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Research Article

A Microclimate Study of Traffic and Pedestrianization Scenarios in a Densely Populated Urban City

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Urban streets are known to have a significant role in creating urban microclimates. This study aims to empirically quantify temporal and spatial microclimate variation within the same street configurations with pedestrian schemes. To evaluate the urban microclimates at the pedestrian level, a detailed monitoring project was performed at five representative locations near intersections, within a busy street canyon of the typical urban community in a densely populated urban city. Monitoring was done for warm and cool seasons. A strong, significant correlation ($p < 0.01$) was found under multiple time scenarios (traffic, nontraffic, and as a whole) and for both seasons. These findings suggest that the average urban daily temperature was not significantly reduced when there was no vehicular traffic present, whereas pedestrian activity contributed to urban heat regardless of the season. These findings provide an essential foundation for further studies on urban microclimates within pedestrianized areas and will likely lead to better urban design and policy management, especially concerning thermal comfort and Quality of Life at the pedestrian level.

1. Introduction

Urban microclimates are the most complex forms of microclimates and one of the most studied and researched topics by geographers and meteorologists [1]. Multiple urban climate studies have examined microclimate conditions influenced by environmental settings within an urban area [2–7]. Shahrestani et al. [5] revealed that microclimatic parameters are significantly influenced by the attributes of the urban textures in the field study for a dense urban area of London. In the Dhaka study, Sharmin et al. [6] indicated that diversity in urban geometry (i.e., tropical warm-humid context and deep or uniform urban canyons) could create significant variation in microclimatic conditions. However, the environmental performances of various causative microclimate factors, including vegetation, water body, anthropogenic heat, canyon geometry, and building factors, remain uncertain [7–9]. One of the most significant aspects of urban microclimates is the elevated air temperature within urban areas, as compared with surrounding rural areas, which is known as the urban heat island effects [10]. A typical urban environment has limited vegetation and is set amongst high-rise buildings and transport infrastructures. Urban environments are also characterized by growing energy consumption and escalating anthropogenic heat from air conditioners [11] and vehicles, as well as increasing disposal of industrial wastes and emission of toxic contaminants [12].

Thus far, a few studies have addressed urban microclimate using experimental wind tunnel modeling or computational fluid dynamic simulations [13–16] to model the complex urban environments in different spatial scales [16]. Also, those studies performed simulations over a short period during the hottest times of the year or under ideal weather conditions. Therefore, a field study that provides empirical evidence to quantify microclimate variation at the street level is vital to understanding the impact of environment and pedestrian activity on long-term temperature and seasonal change.

It is widely known that anthropogenic heat caused by human activities and people themselves are major contributors to microclimate variation [2]. Wong et al. [17] offered empirical evidence suggesting the concentration of anthropogenic activities from crowding as a major source of urban heat. Blows [18] and Wong et al. [19] established the "Penguin effect" and "Herd effect," respectively, to illustrate physiological changes in humans and effects of heat retention on an individual within overcrowded situations. Blows [18] also claimed that heat would transfer from people to the environment and result in a warmer microclimate. Pedestrianization and traffic-calming schemes are increasingly popular-planning policies in developing cities with compact urban development. The goal is to improve the quality of the environment by removing vehicular traffic from city streets. Using Hong Kong as a unique example of a densely populated urban city, pedestrianization is defined by the Hong Kong Transport Department [20] as "to restrict vehicle access to a street or area for exclusive use of pedestrians." These schemes not only improved pedestrian safety but also reduced air pollution and ameliorated the issue of lack of urban space. Areas in which the pedestrian schemes have been implemented have become popular places for street performers and economic activities, which more easily results in overcrowding. To date, most studies have focused only on the economic and social impact of pedestrianization [21, 22]. More studies that investigate the microclimate variations within pedestrianized areas would be timely and necessary to enhance the thermal comfort and Quality of Life within pedestrian areas.

