most of these CBDs achieved success from an economic perspective, their quality from a human-oriented perspective was rarely considered. Positive social impact, including vibrancy, pedestrian quality, and perceptual feelings encouraging social activities on a human scale, is usually an afterthought (Safarik, 2016). Hence, numerous urban problems have been addressed, such as traffic congestion, the devastation of the urban fabric, and the decline of environmental quality and living conditions. As high-density and high-rises constitute a present reality and future condition, redressal of those districts' urban environments becomes essential in further development (Cho et al., 2017).

In recent times, the rethinking of spatial quality and urban design in those CBDs has provided possibilities for solving these problems. However, we should be aware that those works should be undertaken not only on an urban scale, but also on a human scale. This requires further study of tall buildings' lower-level public spaces, the most important and "urban" part of tall buildings, and their social impact. Public spaces, podiums, and the interfaces of tall buildings under five floors, or so-called "lower public spaces," can encourage positive social activities by providing visual pleasure to pedestrians (Gehl, 2006; Mehta, 2014).

Tall buildings have been criticized historically because of their isolation from the surrounding built environment. In this context, efforts have been made to integrate them into the urban context, particularly with regard to their ground conditions (von Klemperer, 2015; Safarik, 2016). Nevertheless, most of these attempts are proposed within an experienced-based and qualitative approach. This is inadequate for promoting more efficient design and maximizing positive social impact for the public. To address this requirement appropriately, a typological analysis of typical patterns of ground conditions and a quantitative measurement of these patterns' social impacts are needed.

This paper attempts to fill the gap by providing a typological analysis of typical patterns of tall buildings' ground

†Corresponding author: Yu Ye
Tel: +86-18217268257; Fax: +86-21-65986707
E-mail: yye@tongji.edu.cn

conditions and a quantitative measurement of these patterns' social impacts. Taking three CBDs in Shanghai, Hong Kong, and Singapore as cases, typical spatial patterns and categories in their lower public spaces have been identified typologically via field studies. Related studies have been reviewed in the next section for selecting appropriate analytical methods. After the summary of data and methods, the results section presents the analysis between those morphological categories of lower public spaces and their positive social impact. The paper concludes with suggestions for urban design paradigms that could assist in the transformation of tall buildings in urban habitats. The limitations of the study and future research direction are also discussed.

2. Related Studies

The relationship between the quality of public spaces and their social impact — that is, visual pleasure and accompanying social activities — has been discussed by many experts and academics. Gehl (1971) notes that the built environment tends to affect social relations by promoting or inhibiting users' behaviors. In turn, people's performances and behavioral preferences may be taken as an index for evaluating environmental attributes. In this context, the Revealed Preference (RP) survey has been generated to assist in the evaluation of preferences through data from user surveys and investigations of on-site behavior (Bradley et al., 1991). A representative example of RP survey is made by Nasar (1990), who interviews local residents about their preferences and the physical features of the surroundings. Objective indicators, such as body mass index (BMI) and air quality, are included as well as questionnaires by Frank et al. (2006). Mehta (2014) evaluates activities in different scales of public spaces in several cities. In short, the RP survey is widely used in less-complicated and small-scale environments where interference and variables can be easily controlled.

Increasingly, the Stated Preference (SP) survey is more suitable for complicated scenarios, where observed behavior is inadequate. By providing various combinations of different features, a quantitative model can be built to weigh the effects. For instance, Ulrich et al. (1991) measure stress recovery in different participants after they were exposed to videotapes with nature and urban settings. Craig (2002) and Ewing and Handy (2009) suggest different approaches for evaluating public spaces. Experts are asked to state their preferences on various kinds of scenes containing combined spatial features in photos or videos. Statistical tools are then used to assess the weighting of the different spatial features composing the scenes. Using this approach, the SP survey can enable researchers to reveal rare or formerly non-existent spatial patterns (Broach et al., 2012). This would therefore be more suitable for complex built environments, such as CBD areas.

However, when faced with a high-density urban environment, the SP method has difficulty with regard to the weightings among numerous categories. Hence, a reliable evaluation method is needed. The introduction of the Analytic Hierarchy Process (AHP) fills this gap. The AHP has been widely employed to deal with models that combine both subjective and objective criteria, and has been used in many fields such as real estate, forest management, and urban public transportation (Bender et al., 2000; Ananda et al., 2008; Nosal et al., 2014). Lo et al. (2003) uses AHP to identify the importance of design criteria in Hong Kong's open spaces. Similar work is done by Lee et al. (2008) using the AHP to assess urban renewal in Hong Kong. They suggest a list of major objectives and design criteria for providing sustainable renewal proposals. While notable, their work does not fully take into account the impact from surrounding buildings in place-making. In this study, the combination of SP and AHP enables the achievement of a systematic and objective evaluation of the social impact of tall buildings' lower public spaces.

3. Research Methodology

3.1. Site Selection

This study chose three typical CBDs in Asia as study areas: Lujiazui in Shanghai, Central in Hong Kong, and Marina Bay in Singapore (Fig. 1). They were selected for the following reasons, in addition to their international competitiveness and significance in the world city network.

1) All of these CBDs started their high-density development during the latter half of the twentieth century. Their construction was completed within a short period of time.
2) These districts have been developed to meet the demands of international business. High land prices and similar land use make them the most concentrated districts of tall buildings in their cities.
3) Capital intensification has brought negative effects in

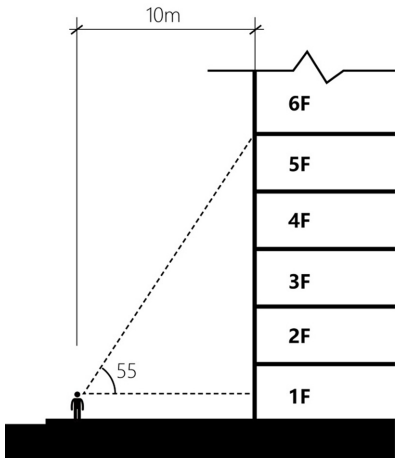


Figure 1. The definition of lower public space in this study.



a. Study area in Shanghai

b. Study area in Hong Kong

c. Study area in Singapore

Figure 2. The three selected study areas; (a) Shanghai, (b) Hong Kong, (c) Singapore.

those districts. Many spatial features and functions that are identified as being important for urban environments, such as retail stores, open spaces, and parks, are more or less lacking in these districts (Wong, 2004; Taylor et al., 1989).

