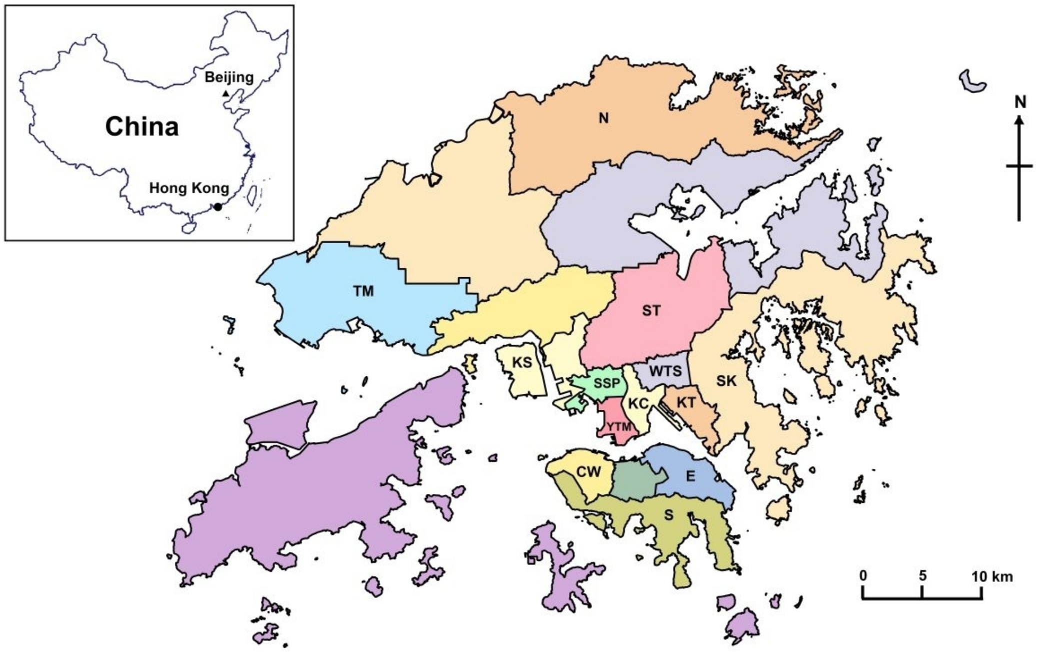

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How climate change perception is reshaping attitudes towards the functional benefits of urban trees and green space:

Lessons from Hong Kong

Abstract

Urban greening has rapidly emerged as a key urban climate change adaptation strategy. Urban greening is thought to confer manifold socio-ecological benefits upon residents in towns and cities. Yet proponents of urban greening have seldom considered how people's support for greening policies may be shaped by weather and climate. This paper reports the results of exploratory research examining public expectations of adverse weather changes and people's attitudes toward the functional benefits of urban trees and green space. Results of a questionnaire survey of 800 residents of Hong Kong indicate a positive relationship. Respondents tended to rate functional benefits as more important if they anticipated adverse weather changes in the near future, namely, rising temperatures, more tropical cyclones and prolonged rain. This subjective weather effect is more salient when these weather changes are perceived as a threat to one's daily life. We found urban greenery is assigned a higher value by individuals concerned about exposure and vulnerability to climatic stressors. Affinity for greening appears to be related to how weather and climatic variability is perceived. This observation is informed by a broader geographic perspective, which construes weather and climate as part of the spatial environment in which urban nature is apprehended and comprehended. An explanation for our findings is that increasingly volatile weather can potentially reshape urban residents' interactions with nature, based on perceived relief and/or protection from climate-related threats.

Keywords: urban trees; urban green space; weather; climate change; public perception; Hong Kong, greening

Introduction

Many city dwellers share a preference for places with trees and green space[1]. Scholars suggest that one explanation for people's affinity for urban greenery is that proximal greenery potentially confers environmental and social benefits upon urban residents (Chan et al., 2015; Cheung and Fok, 2014; Lo, 2012, 2016b; Roy et al., 2012; Wolch et al., 2014; Zhang and Jim, 2014). An emerging research theme is how attitudes toward greenery and uses of green spaces can influence people's perceptions of the overall socio-spatial environment (Balram and Dragicevic, 2005; Rossi et al., 2015). Research has found that people's attitudes toward urban trees and green spaces may be influenced by socio-economic and psychological factors (Jim and Shan, 2013; Tyrväinen et al., 2007). For example, Swanwick (2009) concluded that people's attitudes toward greenery are particularly sensitive to age, social and economic status, ethno-racial origin, familiarity with green spaces, place of upbringing and residence, and environmental value orientations.

Cultural connection and place attachment have emerged as another important factor shaping people's perceptions of, and preferences for, urban greenery (Arnberger and Eder, 2012; Byrne, 2012; Kaltenborn and Bjerke, 2002; Lo and Jim, 2010). For instance, Kaltenborn and Bjerke (2002), have shown that an affective (emotional) bond between residents and the place where they live is associated with general preferences for landscape. Such dynamic factors – although situated at a wider spatial scale – can in turn strongly influence human activities and place perceptions at the neighbourhood scale (Rossi et al., 2015). Surprisingly though, there has been less attention to a particular spatial context which can impact how people experience different places and their vegetation – that is, weather and climate[2].