Urban areas are usually covered by streets, and street design is known to have an impact on the urban microclimates [4, 23]. Urban streets vary in geometry and orientation, which influences the natural ventilation and solar radiation and has a significant impact on microclimates within street canyons and nearby environments [24, 25]. Chen et al. [4] reported that a commonly used indicator to describe urban geometry is the Sky View Factor (SVF), and their study in the high-rise, high-density urban areas of Hong Kong indicated that SVF is useful for understanding the microthermal climate in urban street canyons. These authors found that SVF is inversely proportional to the daytime intraurban temperature differences. Also, more previous studies have reviewed and compared urban microclimates across several neighborhoods with different street configurations [25, 26]. Besides, urban climate studies have mostly relied on meteorological measurements obtained from official urban weather stations. As regulated by the standards of the World Meteorological Organization (WMO), automatic weather stations are required to be situated in areas away from urbanized areas with a high volume of traffic and human activities. As a result, the urbanization effect might have been underestimated in some of the urban microclimate studies. This paper aimed to quantify temporal and spatial microclimate variations caused by heavy traffic and pedestrian activities. To control confounding variables and enhance reliability, the traffic and pedestrian activities were varied under the same street geometry. Also, this study aimed to empirically examine the microclimates within pedestrianized areas through the field study of air temperature measurements and to compare the overcrowding effects of pedestrian against heavy traffic in locations with low SVF. To examine the temperature variations at street level, a field monitoring study was conducted at five representative locations with characteristically different settings in a busy street canyon of Mong Kok in Hong Kong. To identify the causative microclimate factors within the urban street canyon, the study quantified the spatial-temporal distribution of air temperature with the integrative use of Geographical Information Systems (GIS) technology and low-cost sensors. The findings will inform future studies examining the microclimate variations of heavy traffic flow against pedestrian activities and might enhance the thermal comfort at the pedestrian level of a densely populated urban city.

2. Materials and Methods

2.1. Study Area. Hong Kong is one of the most densely populated megacities in the world, with more than 7.8 million inhabitants living within a total land area of approximately 1104 km^2. Most of the inhabitants are aggregated in urbanized areas (24% of the total land area) with a high density of high-rise buildings and skyscrapers and concentrated road networks [4, 11]. The typical subtropical hot and humid weather, along with the high proportion of the population residing in densely packed high-rise buildings with limited open spaces, results in severe thermal discomfort and elevates the energy consumption of the city [17].

This study examined a busy street canyon named Sai Yeung Choi Street South (SYCSS) at Mong Kok of Hong Kong (Figure 1) to gather evidence of temperature variations at the street level. The SYCSS is within areas with part-time pedestrian schemes that were implemented in 2000 [26]. Mong Kok is located in the Kowloon Peninsula of Hong Kong, set inland and away from the coast and with a limited sea breeze. Mong Kok is known as one of the most populated communities in the world [27] was classified as compact high-rise zone (LCZ1) based on the local climate zone (LCZ) classification system [28–30] and was recognized as one of the dominant LCZs in urbanized areas of Hong Kong [29, 30]. SYCSS is located in the heart of Mong Kok and represents a 650 m long urban canyon with an orientation of NNW-SSE direction. This urban street canyon is a typical deep canyon (average canyon aspect ratio (H/W)≈3.78 and average sky view factor (SVF)≈0.174). According to Wong and Chen [9], a street canyon with aspect ratio over 2 (or SVF below≈0.4) would be characterized as deep and with reduced natural ventilation. SYCSS is also a mixture of residential and commercial buildings and is a very typical urban street canyon in Hong Kong. The varied characteristics found within SYCSS, where some of the sections contain high traffic volume and high pedestrian flow at specific periods, enclosed within this deep canyon (low SVF), make it

(a) (b)

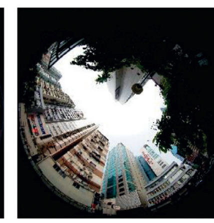
Figure 1: The map (a) and google™ earth 3D view (b) of Mong Kok with an illustration of the five study locations (A–E) along SYCSS. The photograph shows a section of the part-time pedestrian street.