The definitions of tall buildings and their lower public spaces need to be elaborated for a clear discussion. According to the definition given by CTBUH height criteria, the term "tall buildings" can be used to describe those buildings of 14 or more stories — or those more than 50

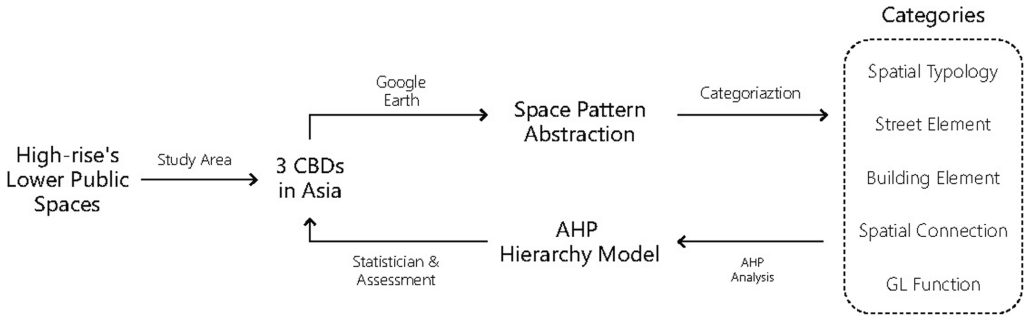


Figure 3. Analytical Framework.

meters in height (CTBUH, 2018). "Public spaces" as used in this paper are defined according to their accessibility to the general public. This includes not only their spatial typologies, objects, and artifacts therein, but also the interfaces that help to define the physical boundaries of the spaces are also connoted (Mehta, 2014). Taking 10 meters as the maximum width of streets, the lower public spaces refer to those public spaces located below the sixth floor of tall buildings, including open spaces, podiums, and interfaces (Fig. 2). Public spaces over this range are regarded as inaccessible or difficult to discern from the street, according to Gehl's (1971) study.

3.2. Analytical Framework

The perception and evaluation of built environments is a process that obtains awareness of sensory information (Ewing et al., 2009). Thus, complete perceptual behavior contains two main variables: physical features from the environment and appraisal by perceivers. This indicates that an in-depth study of lower public spaces' social impacts should be conducted using typological analyses and subjective assessments.

Fig. 3 shows the analytical framework of this paper. First, we selected study areas around 1 km^2 in three CBDs, each of which included 50-150 tall buildings. Typical patterns and categories of their lower public spaces were sorted after field studies and typological analysis. AHP was applied to calculate the weight of each category for rating. The technical details are enumerated in the following section, and the statistic and rating results are discussed in the conclusions.

3.3. Survey Schemes and Data Analysis

Although discussions around tall buildings and their ground conditions need to be enriched, related studies about streets' and open spaces' qualities provide references for this study. Ewing (2009) suggests evaluating urban design qualities through physical features, including sidewalk width, tree canopy, street furniture, transparency, etc. Elsheshtawy (1997) provides a morphological method for measuring the complexity of streetscapes according to their visual dimensions. Earlier studies of public spaces focus primarily on morphological patterns (Carmona et al., 2012). To establish a comprehensive model, we suggest that categories of public spaces and those of surrounding buildings should be considered simultaneously. Based on field studies and assistance from Google Street View, we classified typical patterns of tall buildings' lower public spaces into five categories on three dimensions (Fig. 4).

1) Spatial feature
   a) Spatial typology: how public spaces are located and assembled in the lower part;
   b) Spatial connection: the typology of connection between public spaces located at the same or different height);
2) Building feature
   a) Building element: elements on façades that face the street. Given their distribution, this category is divided into features at street level and those at higher levels;
   b) GL (Ground Level) function: commercial office, shop, residential, parking, etc.
3) Street element: public or semi-public facilities established along the streets that are confirmed to have strong social effects.

As mentioned previously, AHP is introduced to evaluate the social impact of five categories and their subcategories. The AHP model is composed of three parts. The first, the goal level, explains problems that need to be decided. The goal level in this study is to identify the social impact of different patterns of tall buildings' lower public spaces. The second, the criteria level, incudes five main categories: spatial typology, street element, building element (both street level and higher level), spatial connection, and GL function. To determine the priorities in these categories, this level is further broken down into different sub-criteria levels. Pair-wise comparisons are made at both levels.

According to Saaty (2008), a group decision can reduce bias against/toward particular group criteria. To obtain accurate results, this study invited 12 experts specialized in urban design and public building fields from Tongji University to consult on the approach. All experts were required to arrange every category separately in order and

