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Research

Evaluation-perception of site attributes and plant species selection in the public urban green space of a compact city

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ABSTRACT. Understanding citizens' evaluation of public urban green space (UGS) attributes and plant species features can inform greenspace design to meet public expectations. This study evaluated the public's responses to UGS attributes and plant species in Hong Kong using a questionnaire survey of 827 adult respondents. Principal component analysis followed by cluster analysis were applied to analyze the data. The respondents were differentiated into three groups (ecological, eclectic, and pragmatic users) based on the evaluations of UGS attributes. Additionally, three clusters (conservation supporters, all-round perfectionists, and safety defenders) were classified based on evaluating plant species features. Plant knowledge and gender were the main factors associated with respondents' evaluation profiles. Respondents with different expectations of UGS attributes harbored different evaluations of plant species features. The respondent groups agreed unanimously that similar plant species composition was deployed across UGS sites in Hong Kong. Respondents attaching importance to the conservation value of plant species (i.e., "conservation supporters") were more concerned about plant species selection. The conservation supporters were dissatisfied with the current plant selection strategy. A zonation strategy for large UGS could cater to a broad range of user demands and create a socially-inclusive venue for residents. Alternatively, a collection of small UGS in a given district can cover a range of functions. The findings could inform a modified approach to UGS design and plant selection to satisfy the residents' disparate expectations and needs.

Key Words: *biodiversity conservation; citizen perception; Hong Kong; park design attribute; park management; plant species selection; urban green space;*

INTRODUCTION

Public urban green space (hereinafter referred to as UGS) is an essential infrastructure in compact cities where most residents do not have private green spaces. When without information about local perceptions and preferences for plant selection in UGS, landscape designers and managers often select species intuitively according to horticultural fashion or personal fad. Older UGS projects were often designed and managed in such a conventional mode when user perception surveys were not common and budget for surveys was not available. Such a gap in user perception may result in plant composition that does not match citizens' expectations. City-wide citizen perception studies could be conducted to glean relevant opinions to articulate and fine-tune plant selection strategies. When available resources could generously fulfill citizens' expectations, the management needs to be flexible and tries to satisfy the expectations of different citizen groups to realize UGS's multifunctionality (Haaland and van Den Bosch 2015).

Our study defined public UGS as sites accessible to the general public in urban areas. They are mostly designed, managed, and owned by the local authority, serving a wide range of residents and providing diverse functions. The innate traits and management of UGS can affect visitor composition and spatio-temporal usage patterns (Hu et al. 2023). Private UGS, such as domestic gardens, differ notably from public ones, as residents determine the landscape design, plant species selection, and planting practice according to their preferences (Loram et al. 2011, Lin et al. 2017).

Regarded as a community facility, public UGS serves mainly outdoor activities like strolling, jogging, playgrounds for children, and social interactions (Kabisch and Haase 2014). It offers a surrogate natural environment in the urbanized setting for people to experience and relate to nature (James et al. 2009). It also provides ecosystem services like regulating environmental quality (Escobedo et al. 2011, Du et al. 2017) and biodiversity conservation (Goddard et al. 2010, Gomez-Baggethun et al. 2013, Haase et al. 2014).

People visit public UGS for different purposes related to their preferences for some site attributes (Bertram and Rehdanz 2015). Public UGS can be designed to fit the need of residents, maximize the value and utilization rate (Rasidi et al. 2012,) and allow inclusive access for visitors with diverse socioeconomic backgrounds (Larson 2017, Lee et al. 2019). Moreover, UGS has been increasingly enlisted to enhance biodiversity conservation (Aronson et al. 2017), demanding dedicated design and management interventions. Understanding the expectations of residents on public UGS can identify and resolve the potential barriers to managing green space for both visitors and nature.

Many studies have identified the public UGS characteristics driving visitor preference and behavior by gleaning respondents' views in different regions, such as Europe (Özgüner 2011, Bertram and Rehdanz 2015, Daniels et al. 2018, Madureira et al. 2018) and Asia (Qureshi et al. 2013, Zhang et al. 2013). Some studies found that the cultural context can affect residents' expectations of UGS (Özgüner 2011, Madureira et al. 2018). Besides,

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contextual factors like the neighborhood's quality and attractiveness and UGS's history can affect preference (Schwarz et al. 2021). Location-specific investigations could ascertain the uniqueness and commonality of the underlying factors and processes.

Research focusing on Hong Kong residents living in a highly developed and ultra-compact city may throw light on residents' views in other cities with a similar urban fabric. Some earlier studies in Hong Kong explored cognate public UGS issues to inspire our project, such as the preferred functions (Lo and Jim 2012) and the usage and attitude among different residential communities (Lo and Jim 2010). Our study focused on the preferred characteristics of public UGS, including tangible and intangible ones. As we aimed to provide implications on the design of UGS, contextual factors were outside our study scope.