excellent and unique for a street-level urban microclimate study. As reported by the Transport Department [26], during peak periods, the pedestrian flow within SYCSS can reach up to 20,000 pedestrians per hour. There was insufficient road space to accommodate both vehicular traffic and pedestrians, which contributed to traffic accidents. In 2000, a part-time pedestrian scheme and traffic calming were introduced in the crowded parts of SYCSS with a high pedestrian flow (begins from point B and ends at point E in Figure 1). Vehicular access is not allowed during specific periods (Monday to Saturday from 4 pm to midnight, Sunday, and public holidays from noon to midnight), and it is hoped that the reduced traffic flow in the traffic-calming areas can improve the street environment and pedestrian safety [26].

Figure 1 illustrates the five sampling locations near intersections (points A to E). Each location represents different characteristics across the 650 m long and straight urban canyon. Table 1 summarizes the respective features and characteristics of the five locations. The street canyon geometry (average H/W≈3.78 and SVF≈0.174) was similar throughout the five locations and had similar amounts of pedestrian flow and human activities (commercial and retail business). Point A represented major road conditions with a combination of a high volume of traffic and high pedestrian flow. Point A is one of the most common environmental conditions in Hong Kong. Point B, similar to point A, was situated along a major road with a combination of a high volume of traffic and high pedestrian flow. Point B was the beginning of the part-time pedestrian street with no vehicular access at specific periods. Point C, located in the middle of the urban canyon, was also within the part-time pedestrian street (with no vehicle access during specific periods), but it had a low volume of traffic flow (traffic-calming street implemented) perpendicularly across it at all periods. Point D is within the part-time pedestrian street, had no vehicle access at specific periods, and had high levels of pedestrian activities. Point E was at the end of the part-time pedestrian street and had similar traffic condition as point C, with average volume of traffic flow (traffic-calming street was implemented) during all periods. Point E was a small pocket park, 1364 m^2 in size (Figure 2(b)).

2.2. Instrument and Data Collection. At each sampling location (points A to E), the microclimate variable of air temperature was measured and collected by small and inexpensive sensors (Maxim Thermochron iButtons) [31]. The sensors equipped with loggers were each calibrated and housed in nonaspirated solar radiation shield (Onset HOBO RS3). Each of the housed sensors was mounted on designated roadside street signs posted at 2.3 m above ground, thereby complying the regulations of the Highways Department of Hong Kong (Figure 2(a)). The temperature accuracy of the sensors was better than ±0.5°C (from −10°C to +65°C), as stated by the manufacturer, with software corrections to measure temperature with 11-Bit (0.0625°C) resolution [32]. Also, the sensors were tested and validated

Table 1: Urbanization characteristics of five measurement locations (points A to E) with respect to the SYCSS.

Site	A	B	C	D	E
Road type	Major	Major	Minor	Minor	Minor
H/W ratio	4.55	2.91	4.31	3.56	3.57
Pedestrian scheme	No	PT (begin)	PT	PT	PT (end)
Traffic level	High	High	Low	None	Medium
Pedestrian flow	High	High	High	High	High
Characteristics	Full-time traffic flow	—	Traffic calming area	No traffic flow during the pedestrian hours	Small pocket park setting and traffic calming area
Sky view factor (SVF)	0.185	0.242	0.121	0.142	0.182
					

Note: PT = Part-time.

(a) (b)

Figure 2: The photographs showing (a) an iButton sensor and a shielded temperature sensor mounted on a street signpost and (b) a small pocket park setting with limited vegetation at point E.

against the official urban temperature record at the Hong Kong Observatory Headquarter (HKO), as illustrated in Wong et al. [17].

Temperature measurement was logged at 15-minute intervals continuously for 24 h over 7 days in the summer (15–21 Sept in 2012) and repeated in winter (19–25 Jan in 2013). The weather conditions during both sampling periods were consistent with the usual seasonal patterns and with no rain. Also, there were no typhoons or tropical cyclones over the South China Sea affecting Hong Kong. The air temperature was an average of 27.1°C (summer) and 18.5°C (winter). The average wind speed and direction were 5.9 m/s and 110 degrees (summer) and 5.4 m/s and 60 degrees (winter) [32].