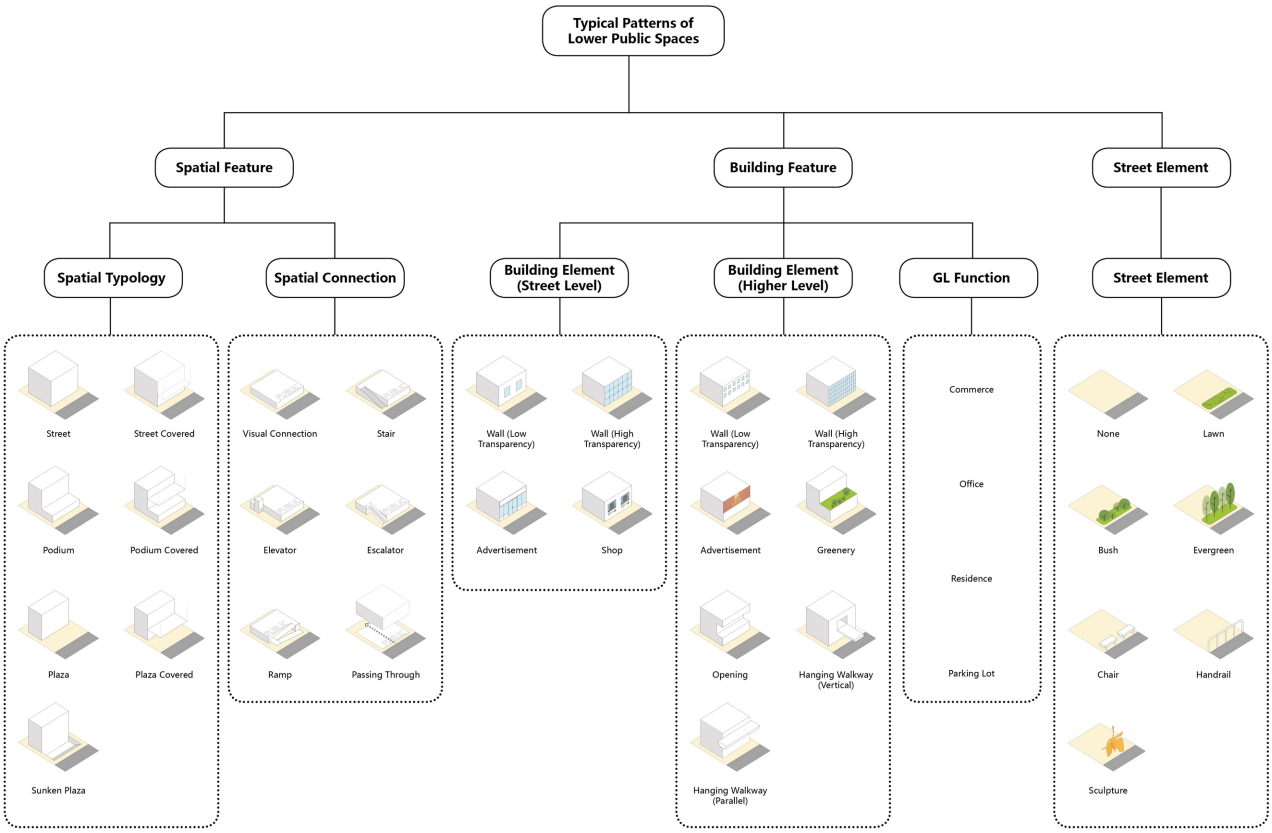


Figure 4. Typical typological patterns of lower public spaces of tall buildings.

consider their impact on perceptual feelings and encouraging social activities (Table 1) Every item in this questionnaire is shown by abstracted diagrams rather than by real images taken from the study area to avoid potential bias.

The final ranks are computed on the basis of the order derived from the questionnaires. Categories in these ranks received scores (S) rated from 1 to 9 by their position:

$$S=\left(\frac{\sigma-\sigma_{min}}{\sigma_{max}-\sigma_{min}}\right)\times 9\,,\quad \sigma=\frac{\Sigma_{i=1}^{a}F_i\omega_i}{\Sigma_{i=1}^{a}F_i} \tag{1}$$

where:

F_i: the item's frequency in every position;

ω_i: weight of the item, determined by their positions. The item in the first position has the largest weight;

a: number of items in each rank.

Thereafter, the weights of these categories were determined with the help of AHP and pair-wise comparisons. $A=(a^{ij})_{n\times n}$ of every category. Values of a_{ij} were taken from rank results (S), which stand for intensities of importance between every two items. $a_{ij}=1$ means that item i and j share the same level of importance. $a_{ij}=9$ means i is far more important than j. YAAHP software was used to calculate the relative weights of criteria; thus, further mathematical details are not shown here.

The weights of categories and sub-categories were used to evaluate lower public spaces of every building located in the study areas:

$$S=\sum_{i=1}^{n}\omega_i(F_1\omega'_1+F_2\omega'_2+\ldots+F_n\omega'_n)\times 200 \tag{2}$$

Where:

F_n: anticipates whether one sub-category is obtained in this building: 0 if none, 1 if true;

ω'_n: weight of sub-category, determined by AHP hierarchy model;

ω_i: weight of category, determined by AHP hierarchy model.

4. Results and Analyses

4.1. Typical Patterns in three CBDs' lower public spaces

The identification of typological patterns reveals their overall distribution and modes of combination in single building. Most tall buildings in the study area provide similar typologies of lower public spaces, usually "streets" (53.62% in Lujiazui, 55.26% in Central, and 31.65% in Marina Bay) or "covered streets" (32.89% in Central and 44.95% in Marina Bay). The "covered podium" exists in only one case in Marina Bay, and there are only four cases

Table 1. Questionnaire for ranking typological categories and sub-categories

Spatial Typology	Street	Street Covered	Podium	Podium Covered	Plaza	Plaza Covered	Sunken Plaza
Street Element	None	Lawn	Bush	Evergreen	Chair	Handrail	Sculpture
Building Element (Street Level)	Wall (Low Transparency)	Wall (High Transparency)	Advertisement	Shop			
Building Element (Higher Level)	Wall (Low Transparency)	Wall (High Transparency)	Advertisement	Greenery	Opening	Hanging Walkway (Vertical)	Hanging Walkway (Parallel)
Spatial Connection	Visual Connection	Stair	Elevator	Escalator	Ramp	Passing Through	
GL Function	Commerce	Office	Residence	Parking Lot			

of a "sunken plaza" in Lujiazui's lower stratum. In fact, the areas of urban open spaces per capita in all three CBDs are much lower than the international standard of 10 m^2/inhabitant (Lo et al., 2003; Tan et al., 2017). The statistics of "spatial connection" also match this conclusion, where over 70% of tall buildings provide only one public space in their lower sections. The "building elements" in the higher levels also show commonalities in these buildings. Especially with regards to newly-built tall buildings, 46.4% in Lujiazui, 30.7% in Central, and 41.04% in Marina Bay choose glass curtain walls as facades. Earlier office buildings and most residential buildings use window walls instead (28.07% in Central and 29.48% in Marina Bay).

Compared with those in Central, public spaces in Lujiazui and Marina Bay have more plants in the streets. Leaving aside implications from the climate, both Shanghai and Singapore introduced local policies to promote greening according to the Regulation of Shanghai Municipality on Afforestation and Greening in 1987, and the Garden City Program in 1963. Although the Hong Kong government added clauses about open spaces and greening into the Hong Kong Planning Standards and Guidelines in 2002, the main construction in Central had already been completed. Therefore, these policies were limited in their capacity to bring about more positive effects in this area.

The most typical patterns from the sites are represented in Fig. 6, which describes a common mode of categories in one building. Although all three patterns have similar ground conditions, their details are different. Owing to different setbacks guided by local construction laws, streets in Lujiazui are the widest. However, those setbacks are usually separated from the streets with roadside greenery, such as bushes or lawns. Only a few entrances are established for pedestrians at the end or in the middle of blocks. Meanwhile, in Central and Marina Bay, limited site areas and high land prices prompt buildings to fully use the sites they occupy. Streets usually contain seating or other resting places along the sites' edges. Shops exist on almost every ground plane in Central, while less than half of the studied area in Marina Bay had shops facing the street. Shops can provide positive impacts for inhabitants' social communications in these areas (Metha, 2014). The percentage of street-facing "shops" in Lujiazui is the lowest (20.41%) of the three areas, and inadequate to support daily living needs in the area.