Atiqul Haq and others (2021) provided a holistic review of public perceptions on the roles UGS can play in climate change. Among the studies on people's attitudes toward UGS, the preferences toward landscape characteristics were evaluated (Jim and Chen 2006, Zhang et al. 2013, Qureshi et al. 2013, Wang and Zhao 2017), few have tackled evaluating plant-species features, even though plants are the key component of green space. Among the studies focusing on plant species features, Goodness (2018) investigated the selection of plant traits in urban parks by park managers but not the public visitors. Other studies evaluated visitors' differential preferences for aesthetic quality (Rahnema et al. 2019) and origin (Hoyle et al. 2017) of plant species in UGS. Studies that assessed multiple attributes tended to cover tree species only (Avolio et al. 2015, Gwedla and Shackleton 2019) or focus on private gardens (Kendal et al. 2012, Lin et al. 2017, Kaya et al. 2018).

Thus far, no study has linked the evaluations of UGS attributes to plant species features in UGS. We reckoned that this association could inform the species selection strategy of public UGS to better meet the clientele's expectations. Meanwhile, the public's views toward plant species selection in public UGS could also hint at the need to improve the current species selection strategy. Unlike private gardens with species composition largely determined by individuals (Philpott et al. 2020, Lin et al. 2017), plant species selection in public UGS is mainly determined by the municipal forestry staff, park managers, or landscape architects (Conway and Vander Vecht 2015). It is important to understand the views of the public UGS users to inform and refine the plant species selection strategy. No previous research indicated divergence or convergence of user expectation and their linkages with socio-demographic variations. Users' conflicted and contradictory feelings about different UGS features and qualities will possibly direct to the hybrid nature of parks with diversified designs and ecosystem service goals.

Accordingly, we aimed at four study objectives: (1) to explore the public's evaluations of different UGS attributes and plant species features in public UGS and analyze the driving factors of the evaluations; (2) to establish the connection between the evaluations of public UGS attributes and plant species features; (3) to understand the public view on current plant species selection strategy in UGS and its relationship with evaluations of plant species features; and (4) to discuss the implications of the findings on UGS design and management.

METHODS

Study area

Our survey was conducted in Hong Kong, a typical compact city on the southern coast of China. The 7.3 million population is accommodated mainly in 25% of the small land area of only 1106 km² beset by rugged topography with little flat land for urban development. It has a subtropical monsoon climate characterized by humid and hot summers and dry and cool winters. The Hong Kong government owns most of the public UGS managed by different departments. In the past five decades, landscape design and construction of public UGS have been increasingly contracted out to the private sector.

The main UGS types include urban parks, sitting-out areas, roadside greenery, and publicly accessible gardens and parks embedded within the grounds of public housing estates which accommodate about half of the population. The provision of green space has become an essential element in public housing estates constructed after the 1970s (Deng et al. 2016). The current UGS stock contains 26 major parks and over 1500 small parks and sitting-out areas (LCSD 2020). In 2014, the government initiated the Greening Master Plan to enhance urban greenery on roadsides, aiming at planting over 400 million mainly herbs and shrubs (CEDD 2012, 2019).

Questionnaire survey and sampling method

A questionnaire was developed based on the literature on plant species selection and landscape design in UGS and the researchers' observation of local green sites (Appendix 1). Our hypotheses are:

1. Citizens of different socio-demographic groups vary in preferences for landscape design attributes and plant species selection
2. Citizens with different knowledge levels and understanding of nature and plant-related matters vary in preferences for landscape design attributes and plant species selection.

Thus, questions in the questionnaire investigated the evaluation of UGS attributes and perception of UGS plant species. It was divided into four parts. First, we gauged the respondents' knowledge about plant species by asking about the number of plant species they could recognize and the geographical origin of six common plant species in Hong Kong. Second, we asked respondents to rate the importance of seven UGS features related to greenery and venue usage. Third, we asked how they judge the importance of nine criteria in selecting plant species in UGS. The degree of importance was rated by a five-point Likert-type scale, from "1" for "not important" to "5" for "very important." Fourth, we investigated their satisfaction with the plant species selection strategy in UGS. We asked respondents to score three statements using a five-point Likert-type scale, from "1" for "strongly disagree" to "5" for "strongly agree." Lastly, we collected basic data on their socio-demographic characteristics, which were compared with the census data to evaluate sampling representativeness.

A pilot test was conducted before live data collection. A total of five citizens from different age groups were invited to participate in the survey. They were then interviewed individually within two days after filling in the questionnaire. The pilot-test respondents were asked to comment on the overall impression of the survey, the length of the survey, what they thought it was trying to achieve, and whether there were ambiguous and biased questions. Besides minor adjustments of some words, no significant amendment to the survey questions was found necessary.