The five sampling locations (points A to E) were strategically selected to represent different characteristics (i.e., traffic volume, pedestrian flow, and pocket park settings) across the 650 m long urban canyon for monitoring microclimatic variables. The traffic volume was referenced from the annual average daily traffic (AADT) provided by the Transport Department, whereas the pedestrian flow was estimated based on field observations at the sampling locations. Full meteorological conditions (i.e., air temperature, wind speed and direction, and rainfall) measured at the HKO were obtained at 1-minute intervals for the duration of the study [32]. These data were referenced and compared against sampled street-level measurements to examine microclimate variations.

2.3. Method of Analysis. The 15-minute air temperature readings collected by the iButton sensors for points A to E in summer and winter were first aggregated to hourly data. The hourly readings of each location (points A to E) were then plotted in line graphs across the temporal scale at an hourly interval over 7 days for both summer and winter. The official HKO temperature readings during the measurement period were also plotted alongside for reference and comparison. Average hourly temperature readings of points A to E were illustrated by box plot graphs. Official urban (HKO) temperature was also referenced. The summer and winter period were plotted alongside for contrast and comparison.

To further evaluate the microclimate differences between conditions of pedestrian activities versus heavy traffic, the summer and winter average daily temperature measurements of point A (full-time traffic) and point D (no vehicle access during the pedestrian period) were selected for further evaluation. To remove the background climatic effects before the analysis, the average hourly temperature measurements of both points A and D were first compared against official urban HKO to determine the urban temperature difference. The measurements of point D were further differentiated into two groups: traffic and nontraffic time periods. The nontraffic periods were expressed as 4 pm to midnight for all days for simplified calculations. The average hourly temperature readings were plotted in line graphs with both summer and winter data presented side-by-side for easy comparison. Student's paired t-test was also employed to examine the microclimate associations between point A and point D under three different time scenarios: traffic, nontraffic, and as a whole. The statistical outcome for point A and point D during the nontraffic period was used to examine the statistical and seasonal difference in various environmental conditions (i.e., high level of pedestrian activities and heavy vehicular traffic at major roads) that would contribute to the local urbanization effect within the deep urban canyon.

3. Results

Five different locations (points A to E) were examined for possible causes of temperature variability. Hourly temperature measurements over 7 days were plotted in line graphs with official urban HKO temperature alongside for reference in Figure 3. The figure shows that all locations exhibited similar temporal patterns of daily fluctuation throughout the study for both seasons. It is noteworthy that the five study locations consistently registered higher readings than the urban HKO. Figure 4 shows the average summer and winter measurements in boxplots. All five locations (points A to E) returned values above the average official urban HKO measurements (black dashed horizontal lines) for both seasons (by an average of 1.5°C and 1.3°C in summer and winter, respectively). The observations made from Figures 3 and 4 are expected since all of the five sampling measurements were conducted at the roadside of busy areas within Mong Kok, enclosed adjacent to vast amount of urban activities, whereas the official urban HKO site was in a park-like settings, away from major roads and traffic, as regulated by the WMO. For all locations, the winter measurements had greater diurnal temperature variations compared with the summer (7.4°C and 11.8°C on average) (Figure 4). Compared with urban HKO measurements, point A with full-time traffic returned warmer temperatures for summer and winter (by 1.7°C and 1.8°C, respectively). Compared with point A, points B to E with part-time pedestrian schemes appeared to experience slightly relatively cooler temperatures (by 1.4°C for summer and 1.2°C for winter), but these were still higher than the official urban HKO measurements. Note that the cooling effects of greeneries at point E were inadequate in both seasons. This observation is expected since the pocket park is small and with limited vegetation to mitigate the urbanization effects (as shown in Figure 2(b)).