In many ways, weather and climate constitute the geographic context in which people make sense of nature – and places (Hulme, 2008; Rayner, 2004; Strauss and Orlove, 2004). These contexts are easily discernable in popular stereotypes of weather and place - Melbourne, Australia is said to have four seasons in a day, Chicago is the windy city and it is always sunny in Florida. However, recent debates on climate change and its impacts on environment and human settlements have raised awareness of how people perceive the interactions between weather and climate, and how in turn this impacts their daily life (Adger et al., 2013; Jones et al., 2012). However, we know

[1] We define urban green space as open spaces situated within city limits with a vegetation cover planted deliberately or inherited from pre-urbanization vegetation left by design or by default. This generally accords with a systematic review of green space definitions (see Taylor and Houchuli, 2017).
[2] Both weather and climate concern changes in the conditions of the atmosphere, but the former involves a relatively shorter period of time than the latter.

comparatively little about the interaction effects between environmental perception and cognition, place attachment, weather and climate, and attitudes towards nature. Because the efficacious adoption of climate adaptation responses such as urban greening depends on place-based knowledge, these interactions warrant closer attention (Hall et al., 2012; Jim, 2015).

In this paper we examine how people's perceptions of expected weather variations associated with climate change might affect their subjective evaluation of urban trees and green space. We report the results of an intercept survey of park visitors that adopted an extended socio-ecological perspective by including the role of weather in assessing people's attitudes towards functional urban greening. We seek to broaden the conceptual scope through which public attitudes toward urban greenery are assessed and understood. Our aim is to ascertain whether impending weather-related adversities (e.g. flooding, heat-waves), linked to climate change, might impact urban residents perceptions of functional urban greening (e.g. cooling, reducing flooding, lessening wind-speed). Specifically, our research investigates the extent to which people's attitudes toward various functions of urban trees and green space are modulated by their expectation of future adverse weather events.

There has been a recent efflorescence of research investigating the role of urban greening as a potential climate change adaptation response (e.g. Byrne et al., 2016, Matthews et al., 2015). Our research seeks to contribute to that effort by better understanding the relationship between people's expectations of adverse weather related to climate change and their attitudes towards urban greenery. We hypothesize that people's attitude toward the functional benefits of urban trees and green space is positively related to their expectations and concerns about weather changes attributed to climate change. The research was conducted in Hong Kong.

Hong Kong is a subtropical coastal city and is known for its exceptionally high population density and concentration of human activities and infrastructures, rendering it vulnerable to weather extremes (e.g. typhoons) (Environment Bureau, 2015). Throughout the cramped urban core there is a grave lack of urban greenery (e.g. trees and vegetated sites) (Jim, 2002; Lo and Jim, 2012). Improved urban green infrastructure is needed to climate-proof built-up areas in the city, for example using green roofs to reduce urban temperatures (Peng and Jim, 2015). Yet previous research suggests that Hong Kong residents have a limited appreciation of urban greenery (Cheung et al., 2014, 2015; Lo and Jim, 2012, 2015). The expectation of dramatic climate changes and associated impacts for Hong Kong could impel residents to reconsider their hitherto weak connection with urban trees and green space, because trees and greenery can offer natural relief and protection.

Weather, people, and urban trees

The impacts of climatic changes are pervasive and traverse multiple spatial and temporal scales (Hulme, 2008, 2009). Awareness of increasing climate change related weather disturbances has begun to transform nature-culture dynamics in cities. Deeply entrenched beliefs that humans have the capacity to escape from disruptive climatic variability are giving way to the realization that in-situ adaptation is urgent and necessary (Hulme, 2009). Some authors contend that this presents an opportunity for reconsidering and transforming our connection with the natural world (Hulme, 2008, 2009; Rayner and Malone, 1998), because the impacts of climate change are reconfiguring socio-ecological relations across multiple scales of governance and lived experience. People's relationships with urban trees and green spaces are an example.

The expected impacts of climate change on cities have driven renewed interests in urban greening (Byrne et al., 2015; 2016). Extreme weather events related to climate change can damage properties, impede economic activities, and pose threats to human life. Urban greening – increasingly referred to as green infrastructure – is thought to confer multiple adaptive benefits, such as better food security, improved energy efficiency, and more efficient storm-water management. Scholars report that the functional benefits of urban greenery, which include modulating ambient air temperatures, intercepting rainfall, and lowering wind speed, can help adapt cities to climate change impacts (Byrne and Yang, 2009; Foster et al., 2011; Gill et al., 2007). For instance, heat waves, cyclones and rainstorms are expected to affect the security and quality of urban food supplies. Some scholars have found that risk-averse urbanites are increasingly motivated to grow their own food in local community gardens (Dubbeling and de Zeeuw, 2011; Guitart et al., 2012). Other researchers report that rooftop greening initiatives have begun to yield energy efficiency dividends and cooling benefits, offering a cost-effective way to adapt to a warming climate (Jim, 2015; Peng and Jim, 2015). In some cities, green alleys are being retrofitted to slow the rate of storm-water runoff onsite, thereby avoiding localized flooding (Foster et al., 2011). And new or renewed aquatic systems are increasingly being used to improve urban biodiversity (Kazmierczak and Carter, 2010). Although the greening of urban infrastructure has thus emerged as a key climate change adaptive response in many cities (Otto-Zimmermann, 2011), the link between people's expectations of future climate change related weather events and their attitudes towards the functional benefits of urban greenery is noticeably absent from the literature.