The questionnaire was distributed online from October 2016 to June 2017 to probe the opinions of adult residents in Hong Kong. To respect the privacy concern, respondents could choose not to disclose some personal information, in which case the blanks would be counted as missing values in data analysis. Hong Kong adult residents are generally disinterested in accepting on-street, mail, and telephone surveys. They may misinterpret academic questionnaires as commercial or marketing surveys and perceive them as irritating disturbances and social nuisances. They often refuse to accept on-street survey invitations from the onset. They live in high-rise buildings with tight security restrictions cordoned by security gates and guards, making face-to-face questionnaire survey administration difficult to achieve (Lo and Jim 2010, 2012). To overcome these research constraints, this study organized an online survey to allow interested people to take part in the questionnaire survey. Subject to the limited resources and human resources, survey participation invitations to the adult population were electronically disseminated via social media and instant messaging applications. Versions in Chinese and English, the principal languages used in Hong Kong, were provided. Public UGS was defined as green spaces accessible to the general public and situated in urban areas. We collected 827 valid responses.

Statistical analysis

Data analysis was conducted using the R studio (version 1.2.5042). The principal component analysis (PCA) with a varimax rotation was applied to the data to assess seven UGS attributes and nine plant species features. Factors with eigenvalues > 1 were retained. The seven features were then loaded into the individual factors. PCA allowed the high dimensional data to be captured in fewer dimensions to reduce data complexity. The K-means cluster analysis used the PCA factor scores to classify the respondents based on their evaluation profile for UGS attributes and plant species features. Applying a K-means clustering analysis followed by a PCA has been adopted in different studies to segment respondents with different attitudes based on a five-point Likert scale survey and hence to identify the relationships between the attitudes and personal characteristics (e.g., socio-demographic characteristics) for marketing and policy-making purposes (e.g., Lai et al. 2009, Hyland et al. 2016, Islam et al. 2021). The silhouette method determined the optimal number of clusters (Kodinariya and Makwana 2013). The number of clusters resulting in the highest silhouette score, a measure of the similarity of a point to its cluster as compared to the neighboring clusters, was selected. We explored the relationships among the evaluations for UGS attributes, perception of species selection, and respondents' demographic characteristics by chi-squared test for association between categorical variables, Spearman correlation for the association between continuous and ordinal variables, Kruskal-Wallis H Test and Wilcoxon rank sum test for comparing numerical data that were not normally distributed. A p-value < 0.05 was adopted as statistically significant.

RESULTS

Socio-demographic profile and self-reported plant knowledge of respondents

The respondents' socio-demographic characteristics are listed in Table 1. Compared with Hong Kong's gender ratio (male:female) in 2016 (close to 1:1), our respondents consisted of a higher proportion of females (close to 4 males to 6 females). Respondents were comparatively young, with age 30 or younger over 40%, but less than 5% were older than 60. Only around 15% of respondents had no tertiary education, whereas the census data had above 60% without a tertiary degree. Nearly 40% of respondents had a monthly income between HKD10,000–20,000 (the officially pegged exchange rate is USD1.00 = HKD7.80). The distribution of residence locations of our respondents was similar to the census data. More than half of the respondents lived in the New

Table 1. Sociodemographic variables and plant knowledge of respondents.

Variable (missing data‡)	Questionnaire data		Census data†
	N	%	%
Gender (missing = 13)			
F	482	59.2	52.5
M	332	40.8	48.5
Age (missing = 15)			
18–30	352	43.3	19.2
31–40	175	21.6	16.5
41–50	120	14.8	18.0
51–60	126	15.5	20.7
60 or above	39	4.8	25.8
Education level (missing = 17)			
Secondary school	127	15.7	66.8
Tertiary education	488	60.2	33.2
Master or above	195	24.1	
Monthly income (HKD)§ (missing = 135)			
<$10,000	223	32.2	25.9
$10,000–$20,000	170	24.6	39.0
$20,000–$40,000	182	26.3	22.4
$40,000–$60,000	60	8.7	6.6
>$60,000	57	8.2	6.2
Residence location			
Hong Kong Island (HKI)	140	16.9	17.1
Kowloon (KL)	226	27.3	30.6
New Territories (NT)	461	55.7	52.3
Plant knowledge (no. of species recognized)			
0	58	7.0	
1–3	237	28.7	
4–8	106	12.8	
9–15	227	27.4	
16–30	62	7.5	
>30	137	16.6	

† Source: C & SD, 2017; education level: data include population aged 15 and over (excluding foreign domestic helpers); monthly income: data include working population only.
‡ Refers to respondents who chose not to disclose personal information; counted as missing values in data analysis.
§ The officially pegged exchange rate is USD1.00 = HKD7.80.

Table 2. Average scores of evaluations of public urban green space attributes and results of PCA and cluster analysis.