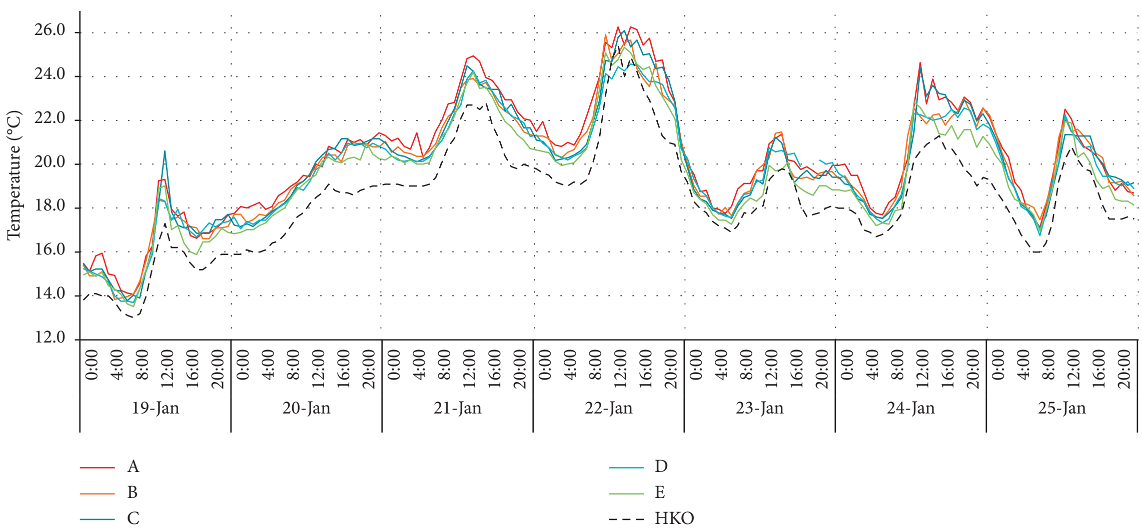
Figure 5 displays the daily (a) 24 h summer and (b) winter average of hourly temperature plots for point A (full-time traffic) and point D (part-time pedestrian street). Point D is characterized by distinct traffic (double line) and nontraffic (dotted line) periods. Official urban HKO measurements were included as a reference (black dashed line). Both locations exhibited similar patterns of fluctuations in the temperature for both seasons. Both locations experienced warmer summer and winter temperatures than the HKO at all time scales. Note that during the nontraffic period between 4 pm and midnight, temperature differences between point A and point D were 0.53°C and 0.23°C on average for summer and winter, respectively. Also note that in both seasons, point D, which has no traffic access during the evening hours, appeared to be warmer, similar to the conditions of point A with full-time traffic. Table 2 summarizes the average difference of urban temperature (compared against urban HKO) for points A and D. Table 2 also summarizes the statistical results comparing seasons at different periods: traffic, nontraffic, and all periods. Student's paired t-test revealed that the means of the urban temperature differences between points A and D were statistically different for both seasons during all periods ($p < 0.01$).

4. Discussion

Time-series temperature data collected along the roadside of SYCSS provided empirical evidence on the temporal patterns of microclimate variations in both seasons. The average temperature measurements (hourly) for points A to E demonstrated similar trends but recorded warmer temperatures (1.5°C and 1.3°C on average for summer and winter, respectively), compared to the official urban HKO. This was observed for all time scales in both seasons. The role of greenery to improve urban microclimate shows no influence in cooling the surrounding areas and alleviating the urbanization effects, as observed in the small pocket park at point E. This result is consistent with the findings of Wong et al. [17] and Ng et al. [33].

A noticeable but not significant (an average difference of 0.63°C) microclimate variations was detected along the 650 m long and deep street canyon. The comparison of average temperature (hourly) during nontraffic periods (4 pm to midnight) for points A and D quantifies the microclimate difference of high pedestrian flow and high traffic volume. Note that in both seasons, during the evening hours

(a)



(b)

FIGURE 3: Hourly temperature changes at points A to E over 7 days for both (a) summer and (b) winter. Note that, for comparison, the official urban temperatures measured by the Hong Kong Observatory (black dashed lines) were plotted alongside and registered lower readings consistently throughout the period.