We argue that weather should be factored into our understanding of the cultural relationship between urban residents and urban greenery. This novel perspective is not evident in previous studies, which have concentrated on aesthetic experience, social-psychological benefits, and recreational needs (Konijnendijk, 2008; Peckham et al., 2013; Zhang et al., 2013). Only a handful of scholars have addressed a tangential issue – thermal comfort. Lafortezza et al. (2009), for example, found that park patronage could alleviate perception of thermal discomfort under heat stress conditions. Perceived benefits of urban trees, as shown by Byrne et al. (2015), are related to intended behavioral adjustments to cope with climate change. However, there is a lack of systematic evidence and a coherent framework for understanding how expected local weather changes might influence people's views about functional urban greening. Although proponents of green infrastructure – the purposive design, location and installation of green cover and associated infrastructure to address urban problems (e.g. storm water runoff, heat island impacts) - have recently begun to engage with climate change (Jim, 2015), weather has yet to be incorporated into conceptual and applied understandings of the spatial environment in which urban trees are apprehended, given meanings, and employed to improve urban livability.

At the individual level, we expect an observable relationship will exist between a lay person's expectations and concern about weather changes related to climate change and their attitude toward urban greenery (because it could mitigate the adverse impacts of such changes). We have examined this possibility using a survey dataset collected via intercept surveys with park visitors in the city of Hong Kong, a city beset by a history of hyper-urbanization and extreme deprivation of usable urban greenspace.

Study area

Weather changes

Hong Kong is situated at the southern coast of China and has a typical humid-subtropical climate influenced by the dominating Asian monsoon climatic system (Environment Bureau, 2015). The summer is hot and humid with frequent showers and thunderstorms, and occasional tropical typhoons (cyclones). According to the Environmental Bureau (2015), Hong Kong has experienced increased temperatures, more frequent extreme rainfall, and rising sea-levels related to climate change. The city is characterized by high population density and high concentration of infrastructure and economic activities in the urban area, rendering it vulnerable to extreme weather events (Environmental Bureau, 2015). Moreover, the dense packing of high-rise buildings with scant interstitial spaces has reduced ventilation and trapped both natural and anthropogenic heat within the urban fabric. Heat-waves have become more frequent and intense, and projections suggest that this trend will continue. The Hong Kong Observatory recorded rise in annual mean temperature, on average, by 0.12°C per decade from 1885 to 2014 (Hong Kong Observatory, 2016a). The average increase amounted to 0.16°C per decade during 1985-2014, suggesting accelerated recent increase. Rainfall records also indicate an increasing trend. In 1947-2012, annual total rainfalls rose at a rate of 38 mm per decade. Weather records indicate that Hong Kong is experiencing a changing climate (Lam et al., 2004; Lee et al., 2011).

Long-term projections suggest a trend of more frequent climatic turbulence. In this century, extreme rainfall events (at the hourly rainfall 100 mm or above) are expected to have a return period of 18 years, contracting from the observed 37 years in the 1900s (Hong Kong Observatory, 2016a). Return period for extremely hot days (daily maximum temperature at 35°C or above) diminishes from 32 years in the 1900s to 4.5 years in this century. Significant changes will become evidently discernible starting from the second half of this century. Very hot days will be more common by the 2050s with an annual frequency of 51 days, soaring to 89 days in the last decade of 21st century. Milder changes in rainfall are anticipated. The annual number of extreme rainfall days is projected to rise from 3.5 days (1980-1999) to 4.3 days (2050-2059) and later 5.3 days (2090-2099). Moreover, Hong Kong is situated on the standard track of tropical cyclones. Every year, two to three tropical cyclones skirt or pass through Hong Kong. But tropical cyclones have been decreasing since 1960s, at a statistically insignificant rate of 0.17 per decade (Lam et al., 2004, p. 39). In recent years (e.g., 2014 and 2015), the number of tropical cyclones reaching typhoon and super typhoon intensity, comparing with the long-term (1961-2010) average, has increased (Hong Kong Observatory, 2016b). Cyclonic impacts on the city can be acute and destructive due to the extraordinarily high concentration of human activities and infrastructure (Fok and Cheung, 2012).

Effective greening strategies have the potential to make cities like Hong Kong more climate-resilient (Byrne et al., 2016; 2015; Jim et al., 2015; Matthews et al., 2015). The functional traits of trees and vegetation cover could help mitigate some of the damage and costs created by weather extremes. Chronic shortages of urban green sites, however, are an enduring problem in Hong Kong.