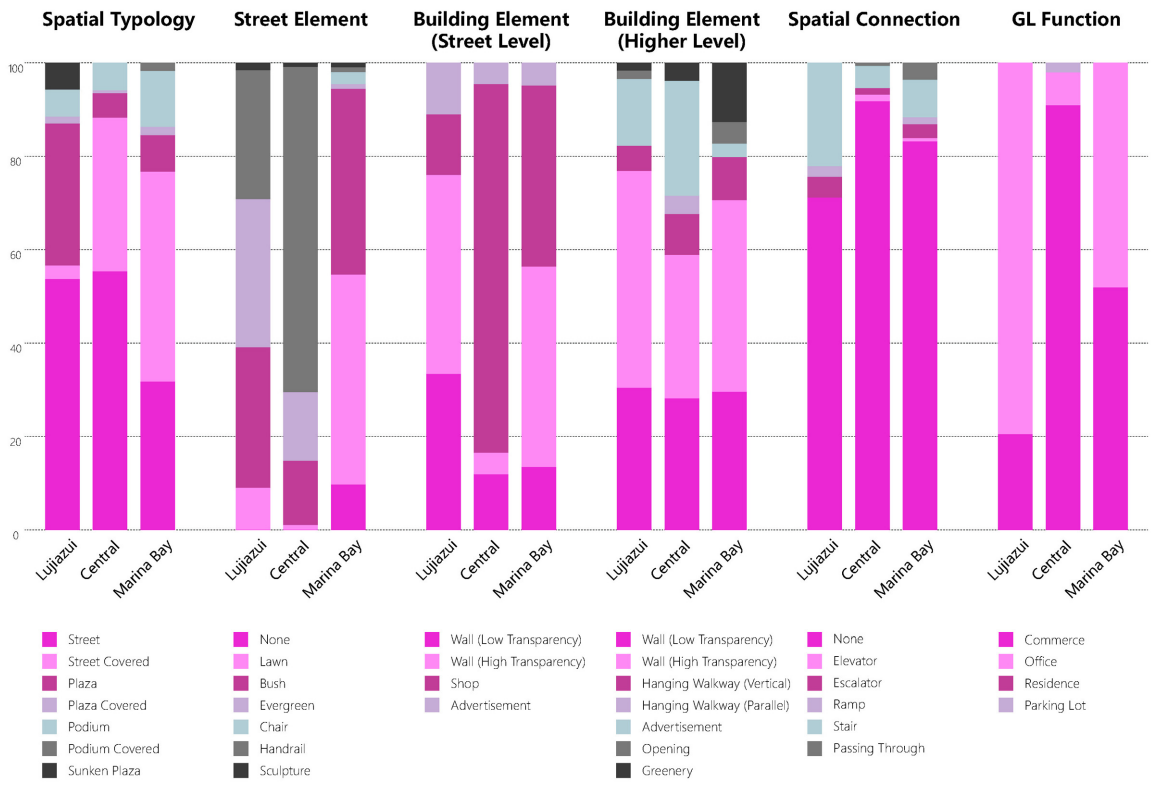


Figure 5. Statistical results in three CBDs.

Table 2. Weights of various categories via AHP analysis

Category	Weight	Category	Weight	Category	Weight
Spatial Typology	0.2903	**Street Element**	0.1935	**Building Element (Street Level)**	0.1290
Street	0.0076	None	0.0051	Wall (Low Transparency)	0.0080
Street Covered	0.0687	Lawn	0.0255	Wall (High Transparency)	0.0323
Plaza	0.0382	Bush	0.0407	Shop	0.0726
Plaza Covered	0.0611	Evergreen	0.0458	Advertisement	0.0161
Podium	0.0458	Chair	0.0407		
Podium Covered	0.0229	Handrail	0.0051		
Sunken Plaza	0.0458	Sculpture	0.0309		
Category	**Weight**	**Category**	**Weight**	**Category**	**Weight**
Spatial Connection	0.1613	**GL Function**	0.1935	**Building Element (Higher Level)**	0.0323
None	0.0000	Commerce	0.1088	Wall (Low Transparency)	0.0010
Visual Connection	0.0208	Office	0.0484	Wall (High Transparency)	0.0010
Elevator	0.0104	Residence	0.0242	Hanging Walkway (Vertical)	0.0069
Escalator	0.0312	Parking Lot	0.0121	Hanging Walkway (Parallel)	0.0059
Ramp	0.0260			Advertisement	0.0029
Stair	0.0208			Opening	0.0059
Passing Through	0.0468			Greenery	0.0088

4.2. Evaluating Results in Urban Scale

The relative weights represent the importance of categories (Table 2). At the criterial level, "spatial typology" is identified as the most important of the qualities of tall buildings' lower public spaces. Following that are "street elements" and "GL function." "Building elements" in the higher levels have the lowest weighting. Most experts regard them as hard for pedestrians to discern from the street. At the sub-criterial level, "shop," "covered street," and "covered plaza" have the highest weight. The result