PC (factor loading)	Mean score†			
	Overall N = 827	Ecological users N = 254 (30.7%)	Eclectic users N = 276 (33.4%)	Pragmatic users N = 297 (35.9%)
PC1: Green attributes (explained variance = 26.9%)				
Eco-friendly practice (0.56)	**4.1 a**	4.0 Bab	**4.6 Aab**	3.7 Cc
Natural scenery (0.72)	**4.1 a**	**4.2 Ba**	**4.6 Aab**	3.4 Cd
Plant species richness (0.67)	3.8 b	3.9 Bb	4.4 Abc	3.2 Ce
Nurturing wildlife (0.73)	*3.3 c*	3.7 Abc	*3.9 Ad*	*2.5 Bf*
PC1 scores		0.313 B	0.732 A	-0.947 C
PC2: Utility attributes (explained variance = 21.5%)				
Safety (0.72)	**4.1 a**	3.3 Cd	**4.6 Aa**	**4.3 Ba**
Spatial design (0.50)	4.0 a	3.7 Cc	4.5 Abc	4.0 Bb
Adequacy of facility (0.77)	3.7 b	*2.9 Ce*	4.3 Ac	3.9 Bbc
PC2 scores		-1.09 C	0.728 A	0.257 B

†Different uppercase letters denote significant differences of scores of same factors across clusters. Different lowercase letters denote significant differences of scores between factors within a cluster. Values in bold and italic indicate highest and lowest values within a group, respectively.

Territories (NT), which has a relatively lower population density. In short, the respondents were somewhat skewed toward females, who were more well-educated and younger than the general population.

Regarding plant knowledge, the ratio of respondents that recognized ≤ 8 species and ≥ 9 species was about 50:50. Around one-fourth of them knew ≥ 15 species, whereas nearly 36% identified ≤ 3 species.

Evaluations of UGS attributes

Four attributes were rated as important by respondents in overall (mean = 4.0-4.1). They were “eco-friendly practice,” “natural scenery,” “safety,” and “spatial design,” with “nurturing wildlife” ranked the last (Table 2). PCA with varimax rotation for evaluating attributes of public UGS yielded two principal components (PC) with a total explained variance of 48.4%. Based on the characteristics of the constituent variables, PC1 was labeled the “green attributes,” with “nurturing wildlife,” “natural scenery,” “plant species richness,” and “eco-friendly practice” having a high factor loading. Meanwhile, PC2 was labeled as the “utility attributes,” and factors with a high loading under it were “adequacy of facility,” “safety,” and “spatial design.”

The cluster analysis of the PC scores classified the respondents into three groups (Table 2). According to their evaluation profiles, the groups could be labeled the “ecological users” (showing stronger evaluation of green attributes), “eclectic users” (showing similarly strong evaluation of almost all attributes), and “pragmatic users” (showing strong evaluation of practical utility attributes). The three groups had quite similar numbers of respondents. The “ecological users” group was characterized by a high appreciation of the PC1 green attributes (mean = 3.7–4.2) but gave low scores to PC2 utility attributes (mean = 2.9–3.3). The “eclectic users” assigned high scores to all attributes relative to other groups. They tended to perceive most attributes as important, with an average score of 4.3–4.6, except for “nurturing wildlife,” which had a mean score of only 3.9. The “pragmatic users” demonstrated a strong evaluation of the utility factor (mean = 3.9–4.3) but gave green attributes rather low scores (mean = 2.5–3.7).

Three variables, namely knowledge of plant species, gender and education level, were statistically associated with respondents' evaluations of UGS attributes (Table 3). Fewer females than males were “ecological users,” and females gave higher scores to “utility attributes.” The “ecological users” and “pragmatic users” had the best and least knowledge of plant species, respectively. Plant species knowledge was linked positively with the evaluation of green attributes and negatively with utility attributes. Meanwhile, the “eclectic users” had proportionally more respondents with only secondary education, but no significant differences were observed between education levels regarding the evaluation of green and utility attributes.

Evaluation of plant species features and perception of plant species selection

Table 4 indicates that “non-toxic/spiny,” “less prone to attract dangerous insects,” “providing food and habitat to wildlife,” “pest and disease-resistant,” and “appealing appearance and fragrant” were regarded as more important species features (mean = 4.0–4.1). However, “native species” and "evergreen / in bloom throughout the year” had a low score (mean = 3.2–3.3). PCA yielded three PCs with a total explained variance of 59.6% for evaluating plant species features. Based on the factors with high factor loadings, PC1 can be labeled the “harmlessness,” PC2 the “conservation value,” and PC3 the “landscaping value.” The plant species features with a factor loading > 0.5 under each PC were “non-toxic/spiny,” “less prone to attract dangerous insects,” “nuisance-free,” and "evergreen / in bloom throughout the year” under PC1; “native species,” “cultural and historical significance,” and “providing food and habitat to wildlife” under PC2; and “appealing appearance and fragrant,” and “pest and disease-resistant” under PC3.