Greenspace provision

The compact city of Hong Kong holds 7.3 million people in only 1,110 km^2 of land, yielding an average population density of 6,690 persons/km^2 (Census and Statistics Department, 2015), which is among the highest in the world. The tiny land area and rugged terrain has imposed physical limitations on urbanization, and built-up areas are squeezed into merely 24.2% of the land (Planning Department, 2015). The city's development history has been underscored by a continual struggle to win urban land from adjacent hills and seas. The excessively compact urban form has resulted in limited residual space for vegetation. Large assemblages of quality trees are concentrated in a handful of urban parks. Woodlands are not preserved in urbanized areas, and roadside trees lack effective maintenance. New small green pockets are increasingly segregated from densely inhabited localities which are chronically deficient in open-space provision (Jim, 2002, 2004; Jim and Chan, 2016; Lo and Jim, 2015). These pockets provide limited relief because of their tiny size, cloistered nature, poor landscape design and meagre vegetation cover. Official greening efforts are dominated by ornamental and aesthetic considerations of landscape plants.

Functional greening is only a recent advent in Hong Kong. Although not explicitly advocated as a planning objective, some of the functional benefits of urban trees could help mitigate the impacts of climate change. Rooftop greening trials, for example, have demonstrated some success (Peng and Jim, 2015). Green roofs can lower roof surface and ambient air temperature, thereby reducing building cooling load and saving energy costs. Private funds have been solicited to support trial installation of green roofs on the terrace of utility and institutional buildings. Broad-scale adoption by private residential buildings, however, encounters practical barriers due to maintenance cost and liability considerations compounded by decentralized site ownership. Green alleys provide permeable surfaces which can assist storm-water management in the event of localized flooding. Yet, there is little progress in installing green alleys through proper engineering and ecological retrofits. Large-scale urban forests and wetlands, which could buffer infrastructure and housing against flooding and cyclonic damage (Foster et al., 2011), are close to non-existent in main built-up areas.

The level of urban greening in Hong Kong, particularly functional greening, is far from adequate. Efforts to turn the growing aspirations for greening into innovative solutions are sluggish and piecemeal (Jim, 2002; Jim and Chan, 2016). Many substantive benefits remain unseen or fail to materialize due to the entrenched community mentality and persistent institutional barriers (Jim, 2004; Lo and Jim, 2015; Lo, 2015, 2016a). Creative efforts are needed to enlist support from all stakeholders, and it would be instrumental to cite the importance of trees for coping with periodic climatic disturbance. Advocating the functional benefits provided by urban greenery, including making the city more climate-resilient, could lend support to the cause. We therefore sought to answer the primary research question: 'are residents' attitudes towards the functional benefits of urban greenery dependent upon their expectations of future extreme weather events related to climate change?'.

Methods

Sampling method

The questionnaire survey was administered in 13 of the 18 local council districts in Hong Kong (Figure 1). These districts include the Central and Western, Southern, and Eastern (Hong Kong Island); Kowloon City, Kwun Tong, Sham Shui Po, Wong Tai Sin, and Yau Tsim Mong (Kowloon); Kwai Tsing, North, Sha Tin, Sai Kung, Tuen Mun (New Territories). They are home to about 80% of the Hong Kong population, and provide a comprehensive representation of the city's urban history, urban morphology, main land-use type, and socio-economic profile of residents. The research was based on face-to-face interviews and conducted in public areas. The sample was distributed amongst these districts according to approximate local population size. One major public park or multiple neighborhood parks were selected from each of the selected districts as study sites, based on proximity to housing clusters, pedestrian traffic, and suitability for executing the intercept survey. In Hong Kong, public areas offer more opportunities to approach residents for interviews than their household units. Most people in Hong Kong live in high-rise residential buildings guarded by security gates and checkpoints. Unsolicited visits are discouraged and estate managers tend to deny access to households for conducting non-government surveys. Our previous experience suggests that both residents and estate managers were more comfortable with conducting interviews in public areas than in the household units (Lo and Jim, 2010; 2012).

Park visitors and pedestrians passing-by the parks were invited to participate in the research. Many urban parks in Hong Kong are tightly integrated with the street footpath system with high pedestrian traffic. Therefore it is difficult to distinguish between bona fide park 'visitors' and 'non-visitors'. Stratified random sampling was adopted based on the latest available census data (2011). One out of every three visitors or passers-by over 18 years old was selected as respondents. The sampling quota was determined by age distribution in the district concerned. Trained interviewers were instructed to approach a particular age group when the sampling quota for the remaining age groups had been exhausted.

A university-based research service provider administrated the questionnaire survey. Several undergraduate students with prior interview experience were recruited as interviewers and trained in the survey procedure. Fieldwork was supervised and each completed questionnaire was checked in situ by the interviewer. Most respondents completed the interview within 10 minutes. Survey activities took place in autumn and winter, because Hong Kong is hot and humid during summer and spring, and some respondents would be reluctant to stay for the interview, thus lowering the response rate. The autumn and winter are relatively mild and suitable for outdoor fieldwork. The survey commenced in October 2012 (both weekdays and weekends) and finished in February 2013.