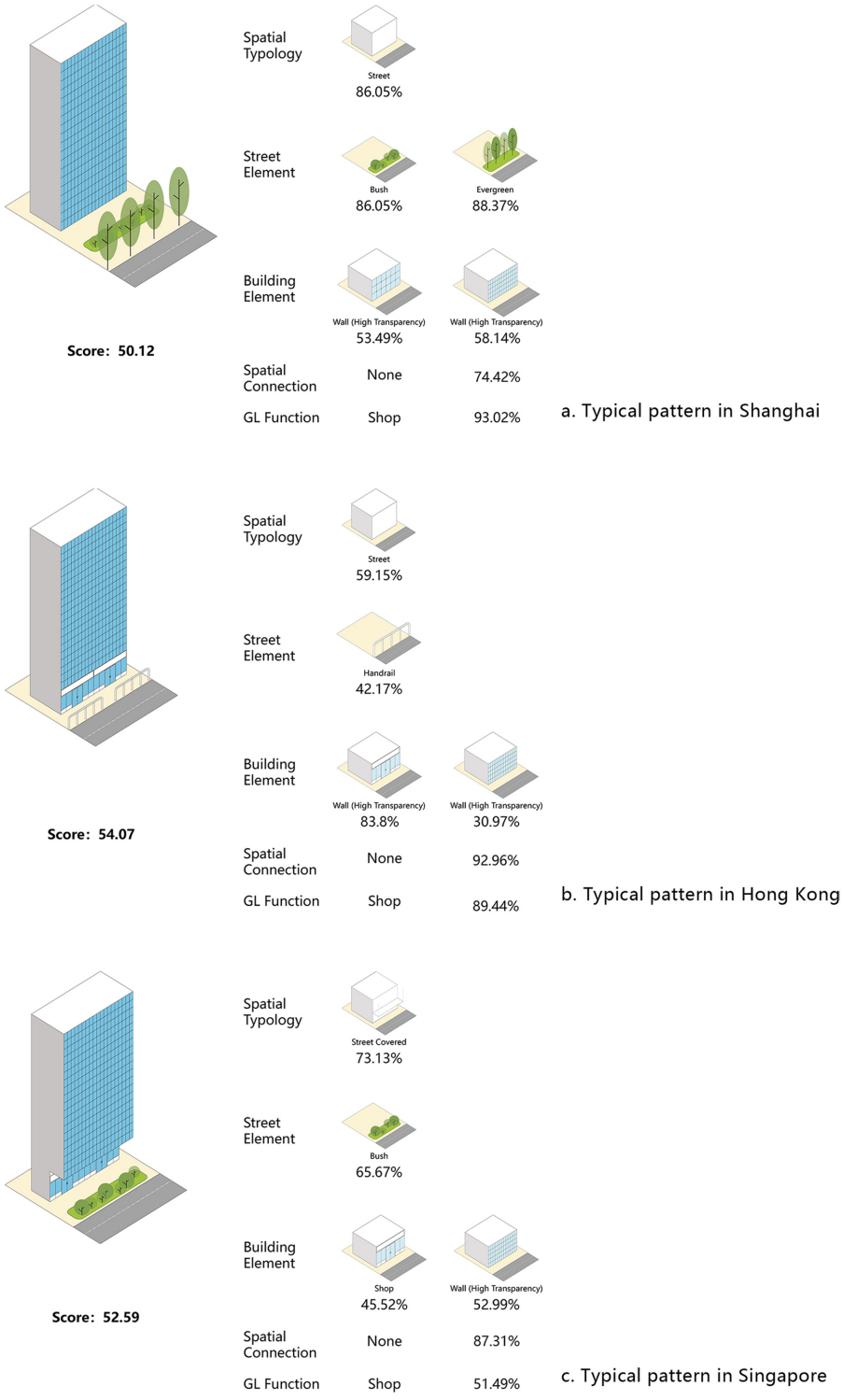


Figure 6. Typical patterns; (a) Shanghai, (b) Hong Kong, (c) Singapore.

suggests that shops on the ground floor with a particular spatial typology have the most positive impact on lower public spaces. Following that are "passing through," "sunken plazas," "podiums," and "plants." The "wall" on the higher levels has the lowest impact, despite its transparency. "Handrail" and "no street element" also rank as less important in the place-making of lower public spaces.

The weights of categories were then used to evaluate impacts from particular buildings. Ranging from 0 to 100, a higher rate indicates a better social impact in lower

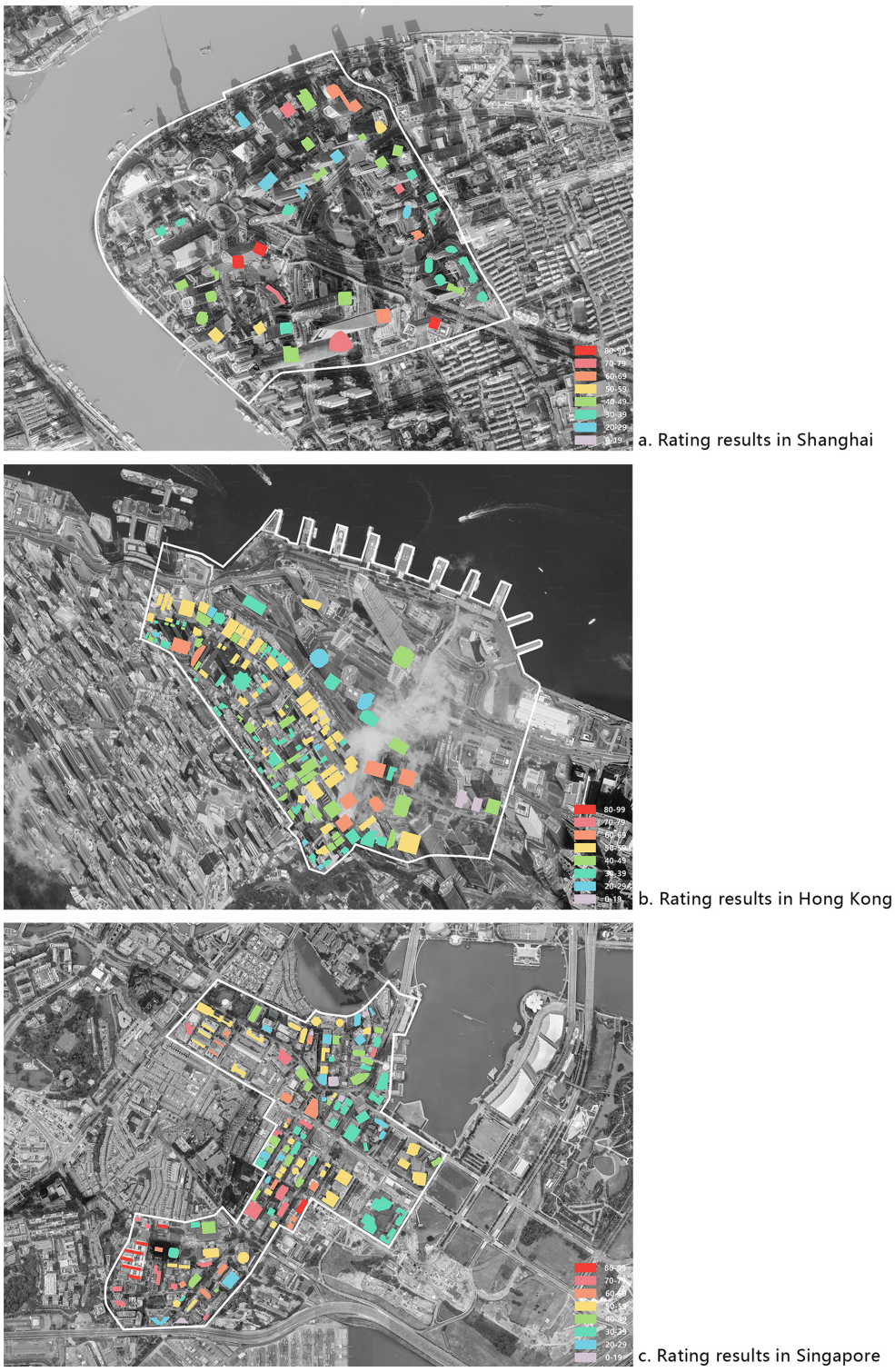


Figure 7. Rating results (a. Shanghai, b. Hong Kong, c. Singapore).