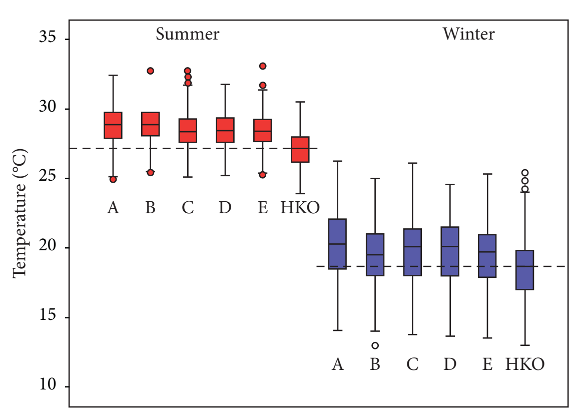


FIGURE 4: Boxplots of the temperature measurements for points A to E in summer and winter. Summer temperatures are shown in red boxplots, and winter temperatures in blue boxplots. Boxplots of the official urban HKO for both seasons are referenced (black horizontal lines). The small circles above and below the boxplots represented the outliers of the measurements.

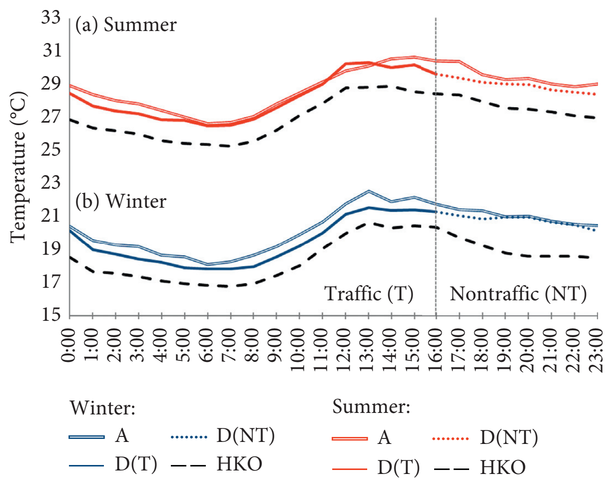


Figure 5: (a) Summer and (b) winter average temperature (hourly) measurements at point A (full-time traffic) and point D (part-time Pedestrian Street). Point A is illustrated by a double line, and point D is separated into two parts: traffic (solid line) and nontraffic periods (dotted line). The official urban (HKO) data from official urban weather stations is shown as a black dash.

Table 2: A statistical summary of point A and point D under different time scenarios in both seasons, compared against the official urban HKO. This allowed us to remove background climatic effects (urban temperature difference).

Season	Summer			Winter		
Period	Traffic	Nontraffic	All	Traffic	Nontraffic	All
Mean difference (A–D in °C)	0.28	0.53	0.36	0.60	0.23	0.48
Means test	0.00*	0.00*	0.00*	0.01*	0.00*	0.00*

*Statistical significance at $p = 0.05$.

(around 7 pm to 11 pm from Figure 5), the daily average of hourly temperature of point D (high level of pedestrian activities) appeared to be similar to point A (heavy traffic at the major road). This might be because these are peak hours, with a high level of pedestrian flow and urban activities (i.e., commercial, retail business, and street performance) along SYCSS. The statistical results on urban temperature difference revealed strong and statistically significant correlations ($p < 0.01$ in Table 2) between point A and point D under the various time scenarios (traffic, nontraffic, and as a whole) and both seasons. Both observational and statistical results confirmed that reduced traffic did not significantly lessen the microclimatic urbanization effect at the pedestrian level, whereas a high level of pedestrian activities contributed to a warmer microclimate in both seasons. This signifies a more severe problem that requires further examination.