Survey instrument

A questionnaire solicited respondents' attitudes toward urban greening. The survey questions focused on the functions of urban trees and green space, instead of their different types or forms, because our study sought to explore the relationship between weather expectations and the perceived benefits of urban greening in general. The questionnaire presented seven different functions of urban trees and green space as a hedge against adverse weather changes, such as cooling, dampening wind, intercepting storm-water, etc. These survey items were selected for their potential role in climate change adaptation and relevance to the local context. Many of them are derived from similar studies on urban trees and green space in Hong Kong and China (Jim and Chen, 2006; Lo and Jim, 2012). A five-point Likert scale was employed to assess opinions, with options ranging from 'Very Important' (coded as 5) to 'Not at all important' (coded as 1).

The second part of the questionnaire gauged respondents' expectations about medium-term weather changes. It included six items, consisting of three pairs of questions each relating to a specific form of weather change, i.e. heat, prolonged rain, and wind. The first item of each pair probed belief about the possibility of an adverse weather change (i.e. hotter, more frequent rain, or more cyclones), and the second asked respondents whether or not that change would adversely affect their standard of living or convenience to daily life. Responses to these questions were elicited based on a five-point Likert scale, with options ranging from 'Strongly Agree' (coded as 5) to 'Strongly Disagree' (coded as 1).

Socio-demographic information about the respondents was also collected, including age, income, education, sex. Membership in an environmental organization and experience in volunteering were elicited and used as a general indicator of the frequency of engaging in environmental and social activities respectively. These variables were used to control for socio-economic effects and general attitudes towards environmental and social imperatives.

These three sets of data form the basis of a regression analysis. Attitude was regressed on the weather expectation and socio-demographic variables to examine the statistical relationship between them. Results of the quantitative analysis are reported in the next section.

Results

Response rate and respondent characteristics

A total of 800 face-to-face interviews were completed in the selected council districts. A comparable number (787) of individuals contacted on-site refused to participate or terminated the interview halfway through. This yielded a completion rate of 50.4%[3].

The socio-demographic profile of respondents is displayed in Table 1. The number of males (53.2%) exceeded females (46.8%). Most of them identified themselves in the 25 - 44 age group (38.8%), followed by the 45 - 64 group (33.8%). Senior respondents in their sixties or older (14%) were as numerous as younger ones aged 24 or below (13.5%). For personal income, 24.7% of respondents earned less than HK$8,000 (HKD/USD : 7.8/1.0) per month, and 31.1% had HK$8,000 - $14,999. There were 22.8% of respondents in the highest income group, i.e. $25,000 or above, and 21.4% in the $15,000 - $24,999 group. About 41.1% of respondents held a tertiary degree, 31.2% possessed a high school qualification, and 27.6% are at a lower education level (junior high school or below). Very few respondents (2.5%) reported general membership in an environmental organization. More than half (55.6) had experience in volunteering. The main difference between our sample and official census statistics is educational attainment. Well-educated individuals are over-represented in the sample. Care is required when interpreting the results reported below.

[TABLE 1 ABOUT HERE]

Public attitude toward urban greening

The level of agreement and the mean score for each survey statement about public attitude toward urban greening are reported in Table 2. Results indicate general affinity

[3] Response rate is 60.7% if those who agreed to participate but were not qualified or their age group had exceeded the quota were taken into account (417 individuals).

for urban trees. More than 95% of respondents affirmed the contributions of urban trees in carbon sequestration and providing shade on hot days. The great majority (93.6%) recognized the cooling effects of trees, although fewer of them (76.1%) recognized the role of rooftop greening in cooling buildings. All of these items recorded a mean score of 4 or close to 4. Only a small number of individuals failed to recognize these benefits.

[TABLE 2 ABOUT HERE]

Non-cooling functions attracted lower ranks, as indicated by the lower mean scores ranging from 3.12 to 3.51. More than half of the respondents (55.1%) acknowledged the capacity of urban trees for rainwater interception and thereby avoiding street flooding, but nearly one-third of them were undecided. A comparable number of individuals (53.9%) held a positive view about the wind-dampening function of urban trees which could minimize damage on infrastructure and buildings. Shelter against heavy rains found support from only 37.2% of respondents, and 29.9% were unconvinced.

An aggregate term was created for subsequent regression analysis by aggregating all of the seven items in Table 2. It is labeled as 'Public Tree Attitude' and has a Cronbach's alpha of 0.69, indicating a generally acceptable level of scale reliability.

Public expectation about weather changes

Itemized responses to probable weather changes are listed in Table 3. The vast majority of respondents (88.3%) believed that air temperatures in Hong Kong will increase (Item 1a), and slightly more (90.8%) were worried about the impacts on their standard of living (Item 1b) (Table 3). The mean scores across both items exceed 4, suggesting that the average respondent agrees that the weather is increasingly hot and this is an issue of concern, impacting their quality of life.

[TABLE 3 ABOUT HERE]

Less than half of the respondents (40.3%) expected more rainy days in the future (2a), while the marginal majority (46.5%) were undecided. Nevertheless, there were clear concerns about the potential impacts of prolonged rain on daily life, with agreement from 78.3% of respondents (2b). Similarly, slightly more than half (51.4%) were confident that cyclones would become more frequent in Hong Kong (3a), but most of them (82.1%) admitted that this would create inconvenience (3b). It is noteworthy that the respondents appeared to be uncertain about the likelihood of these weather changes, as indicated by the number of 'Neutral' responses. Concerns about the personal impacts of these changes, however, remain strong.