public spaces or, in other words, a stronger capacity to encourage positive social behavior and use of the environment. The results show that the average rates for three CBDs are close to each other (Fig. 7(a)-(c)). The reasons should be considered from both morphological and static viewpoints. "Shops" contribute 83.8% of the "GL function" in Central, and thus make a great contribution to supporting public activities and commercial atmosphere. Nevertheless, pedestrians' pleasure is decreased on narrow sidewalks without any setbacks, and a lack of public street

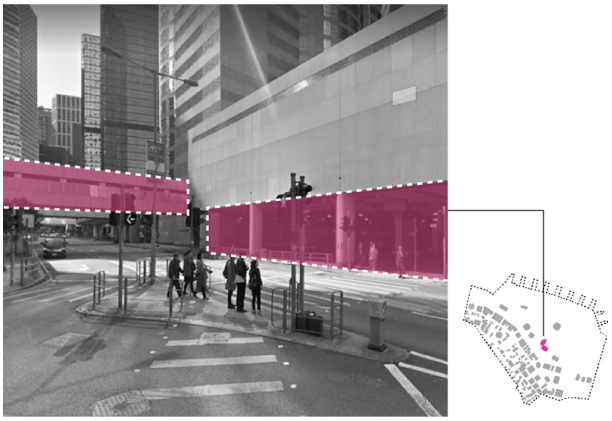


Figure 8a. Lower public spaces in No. 03c in Central.

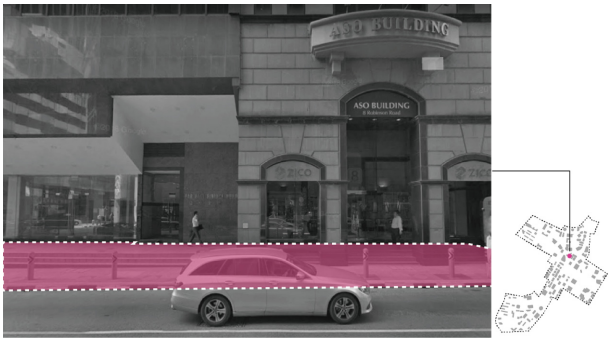


Figure 8b. Lower public spaces in No. 46 (Right) and No. 48 (Left) in Marina Bay.

furniture and greenery significantly worsens their mental stress (Ulrich et al., 1991). This becomes more conspicuous in Central's hinterland. Lujiazui and Marina Bay have more types of "street elements," but the low proportion of "shops" to "GL function" (usually banks instead of retail enterprises, which are less attractive) hampers public activities.

4.3. Evaluation Results of Buildings' Scale

Targeted analysis of buildings explains how those visual categories affect the qualities of lower public spaces. It is clear that there are some similarities among the low-rated buildings in the three CBDs. Most of those buildings have the "street" in "spatial typology," and provide narrow public spaces for pedestrians (Fig. 8(b)). The "building elements" of these buildings are usually "walls (low-transparency)" without shops to support street life. It is worth noting that the abundance of "street elements," although having higher weight in the hierarchy model, shows a weak influence on a particular building's rates. The largest distinction appears in "GL function." Although both No. 03b and No. 03c in Central perform well in other categories, the "parking lots" on the ground floor down pull their final rates (Fig. 8(a)).

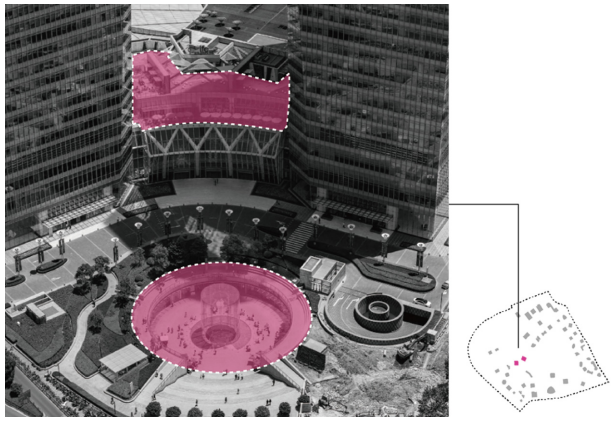


Figure 9a. Lower public spaces in No. 32a and No. 32b in Lujiazui.

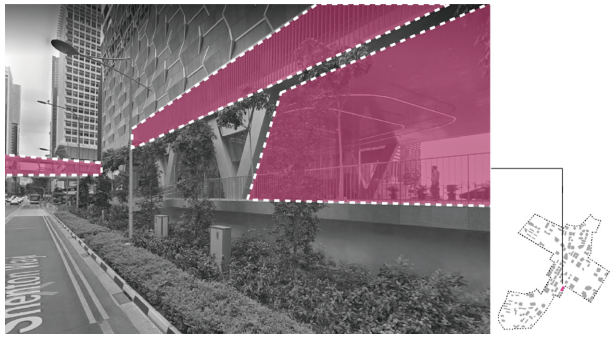


Figure 9b. Lower public spaces in No. 94 in Marina Bay.

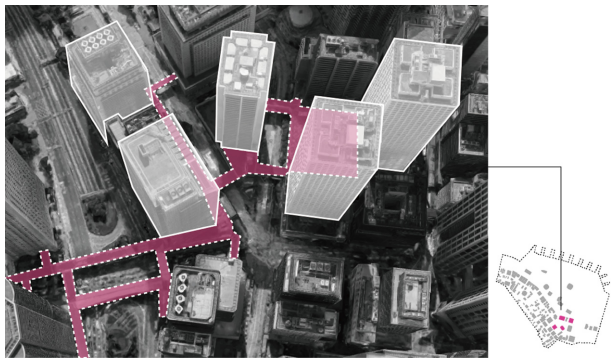


Figure 9c. Central elevated walkway among Nos. 43, 41, 107, 103a and 103b (from left to right) in Central.