The respondents were classified into three groups by cluster analysis in terms of evaluation of plant species features (Table 4). The first cluster was “conservation supporters,” who accorded a strong evaluation for “conservation value” (mean = 3.7–4.4) of plant species, compared with a weak evaluation of “harmlessness” (mean = 2.5–3.1). The second cluster attached importance to most plant species features (mean > 4.0 except for two), and it was labeled the "all-round perfectionists." The third cluster was the "safety defenders." They expressed a low appreciation of the "conservation value" of plant species (mean = 2.5–3.5) but a strong evaluation of "harmlessness" except for "evergreen / in bloom throughout the year" (mean = 3.7–4.2).

Only gender and plant knowledge had a significant association with evaluating plant species features (Table 5). Males and better plant knowledge were negatively associated with the importance rating of "harmlessness." Better plant knowledge was positively linked with "conservation value." Females were more likely to be "all-round perfectionists" in plant species selection, while those with better plant knowledge were probably "conservation supporters."

Table 3. PC scores and cluster of respondents based on the evaluations of public urban green space attributes by socio-demographic groups and plant knowledge.

Variable	By PC score†		By cluster (%)‡		
	Green attribute	Utility attribute	Ecological group	Eclectic group	Pragmatic group
Gender					
F	0.013	0.083 a	50.6	66.9	59.5
M	-0.027	-0.132 b	**49.4**	33.1	40.5
	p = 0.414	p = 0.001	χ^2 = 14.396, p = 0.001		
Age					
18–30	-0.069	0.062	39.6	41.7	48.1
31–40	0.016	0.109	19.2	23.6	21.6
41–50	0.168	-0.196	19.6	14.4	11.0
51–60	-0.021	-0.152	18.0	13.7	15.1
60 or above	0.057	0.068	3.6	6.6	4.1
	p = 0.228	p = -.026	χ^2 = 15.029, p = 0.059		
Education level					
Secondary school	0.097	0.016	14.4	**21.2**	11.7
Tertiary education	-0.027	0.001	61.6	54.6	64.3
Master or above	-0.029	-0.032	24.0	24.2	24.1
	p = 0.364	p = 0.859	χ^2 = 10.698, p = 0.030		
Monthly income (HKD)§					
<$10,000	-0.010	0.161	36.5	34.1	32.2
$10,000–$20,000	0.047	-0.037	24.3	22.2	24.6
$20,000–$40,000	-0.060	-0.029	23.9	27.4	26.3
$40,000–$60,000	-0.116	-0.099	7.4	7.9	8.7
>$60,000	-0.082	-0.044	7.8	8.3	8.2
	p = 0.603	p = 0.167	χ^2 = 8.826, p = 0.357		
Residence location					
HKI	-0.036	0.002	16.7	17.2	16.9
KL	-0.029	0.029	28.3	29.0	27.3
NT	0.025	-0.015	55.1	53.9	55.7
	p = 0.793	p = 0.791	χ^2 = 1.786, p = 0.775		
Plant knowledge (no. of species recognized)					
0	-0.337 b	0.184 a	5.9	7.6	7.4
1–3	-0.162 ab	0.162 a	22.8	27.2	**35.0**
4–8	0.143 ab	-0.032 ab	13.0	15.9	9.8
9–15	-0.010 ab	0.075 a	22.8	28.3	30.6
16–30	0.320 a	-0.157 ab	9.4	7.6	5.7
>30	0.183 a	-0.386 b	**26.0**	13.4	***11.4***
	p = 0.000	p = 0.000	χ^2 = 37.966, p = 0.000		

† p value obtained from the Kruskal-Wallis H Test. Different letters denotes significant differences by Pairwise Wilcoxon Rank Sum Tests (Bonferroni correction).
‡ χ^2= Chi-square test. **Bold**/***bold-italic*** indicates the observed cell count is significantly more/less than expected.
§ The officially pegged exchange rate is USD1.00 = HKD7.80.

Views toward plant selection strategies in public UGS
Figure 1 showed the views toward plant selection strategies in public UGS. The respondents had no strong one-sided opinions with the view "It is fine to plant whatever plant species in urban green spaces" (mean = 2.8) and "I am satisfied with the plant composition and selection strategy in public greenery" (mean = 3.0). On the other hand, there was a more apparent consensus that the species planted in urban parks and other green spaces appeared similar (mean = 3.7).