In the following analysis, each pair of weather variables is represented by an interaction term between expected likelihood and impacts, e.g. Item 1a multiplied by Item 1b, creating a new variable known as *Rising Temperature* (Table 3). The same procedure applied to the other two pairs of weather variables, resulting in two other variables, i.e. *More Cyclones* and *More Rain*. These interaction items denote public perception of risks associated with local weather change.

Regression analysis

Bivariate correlation coefficients between Public Tree Attitude and the three weather expectation variables are listed in Table 4. All of these coefficients have a positive sign and are significant at the .01 level. This suggests that the positive attitude toward urban greenery increases with the belief that the weather is becoming hotter, windier and wetter and that these changes would adversely affect the standard or convenience of living. The more the individuals expect volatile weather and are concerned about it, the more likely they are to rate the functions of urban trees as important.

[TABLE 4 ABOUT HERE]

The three weather expectation variables were included in a linear regression model (Table 5). All of these variables produced significant effects, and their predictive power remained robust when the other variables were controlled. *Rising Temperatures*, in particular, demonstrates the strongest impact. The interacting weather variables explain a total of 14% of the variance in the dependent variable (Public Tree Attitude).

Socio-demographic variables are included in a separate regression model. As shown in Table 5, only sex and income are statistically significant. Females and higher income individuals attribute higher importance to urban trees. However, this model accounts for only 2% of the variance. Explanatory power is much weaker than the weather expectation model.

A combined model was then constructed by merging the two models and excluding insignificant variables. Although sex remains a significant predictor, income lost explanatory power when weather variables were controlled. All of the three weather variables remain robust. The combined model explains 14% of the variance in the dependent variable.

[TABLE 6 ABOUT HERE]

Discussion

Hong Kong residents accord a high level of importance to urban trees (Lo and Jim, 2010). The present study shows that they place higher value on the role of urban trees in heat stress relief than other climate-moderating functions. Thermal perception and experience could offer an explanation for the widespread recognition of these contributions (Lafortezza et al., 2009). The subtropical climate of Hong Kong, coupled with aggravating urban heat island (UHI) effects, has contributed to the desire for natural cooling and thermal relief, leading to the higher ranking of the heat-ameliorating functions of urban trees. This observation corroborates similar studies in Guangzhou (Jim and Chen, 2006) and Gold Coast, Australia (Byrne et al., 2016), which have strong tropical sunshine in summer, but not in Nordic countries such as Finland (Tyrväinen et al., 2007), where summer is milder and sunshine is welcomed. Warm climates with a warming trend seem to heighten people's awareness of the heat-ameliorating functions of urban trees.

Importantly, the exceptionally compact mode of urban development in Hong Kong tends to accentuate the actual and perceived impacts of oppressive UHI. The overwhelming coverage by artificial materials of buildings and roads has generated a city with minimal urban green spaces and hence meager natural cooling by evapotranspiration with the help of solar radiation. The intense sunshine is actively absorbed and retained by the urban fabric meaning the city stays warm during both the day and night. The fast pace of urbanization, expressed as intensification of existing urban areas and extension into former countryside areas, likely heightens people's concern about rising urban temperatures. The urban environment is increasingly characterized by nature-depleting and heat-accumulating infrastructure, fortifying the general feeling of environmental degradation. The attitude toward warming in compact tropical cities like Hong Kong could be amplified by interactions amongst people, the built-environment and weather.

The warmer climate could also explain why many residents are concerned about the possible increase in the frequency of hot days. The local weather station has recorded an increasing trend of hot-day (diurnal maximum temperature exceeding 33°C) and hot-night (nighttime minimum temperature exceeding 28°C) (Hong Kong

Observatory, 2016a). Besides high ambient air temperature, the human heat sensation is aggravated by radiant energy emitted by warmed urban surfaces expressed as heat stress indices (Höppe, 1999; Thorsson et al., 2007). Such increased heat has implications on the health of the elderly, young and weak members of the community and workers involved in extended outdoor activities, with warnings now emphasized in weather bulletins. The de facto regular publicity and public education program has heightened residents' awareness and understanding of the heat-stress risks and related impacts. The more frequent incidences of exceptionally high temperature exacerbate heat stress with health and mortality consequences (Lam et al., 2010).

The increasing hot summer months have also pushed up air-conditioning use. About 63% of energy consumption in Hong Kong is used by buildings mainly for air-conditioning (Electrical and Mechanical Services Department, 2013). With rising electricity bills, the warming effect is hitting the pockets of vulnerable residents, especially those with limited income. Economic vulnerability thus reinforces links with climate change. Thus the anticipation of rising temperature can strike home more forcefully and effectively than other weather-change phenomena. Studies have shown that global warming belief is associated with actual fluctuations in ambient air temperature (Egan and Mullin, 2012; Joireman et al., 2010) and perceived deviations from usual temperature range (Li et al., 2011). The feeling of high air temperatures strengthens the belief that the global climate is warming and, by implication, the local weather is changing in similar ways.