5. Conclusions

This study presented empirical evidence on urban microclimate variations at the street level within pedestrianized areas in densely populated urban areas of Hong Kong, for both warm and cool seasons. Our findings along pedestrianized areas of SYCSS might not be precise because pedestrian traffic at different times of the day could have impacted the microclimate in different ways. However, the study does report interesting findings and has laid a good foundation for future studies addressing microclimate variations within pedestrianized areas of Hong Kong. The results found that heat impact is not entirely alleviated by a reduction of heavy traffic and observed high levels of pedestrian flow and activities that were statistically supported for both seasons in this study.

Further studies should assess the Physiologically Equivalent Temperature (PET) and thermal comfort of pedestrians and explain factors contributing to the variation within pedestrianized areas. Moreover, examination of the cooling effects of pocket parks with limited vegetation in compact urban areas of Hong Kong would be timely and necessary to inform better practice. A better understanding of microclimate variations at the pedestrian level will benefit urban design and policy management concerning thermal comfort and Quality of Life in urban areas that are expected to be homes to more than two-thirds of the world's population by 2025.

Data Availability

The sensor data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this paper.

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References

[1] Met Office, *The National Meteorological Library and Archive Fact Sheet 14—Microclimates*, Met Office, Exeter, UK, 2011.

[2] L. Gartner, *Heat Islands: Understanding and Mitigating Heat in Urban Areas*, Earthscan Press, London, UK, 2008.

[3] T. Susca, S. R. Gaffin, and G. R. Dell'Osso, "Positive effects of vegetation: urban heat island and green roofs," *Environmental Pollution*, vol. 159, no. 8-9, pp. 2119–2126, 2011.

[4] L. Chen, E. Ng, X. An et al., "Sky view factor analysis of street canyons and its implications for daytime intra-urban air temperature differentials in high-rise, high-density urban areas of Hong Kong: a GIS-based simulation approach," *International Journal of Climatology*, vol. 32, no. 1, pp. 121–136, 2012.

[5] M. Shahrestani, R. Yao, Z. Luo, E. Turkbeyler, and H. Davies, "A field study of urban microclimates in London," *Renewable Energy*, vol. 73, pp. 3–9, 2015.

[6] T. Sharmin, K. Steemers, and A. Matzarakis, "Microclimatic modelling in assessing the impact of urban geometry on urban thermal environment," *Sustainable Cities and Society*, vol. 34, pp. 293–308, 2017.

[7] C. M. Nakata-Osaki, L. C. L. Souza, and D. S. Rodrigues, "This tool for Heat Island Simulation: a GIS extension model to calculate urban heat island intensity based on urban geometry," *Computers, Environment and Urban Systems*, vol. 67, pp. 157–168, 2018.

[8] N. H. Wong and C. Yu, "Study of green areas and urban heat island in a tropical city," *Habitat International*, vol. 29, no. 3, pp. 547–558, 2005.

[9] N. H. Wong and Y. Chen, "Tropical urban heat islands: climate, buildings and greenery," *International Journal of Ventilation*, vol. 7, no. 4, pp. 379-380, 2009.

[10] J. A. Voogt and T. R. Oke, "Thermal remote sensing of urban climates," *Remote Sensing of Environment*, vol. 86, no. 3, pp. 370–384, 2003.

[11] Y. Wang, Y. Li, S. Di Sabatino, A. Martilli, and P. W. Chan, "Effects of anthropogenic heat due to air-conditioning systems on an extreme high temperature event in Hong Kong," *Environmental Research Letters*, vol. 13, no. 3, Article ID 034015, 2018.

[12] R. Giridharan, S. Ganesan, and S. S. Y. Lau, "Daytime urban heat island effect in high-rise and high-density residential developments in Hong Kong," *Energy and Buildings*, vol. 36, no. 6, pp. 525–534, 2004.

[13] R. Priyadarsini, W. N. Hien, and C. K. Wai David, "Microclimatic modeling of the urban thermal environment of Singapore to mitigate urban heat island," *Solar Energy*, vol. 82, no. 8, pp. 727–745, 2008.

[14] Y. Tominaga, "Visualization of city breathability based on CFD technique: case study for urban blocks in Niigata City," *Journal of Visualization*, vol. 15, no. 3, pp. 269–276, 2012.