Linkage of evaluation of UGS attributes, plant species features and views of plant species selection strategies
Strong relationships were found between the evaluation of UGS attributes and plant species features. Respondents who attached higher importance to UGS green attributes also valued the conservation value (r = 0.449, p = 0.000) and landscaping value (r = 0.124, p = 0.000) of plant species but were less concerned about their harmlessness (r = -0.129, p = 0.000). On the other hand, the stronger evaluation of utility attributes was linked positively with the evaluation of harmlessness (r = 0.375, p = 0.000) and landscaping value (r = 0.233, p = 0.000) of UGS plant species. In terms of clustering groups, the "ecological users," "eclectic users," and "pragmatic users" were significantly related to the "conservation supporters," "all-round perfectionists," and "safety defenders" of plant species features, respectively. (Fig.2)

The "safety defenders" held a general view that species selection was not an important issue, but the opposite opinion was observed among the "conservation supporters" (Table 6). Regarding the satisfaction of the recent plant selection strategy, the "conservation supporters" tended to express a negative view. Meanwhile, all groups with different evaluation profiles of plant species shared a relatively convergent view that the adoption of plant species in UGS was similar everywhere.

DISCUSSION

Differential assessment of respondents' views
Unlike most previous studies, which tended to conduct an overall evaluation of all respondents as a monolithic group (e.g., Özgüner 2011, Qureshi et al. 2013, Bertram and Rehdanz 2015), we adopted a biocultural approach by differentiating our respondents into groups using clustering to allow a deeper analysis of the respondents' disparate views. For example, while we compared the overall evaluation of some green and utility attributes of the respondents, the cluster analysis could discover the respondents' divergent views as expressed by the clusters.

The motivations for using a green space could affect the attitudes toward UGS design (Whiting et al. 2017, Lampinen et al. 2020). Our pragmatic users who demanded safety and good facilities would likely regard UGS as a routine outdoor recreational venue to enjoy general outdoor activities. On the other hand, our ecological users, who valued more natural ingredients than artificial elements, would regard UGS as a place to experience nature and a site for conservation. This linkage between people's evaluation of UGS attributes and plant species features in UGS was not unexpected. The "ecological users" expected the plant species in UGS to have a high conservation value, whereas the "pragmatic users" envisaged the "harmlessness" of the plant

Table 4. Average scores of evaluations of plant species features in public urban green space and results of PCA and cluster analysis.

PC (factor loading)	Mean score[†]			
	Overall	Conservation supporters N = 189 (22.9%)	All-round perfectionists N = 353 (42.7%)	Safety defenders N = 285 (34.4%)
PC1: Harmlessness (explained variance = 25.9%)				
Safety (non-toxic/spiny) (0.82)	4.1 a	3.0 Cd	4.7 Aa	4.2 Ba
Will not attract pest and dangerous insects (0.81)	4.1 ab	3.1 Cd	4.6 Aa	4.1 Ba
Nuisance-free (0.81)	3.6 d	2.4 Ce	4.2 Acd	3.7 Bbc
Evergreen / in bloom throughout the year (0.51)	3.2 e	2.5 Ce	3.6 Ae	3.1 Bd
PC1 scores		-1.34 C	0.670 A	0.058 B
PC2: Conservation value (explained variance = 19.3%)				
Provide food and habitats for wildlife (0.62)	4.1 ab	4.4 Aa	4.5 Ab	3.5 Bc
Cultural and historical significance (0.81)	3.6 d	4.0 Abc	4.1 Ad	2.9 Be
Native plant species (0.82)	3.1 e	3.7 Ac	3.7 Ae	2.5 Bf
PC2 scores		0.424 A	0.523 A	-0.930 B
PC3: Landscaping value (explained variance = 14.4%)				
Pest and disease-resistant (0.66)	4.1 bc	4.0 Bbc	4.4 Abc	3.8 Bb
Appealing appearance and fragrant (0.81)	4.0 c	4.1 Ab	4.1 Ad	3.7 Bb
PC3 scores		0.272 A	0.232 A	-0.468 B

[†] Different uppercase letters denote significant differences of scores of same factors across clusters. Different lowercase letters denote significant differences of scores between factors within a cluster.

species. This result could inform appropriate adjustments to the plant selection strategy in UGS catering to different functions and target users.

Commonality of respondents' evaluations

Despite the diverse evaluations of UGS and plant species expressed by our respondents, several notable observations shared by different clusters were worthy of discussion.

The "eco-friendly practice" attribute, not demanding substantial inputs of resources for park management such as water, fertilizer, and labor, was seldom evaluated in previous studies. The general view that it was an important attribute in our study could be attributed to residents' high environmental awareness regarding resource and energy conservation. This finding could support adopting an eco-friendly approach in park management to cater to public expectations.

The relatively low importance rating of "evergreen / in bloom throughout the year" (mean: 3.2) and "native plant species" (mean: 3.1) among the different clusters suggested that the public did not consider such inherent species traits important. The low loadings (< 0.5) of "evergreen / in bloom throughout the year" under PC3 "landscaping value" reflected that the public's appreciation of the plant species was detached from the year-round phenological or ornamental features. On the other hand, the relatively weak evaluation of "native plant species," compared to the other two factors under the PC2 "conservation value," might suggest that the "nativeness" brand had lower importance to the public. They did not connect it to the associated ecological and cultural values. This result dovetailed with previous studies finding that species nativeness alone was not an important consideration among the public (Fischer et al. 2011, Hoyle et al. 2017).