Hong Kong's high relative humidity in summer worsens physiologically equivalent temperature and hence diminishes human thermal comfort. The sensation of high temperature has direct, internal, physical and physiological impacts on comfort and well-being. In comparison, increasing frequencies of rainfall or cyclones bring impacts that are largely external to the human body, rendering them relatively more tolerable. Their main consequences are more inconvenient than uncomfortable. Besides, these two extreme weather events are associated with cooling days, which may dampen the more dominating negative feeling toward warming – partly explaining our results.

As we noted in our introduction, weather influences how people think about the role of nature in providing natural relief and the safety of places. Our findings indicate a strong relationship between weather expectations and attitude toward the functional benefits of urban greenery. Functional contributions of urban trees received higher levels of appreciation when the individuals expected adverse weather variations in the future. This subjective weather effect is more salient when these variations are expected to pose difficulties to one's daily life. We have found that attitude toward urban greenery is thus a function of perceived risks associated with local weather change.

Our results suggest that when changes in weather and climate are seen as a threat, urban greenery may be more likely to be regarded as a source of relief and an important asset. Individuals who express concern about future weather changes assign a higher value to the functional benefits of urban greenery, perhaps expressing a newfound appreciation for urban green spaces. How individuals view short-term climatic fluctuations appears to alter how they evaluate the functional importance of urban greenery. Urban greenery can thus be understood and subjectively assessed within a broader spatial context within which people experience cities and their vegetation, a context comprised by weather and climate, that has rarely been acknowledged by previous studies.

A growing cadre of researchers are finding that awareness of climate change impacts is associated with how human communities relate to the natural environment (Strauss and Orlove, 2004; Hulme, 2009). We have found evidence that residents' awareness of increasingly volatile weather events, linked to climate change, may influence their (inter)connections with nature, including urban greenery. The spatial scale by which urban greenery is understood thus needs to be extended from the body to the atmosphere. The results of our research imbricate people, trees, cities and weather to each other in new ways. We argue that weather and climate are fundamentally part of the socio-ecological environment in which urban greening is occurring. It is odd then, that less attention has been given to understanding their role in shaping residents attitudes to urban greening. We believe scholars need to give greater attention to the interrelationships between people, trees, cities and weather, because these interrelationships seem to influence people's attitudes towards the functional benefits of greenery. Getting urban greening right – as a key climate change adaptive response – will depend on a nuanced appreciation of these sorts of dynamics in built environments.

Conclusion

The planning and management of urban greenery can incur high opportunity costs in compact cities, where land scarcity is pervasive. Pragmatic needs for urban development often override the imperative for preserving or expanding greenspace. However, the prospects for future weather extremes associated with climate change require reconsideration of the logic underpinning greenspace protection, and strengthen the rationale for urban greening. Compact cities such as Hong Kong are in need of functional urban greening to cope with the changing climate. Our findings suggest that residents' demand for urban greenery is likely to grow as local weather becomes more volatile.

Results of our study suggest that individuals who are concerned about their exposure and vulnerability to climatic stressors tend to assign a higher value to urban greenery. This observation is understood from a broader geographic perspective that accounts for the impacts of expected weather change. People's encounter with nature in the spatial environment is shaped by weather and climate. The desire for more urban trees and green elements in the city is linked to how climatic variability is perceived. A possible explanation that warrants further investigation is that increasingly volatile weather has led, consciously or unconsciously, to a renewed interest in connecting to nature in new ways that could offer relief and protection from perceived climate-related threats.

We suggest that attitudes toward urban trees should now be conceptualized at a wider spatial scale and in the context of the overall environment, and are not limited to personal or neighborhood characteristics and the immediate spatial context in which individuals interact with and evaluate green elements. The scale by which these attitudes can be understood is extended from the body to the atmosphere. Further research should test this assumption and explore the potential for generalization to other cities in other climatic zones (e.g. temperate areas, arid areas) and across differing urban morphologies (e.g. sprawling cities, linear cities etc.). Future research should also consider the possibility that culture may mediate the degree of the relationship we have found here – heightening or diminishing it depending upon the extent of green areas and affinity for nature. Would the same relationships be found in the sprawling mega-cities of Africa, consolidating cities in Australia, or other compact cities in sub-tropical Asia? Would city dwellers express the same affinity for trees if the climate was stormier and windthrow was a concern, or more arid and bushfire risks were heightened?

This scaled-up conceptualization of urban greening could inform the formulation of different communication strategies aimed at enhancing the public's understanding of functional urban greening. Tree conservationists and environmental campaigners could maximize public support by articulating the functional benefits of greening more explicitly and creatively in terms of the potential catastrophic changes in weather and climate (Byrne et al., 2016). Individuals who are concerned about the prospects for increased weather volatility and associated impacts on daily life may offer greater support to urban greening initiatives, regardless of their prior knowledge about contributions of urban trees to adaptation to climate change. As Hulme (2009) suggests, climate change may be an opportunity for humanity to reconsider our connection with the natural world. This impending 'crisis' may open up new opportunities for significantly increasing urban green cover, especially for compact cities where green spaces scarce.