[15] Y. Toparlar, B. Blocken, P. Vos et al., "CFD simulation and validation of urban microclimate: a case study for Bergpolder Zuid, Rotterdam," *Building and Environment*, vol. 83, pp. 79–90, 2015.

[16] Y. Toparlar, B. Blocken, B. Maiheu, and G. J. F. van Heijst, "A review on the CFD analysis of urban microclimate," *Renewable and Sustainable Energy Reviews*, vol. 80, pp. 1613–1640, 2017.

[17] P. P.-Y. Wong, P.-C. Lai, C.-T. Low, S. Chen, and M. Hart, "The impact of environmental and human factors on urban heat and microclimate variability," *Building and Environment*, vol. 95, pp. 199–208, 2016.

[18] W. T. Blows, "Crowd physiology: the "penguin effect"," *Accident and Emergency Nursing*, vol. 6, no. 3, pp. 126–129, 1998.

[19] P. Wong, P.-C. Lai, and M. Hart, "Microclimate variations between semienclosed and open sections of a marathon route," *Advances in Meteorology*, vol. 2013, Article ID 287934, 10 pages, 2013.

[20] Transport Department, "Pedestrianization," 2015, http://www.td.gov.hk/en/transport_in_hong_kong/pedestrianisation/pedestrianisation/index.html.

[21] C. Yim Yiu, "The impact of a pedestrianisation scheme on retail rent: an empirical test in Hong Kong," *Journal of Place Management and Development*, vol. 4, no. 3, pp. 231–242, 2011.

[22] T. Whitehead, D. Simmonds, and J. Preston, "The effect of urban quality improvements on economic activity," *Journal of Environmental Management*, vol. 80, no. 1, pp. 1–12, 2006.

[23] N. Shishegar, "Street design and urban microclimate: analyzing the effects of street geometry and orientation on airflowand solar access in urban canyons," *Journal of Clean Energy Technologies*, vol. 1, no. 1, pp. 52–56, 2013.

[24] P. Rajagopalan, K. C. Lim, and E. Jamei, "Urban heat island and wind flow characteristics of a tropical city," *Solar Energy*, vol. 107, pp. 159–170, 2014.

[25] A. Qaid, H. Bin Lamit, D. R. Ossen, and R. N. Raja Shahminan, "Urban heat island and thermal comfort conditions at micro-climate scale in a tropical planned city," *Energy and Buildings*, vol. 133, pp. 577–595, 2016.

[26] Transport Department, "Pedestrianization—MongKok," 2015, http://www.td.gov.hk/en/transport_in_hong_kong/pedestrianisation/pedestrianisation/mong_kok/index.html.

[27] M. Ingham, *A Cultural and Literary History*, Signal Books, Oxford, UK, 2007.

[28] I. D. Stewart and T. R. Oke, "Local climate zones for urban temperature studies," *Bulletin of the American Meteorological Society*, vol. 93, no. 12, pp. 1879–1900, 2012.

[29] R. Wang, C. Ren, Y. Xu, K. K.-L. Lau, and Y. Shi, "Mapping the local climate zones of urban areas by GIS-based and WUDAPT methods: a case study of Hong Kong," *Urban Climate*, vol. 24, pp. 567–576, 2018.

[30] Y. Zheng, C. Ren, Y. Xu et al., "GIS-based mapping of local climate zone in the high-density city of Hong Kong," *Urban Climate*, vol. 24, pp. 419–448, 2018.

[31] Maxim. DS1923 iButton capsule data sheet. Maxim integrated products, Rev 3. 2009.

[32] Hong Kong Observatory, *The Hong Kong Observatory Official Website—Hong Kong Observatory Weather Station*, Hong Kong Observatory, Hong Kong, China, 2015, http://www.weather.gov.hk/wxinfo/ts/display_graph_e.htm?hko&.

[33] E. Ng, L. Chen, Y. Wang, and C. Yuan, "A study on the cooling effects of greening in a high-density city: an experience from Hong Kong," *Building and Environment*, vol. 47, pp. 256–271, 2012.