However, providing various typologies for lower public spaces with better accessibility makes a notable contribution to high-rises' lower public spaces. In Shanghai, No. 32a and No. 32b are considered to have obviously better spatial qualities, because both provide a "sunken plaza" with multiple levels, which help to attract pedestrians to stay or rest (Fig. 9(a)). Moreover, both are connected by a "podium" with a roof garden above, containing greenery hanging over the rails that is easily noticed from street

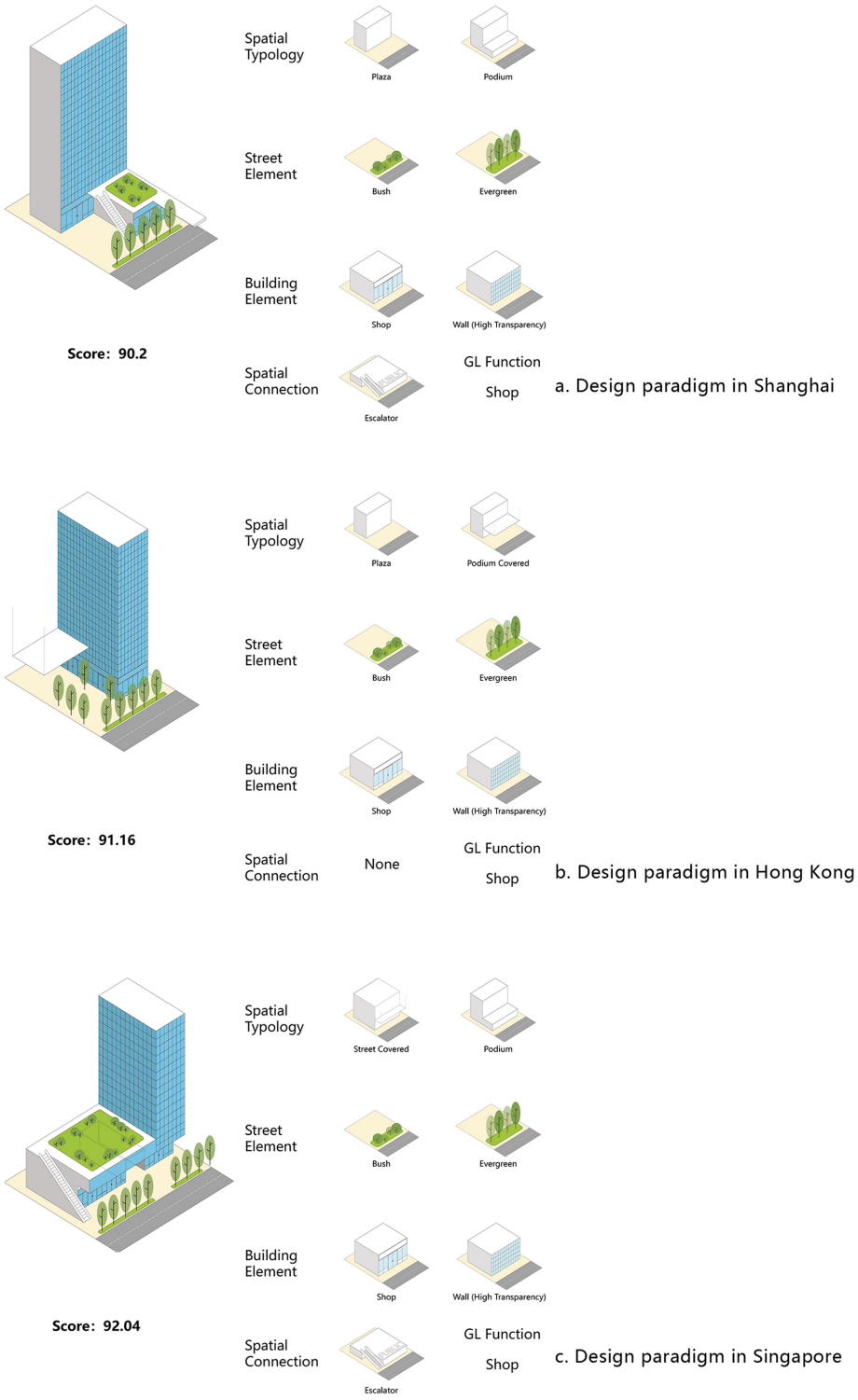


Figure 10. Design paradigm (a. Shanghai, b. Hong Kong, c. Singapore)

level. Examples in Marina Bay and Central prove the importance of a multi-level walking system to the success of lower public spaces in tall buildings. No. 94 in Marina Bay is linked with another building on the opposite side via a skybridge. The whole walkway on the second floor is also fully exhibited along the street façade. In addition, an access point in the middle of No. 94 provides a shortcut for pedestrians to cross the block, which improves the quality of its public space as well (Fig. 9(b)). The gathering effect of a multi-level walking system appears strongly

in Central. Nos. 41, 43, 103a, 103b, and 107 connected by a central elevated walkway extend their public spaces among each other, thereby overcoming the disadvantages brought by narrow streets and heavy traffic (Fig. 9(c)). These results prove the importance of a multi-level walkway in a high-density metropolis like Hong Kong.

5. Discussion

The analysis of around 300 tall buildings in three CBDs reveals some interesting understandings of the social impact of their lower public spaces. These spaces show a high degree of similarity, partly because most of the tall buildings counted share a similar "spatial typology" (usually "streets" or "covered streets," see No. 46 and No. 48 in Marina Bay). High-density development in those areas has crowded out room for public space, and concentrated those joint spaces into large and separated plazas that are historically foreign to Asian cities (Miao, 2013). Outside of those large-scale open spaces, the combination of tall buildings and their lower spaces are limited to a few typologies from cases in Lujiazui (No. 32a and No. 32b) and Marina Bay (No. 94) where we can see that the diversity of lower public spaces has a large and positive effect on the urban environment.

Based on the AHP analyses and cases from Central (Nos. 43, 41, 107, 103a and 103b), another possible strategy is to promote multi-level walking systems in CBD areas. The improvement from connecting public spaces among different blocks shows an obvious effect in the results above. Vertical pedestrian networks with high accessibility could mitigate the limits of cramped public spaces in particular buildings. Besides, creating public spaces in the vertical dimension could also release contradiction between FAR and civic activity demands.

Moreover, results from the morphological analysis and AHP could help to suggest appropriate design paradigms for the three CBDs. First, Lujiazui has been criticized for its large-scale and imperfect city functions (Liu et al., 2012). Given that reconstruction of the urban context and reform of public spaces has become a primary goal, it would be better to expand building volume into additional podiums using existing setback spaces, and provide room for retail enterprises and other urban facilities (Fig. 10(a)). A multi-level public space system could be built with a small-scale plaza and roof garden instead of large setbacks, bringing public spaces on a human scale back into this area. Second, the tall buildings in Central ought to engage with their surroundings more positively through plazas or pocket gardens around the sites' corners or edges (Fig. 10(b)). These public spaces could create open spaces and even passages for pedestrians. Given the local climate, the plaza could be partly covered. However, the case of a fully covered plaza in at the HSBC building in Hong Kong has led to unsatisfactory use of the environment due to its "hostile" design (Cuthbert et al., 1997). Hence, these spaces should be filled with plants and urban furniture for validating social activities. In addition, Marina Bay is faced with a new period of transformation because of the uneven and highly selective nature of multinational corporations (Wong, 2004). Creating an urban public system that connects this district as a whole matches the increasing demands for flexibility. A paradigm focusing on accessibility between the urban environment and several lower public spaces would be helpful. We suggest creating more passable public spaces on the ground level, with higher levels of gardens and platforms linked via clear connections, such as escalators (Fig. 10(c)). Covered streets should also be continuous between neighboring buildings given climate concerns. In the end, we evaluated the three design paradigms with the assessment method noted above. All of these design paradigms obtained ratings higher than 90 in our evaluation system.