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Table 1 Socioeconomic characteristics of respondents

Socioeconomic variables	Categories	Sample	Census
		Frequency (%)	
Gender	Male	53.2	46.7
	Female	46.8	53.3
Age	18 – 24	13.5	10.4
	25 – 44	38.8	37.0
	45 – 64	33.8	36.9
	≥ 65	14.0	15.7
Monthly Personal Income (HK$)^	0 - $7,999	24.7	27.2
	$8,000 – 14,999	31.1	34.1
	$15,000 – 24,999	21.4	19.6
	≥ $25,000	22.8	19.1
Education	Junior high school or below	27.6	53.9
	High school	31.2	25.1
	Tertiary degrees	41.1	21.0
Environmental membership	Member in an environmental organization	2.5	N/A
	Not a member	97.5	

Volunteering	Have experience in volunteering	55.6	N/A
	Do not have such experience	44.4	

^ HKD/USD = 7.8/1.0. Some of the percentages do not add up to 100 due to rounding-up.

Census statistics were extracted from the 2011 population census online database: (census2011.gov.hk).

Table 2 Public attitude toward selected functions of urban greenery

Model variable	Survey Statement	Important #	Neutral (%)	Not important^	Mean	SD
Public Tree Attitude (α = 0.69)	Trees can sequester carbon dioxide, mitigating greenhouse effect	95.8	2.9	1.3	4.41	0.62
	Trees can provide shading on hot days	95.2	3.6	1.2	4.32	0.62
	Trees can reduce urban temperature and avoid overheat	93.6	5.0	1.4	4.28	0.63
	Greening rooftops can cool down building and reduce indoor temperature	76.1	18.5	5.4	3.92	0.80
	Urban greens can trap rainwaters, avoiding street flooding	55.1	31.3	13.6	3.51	0.89
	Trees can stop winds, thus reducing the damage on urban infrastructure and building	53.9	28.7	17.4	3.46	0.97
	Trees can provide shading on rainy days	37.2	32.9	29.9	3.12	0.98

including 'Very important' (5) and 'Important' (4) responses. ^ including 'Not very important' (2) and 'Not at all important' (1) responses.

Table 3 Public expectation about weather changes

Item	Survey Statement	Agree#	Neutral (%)	Disagree^	Mean	SD	Correlation
1a	I believe the weather in Hong Kong will become hotter in the next few years	88.3	9.2	2.5	4.09	0.66	-
1b	Hotter weather will affect my standard of living	90.8	7.2	2.0	4.22	0.67	-
1a x 1b	Interaction term: *Rising Temperature*				17.46	4.58	0.41
2a	I believe Hong Kong will have more rainy days in the next few years	40.3	46.5	13.2	3.32	0/78	-
2b	More rains will create inconvenience to my daily life	78.3	15.9	5.9	3.92	0.78	-
2a x 2b	Interaction term: *More Rains*				13.17	4.56	0.29
3a	I believe cyclones in Hong Kong will become more frequent in the next few years	51.4	40.3	8.2	3.52	0.78	-
3b	More cyclones will create inconvenience to my daily life	82.1	13.9	4.0	4.02	0.75	-
3a x 3b	Interaction term: *More Cyclones*				14.30	4.66	0.26

including 'Strongly agree (5)' and 'Agree (4)' responses. ^ including 'Disagree'(2) and 'Strongly Disagree' (1) responses. All correlation coefficients are significant at the 0.01 level.

Table 4 Bivariate correlations between resident attitude toward urban greenery and expectations about weather changes

Variable	Rising Temperature	More Rains	More Cyclones
Public Tree Attitude	.343**	.251**	.257**

** denotes significant at 0.01 level (two-tailed)

Variable	Weather expectation model		Socio-demographic model		Reduced model	
	Beta	t	Beta	t	Beta	t
(Constant)		43.981		84.42		32.52
Female			0.10	2.82 **	0.08	2.16 *
Aged 45 or above			-0.02	-0.40		
Monthly income HKD15,000 or more			0.08	2.03 *	0.05	1.33
Tertiary degree			0.05	1.26		
Environmental membership			0.05	1.49		
Volunteering			0.02	0.56		
Rising Temperature	0.27	7.29 **			0.25	6.73 **
More Rains	0.10	2.44 *			0.10	2.38 *
More Cyclones	0.10	2.34 *			0.09	2.15 *
Adj. R^2		0.14		0.02		0.14
F statistic		41.214		3.60		14.021
Std. Error		3.05		3.28		3.01
Total df		754		764		736

* denotes significant at 0.05 level, and ** at 0.01 level

Dependent variable: Attitude toward urban greening

Table 5 Regression models for public attitude toward urban greening

Figure 1 Location of sampling sites in Hong Kong

Caption:

CW - Central and Western District ; S - Southern District; E - Eastern District; KC - Kowloon City District; KT - Kwun Tong District; SSP - Sham Shui Po District; WTS - Wong Tai Sin District; YTM - Yau Tsim Mong District; KS - Kwai Tsing District; N – Northern District, ST - Sha Tin District; SK - Sai Kung District; TM - Tuen Mun District.