Also, the highly appreciated plant attributes "pest and disease-resistant" and "appealing appearance and fragrant," harbored by different respondents, suggested a widely shared citizen concern toward the landscaping value of plant species in UGS. Notably, these species features did not receive the highest importance scores from all respondent clusters. Therefore, a plant species selection strategy emphasizing merely the landscaping quality of plant species might not match the public's general expectation.

Across all cluster groups, people valued the species attribute "provide food and habitats for wildlife" much more important than "native plant species," with a mean score difference ranging from 0.7 to 1. A recent review study by de Carvalho et al. (2022) indicated general views that native plant species favor and support native fauna, and exotic plant species negatively affect native fauna and also support exotic fauna. Over the decades, various studies showed that exotic plants could decrease the food availability for insects that feed on plant tissues (Sjöman et al. 2016), and native plants were more likely to provide resources for urban animals and increase biodiversity in UGS (Mohamad et al. 2013, Berthon et al. 2021). This result indicated a missing knowledge link between plant origin and providing food and habitats by native plant assemblage among Hong Kong citizens. On the one hand, they wish to nourish local wildlife in UGS. On the other hand, they could not connect such a goal that should be achieved by planting native plant species.

Gender and plant knowledge as evaluation drivers

Not surprisingly, respondents with better plant species knowledge tended to offer stronger evaluations of ecological and conservation-related elements, be it UGS attributes or plant species features. They usually have a higher affinity for nature. Therefore, they were expected to pay more attention to ecologically-oriented factors. This observation aligned with the findings reported in different studies (Caula et al. 2009, Qiu et al. 2013, Muratet et al. 2015).

Gender as a socio-demographic variable has been widely reported to drive attitudes toward UGS (Sang et al. 2016). Previous studies observed that females were more attached than males to UGS

Table 5. PC scores and cluster of respondents based on the evaluations of plant species features of public urban green space by socio-demographic groups and plant knowledge.

Variable	By PC score[†]			By cluster (%)[‡]		
	Harmlessness	Conservation value	Landscaping value	Conservation supporters	All-round perfectionists	Safety defenders
Gender						
F	0.118 a	0.043	0.000	50.8	65.5	57.0
M	-0.176 b	-0.062	0.000	49.2	34.5	43.0
	p = 0.000	p = 0.150	p = 0.945		χ^2 = 11.776, p = 0.003	
Age						
18–30	0.042	-0.065	-0.015	38.5	43.5	46.4
31–40	-0.031	0.085	0.075	21.4	22.8	20.1
41–50	-0.071	0.061	-0.036	16.6	14.1	14.4
51–60	-0.087	-0.037	0.039	19.8	13.5	15.1
60 or above	0.250	0.050	0.104	3.7	6.1	4.0
	p = 0.257	p = 0.392	p = 0.708		χ^2 = 7.723, p = 0.461	
Education level						
Secondary school	0.078	0.065	-0.094	11.9	16.8	16.9
Tertiary education	0.019	-0.006	0.025	62.2	60.7	58.4
Master or above	-0.095	-0.053	0.002	26.0	22.5	24.7
	p = 0.297	p = 0.675	p = 0.553		χ^2 = 3.128, p = 0.537	
Monthly income (HKD)[§]						
<$10,000	0.104	-0.039	-0.001	26.8	35.3	32.1
$10,000–$20,000	-0.111	0.146	-0.017	31.2	22.3	23.0
$20,000–$40,000	0.030	-0.134	0.044	23.6	25.7	28.8
$40,000–$60,000	-0.055	0.142	0.049	9.6	9.9	6.6
>$60,000	-0.162	-0.227	0.146	8.9	6.8	9.5
	p = 0.130	p = 0.079	p = 0.816		χ^2 = 10.116, p = 0.254	
Residence location						
HKI	-0.013	0.078	0.073	19.1	17.6	14.7
KL	0.040	-0.107	-0.034	23.3	27.5	29.8
NT	-0.016	0.029	-0.006	57.7	55.0	55.4
	p = 0.677	p = 0.137	p = 0.393		χ^2 = 3.350, p = 0.501	
Plant knowledge (no. of species recognized)						
0	0.407 a	-0.505 b	0.129	***2.6***	6.5	**10.5**
1–3	0.254 ab	-0.084 ab	-0.130	***14.8***	30.9	**35.1**
4–8	-0.080 bc	0.144 a	-0.085	16.9	11.6	11.6
9–15	0.205 ab	0.033 a	0.063	***17.5***	**35.1**	24.6
16–30	-0.532 cd	0.301 a	0.029	**15.3**	5.1	5.3
>30	-0.649 d	0.058 a	0.118	**32.8**	***10.8***	13.0
	p = 0.000	p = 0.000	p = 0.135		χ^2 = 105.78, p = 0.000	