6. Conclusion

Asian cities experienced a rapid transformation of their built environments in the late twentieth century. The high-density development model brought numerous challenges to the local urban environment, especially in newly-built CBD areas. Taking three CBDs in Shanghai, Hong Kong, and Singapore as cases, this study provides a quantitative approach to assessing the social impact of lower public spaces in these areas. The integration of typological analyses and AHP reveals how different patterns of tall buildings and their surrounding environments affect perceptual feelings. In this study we find that "spatial typology" and the presence of a "shop" have the strongest impact on positive social communications. The connection and accessibility of multiple public spaces also show great importance in place-making, which indicates a possible solution for high-density urban areas. The study also suggests appropriate design paradigms for the three CBDs based on the analysis. Both the assessment methods and design paradigms could be used for further urban designs that aim to create a human-oriented habitat in these areas.

However, this study contains several limitations as well. First, the current analysis takes into consideration only different impacts among several categories. The potential effects caused by high or low values in sub-categories are not fully taken into account. Further study is required to make in-depth assessments with detailed measurements of inner values among sub-categories. Second, the pool of experts invited for assessment needs to be expanded in the next step. Experts from other fields and users of lower public spaces in CBD areas ought to be included as well. Third, methods such as virtual reality (VR)/wearable devices will be included in our future studies. These new techniques can introduce an objective approach to measuring people's potential preferences for different patterns. They will also help to provide an immersive environment to improve the validation of analyses, which may help to control possible errors caused by the existing methods.

Acknowledgements

The authors would like to show our gratitude to the kind support of the Council on Tall Buildings and Urban Habitat and Sun Hung Kai Properties.

References

Ananda, J. and Herath, G. (2008) "Multi-attribute preference modelling and regional land-use planning," *Ecological Economics*, 65, 325-335.

Bender, A., Din, A., Hoesli, M., and Brocher, S. (2000) "Environmental preferences of homeowners: further evidence using the AHP method," *Journal of Property Investment and Finance*, 18, 445-455.

Bradley, M. A. and Daly, A. J. (1997) "Estimation of logit choice models using mixed stated preference and revealed preference information," *Understanding Travel Behaviour in an Era of Change*, 209-232.

Carmona, M., Heath, T., Oc, T., and Tiesdell, S. (2012) "Public places-Urban spaces," Routledge.

Cho, I. S., Trivic, Z., and Nasution, I. (2017) "New high-density intensified housing developments in Asia: Qualities, potential and challenges," *Journal of Urban Design*, 22, 613-636.

Craig, C. L., Brownson, R. C., Cragg, S. E., and Dunn, A. L. (2002) "Exploring the effect of the environment on physical activity: A study examining walking to work," *American Journal of Preventive Medicine*, 23, 36-43.

CTBUH (2018) CTBUH Height Criteria. [online] Available at: http://ctbuh.org/LinkClick.aspx?fileticket=KdtWFbXpBQc%3dandtabid=446andlanguage=en-US.

Cuthbert, A. R. and McKinnell, K. G. (1997) "Ambiguous space, ambiguous rights — Corporate power and social control in Hong Kong," *Cities*, 14, 295-311.

Elsheshtawy, Y. (1997) "Urban complexity: Toward the measurement of the physical complexity of streetscapes," *Journal of Architectural and Planning Research*, 301-316.

Ewing, R. and Handy, S. (2009) "Measuring the unmeasurable: Urban design qualities related to walkability," *Journal of Urban Design*, 14, 65-84.

Frank, L. D., Sallis, J. F., Conway, T. L., Chapman, J. E., Saelens, B. E., and Bachman, W. (2006) "Many pathways from land use to health: associations between neighborhood walkability and active transportation, body mass index, and air quality," *Journal of the American Planning Association*, 72, 75-87.

Gehl, J. (1971). *Life between buildings*. Kbh.: Danish Architectural Press.

Lee, G. K. and Chan, E. H. (2008) "The analytic hierarchy process (AHP) approach for assessment of urban renewal proposals," *Social Indicators Research*, 89, 155-168.

Liu, X. and Chen, Y. (2012) "From state perspective to everyday life perspective — A research on urban spatial transformation of Lujiazui central area [J]," *In Urban Planning Forum*, 3, 102-110.

Lo, S. M., Yiu, C. Y., and Lo, A. (2003) "An analysis of attributes affecting urban open space design and their environmental implications," *Management of Environmental Quality: An International Journal*, 14, 604-614.

Mehta, V. (2014) "Evaluating public space," *Journal of Urban Design*, 19, 53-88.

Miao, P. (Ed.). (2013) "Public places in Asia Pacific cities: Current issues and strategies (Vol. 60)," *Springer Science and Business Media*.

Nasar, J. L. (1990) "The evaluative image of the city," *Journal of the American Planning Association*, 56, 41-53.

Nosal, K. and Solecka, K. (2014) "Application of AHP method for multi-criteria evaluation of variants of the integration of urban public transport," *Transportation Research Procedia*, 3, 269-278.

Population.un.org. (2018) World Urbanization Prospects - Population Division - United Nations. [online] Available at: https://population.un.org/wup/Country-Profiles/.

Saaty, T. L. (2008) "Decision making with the analytic hierarchy process," *International Journal of Services Sciences*, 1, 83-98.

Safarik, D. (2016) "The other side of tall buildings: The urban habitat," *CTBUH Journal*, (1), 20-25.

Tan, P. Y. and Samsudin, R. (2017) "Effects of spatial scale on assessment of spatial equity of urban park provision," *Landscape and Urban Planning*, 158, 139-154.

Taylor, B. and Kwok, R. Y. W. (1989) "From export center to world city: Planning for the transformation of Hong Kong," *Journal of the American Planning Association*, 55, 309-322.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., and Zelson, M. (1991) "Stress recovery during exposure to natural and urban environments," *Journal of Environmental Psychology*, 11, 201-230.

von Klemperer, J. (2015) "Urban density and the porous high-rise: The integration of the tall building in the city - from China to New York," *International Journal of High-Rise Buildings*, 4, 135-142.

Wong, T. C. (2004) "The changing role of the central business district in the digital era: The future of Singapore's new financial district," *Land Use Policy*, 21, 33-44.