[†] p value obtained from the Kruskal-Wallis H Test. Different letters denotes significant differences by Pairwise Wilcoxon Rank Sum Tests (Bonferroni correction).
[‡] χ^2= Chi-square test. **Bold**/***bold-italic*** indicates the observed cell count is significantly more/less than expected.
[§] The officially pegged exchange rate is USD1.00 = HKD7.80.

natural elements (Caula et al. 2009, Lo and Jim 2012). However, our study did not find such a clear trend. Rather, the females were inclined to place more importance on safety features, as found in other studies (Zhang et al. 2013). A possible reason is that women were more likely than men to bring children to UGS, thus they would be more concerned about safety and facilities in addition to green elements.

Perception of plant species selection strategy in public UGS

Another issue worth noting was the dissatisfaction with the plant species selection strategy by the "conservation supporters." This user group was particularly concerned about plant species selection in UGS. The current selection strategy has failed to meet the standard taken from an ecological and conservation viewpoint. Also, different respondent groups have a mainstream view that the plant species looked "the same" across different UGS. The Hong Kong government implemented Greening Master Plans (GMP) since 2004 in different districts. A main feature of the plans was the dedicated plant species palette for individual districts. Despite the progressive realization of these plans, our results indicated that the UGS design in terms of plant species selection still failed to achieve diversity at the city-scale level.

Practical recommendations for UGS design

Our study observed a rather broad range of expectations expressed by the interviewees. The diverse, if not disparate, needs of residents posed a challenge to UGS design. Often, a trade-off

Fig. 1. Views of respondents towards plant species selection strategy in public urban green space.

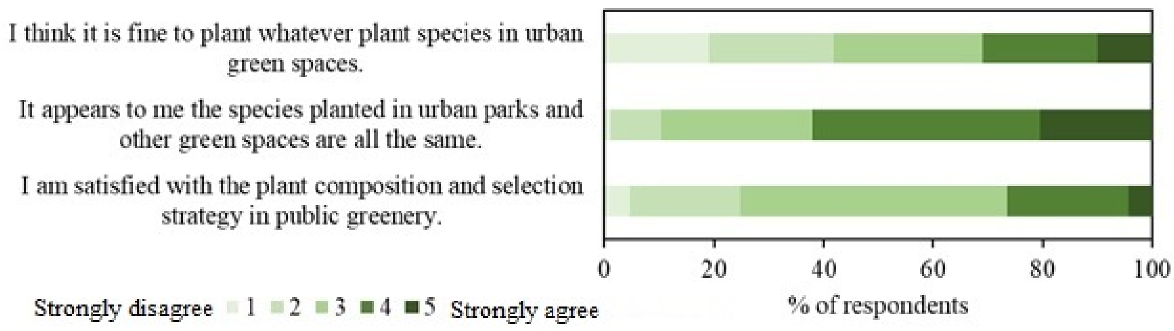
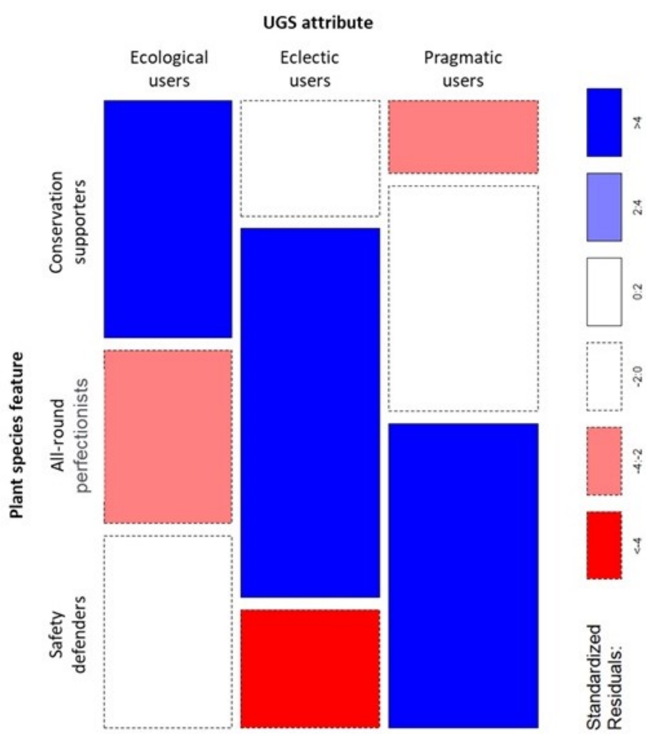


Fig. 2. Mosaic plot showing the relationship of evaluations of public urban green space (UGS) attributes and plant species features in terms of cluster.



strategy could be adopted to find a balance between different strands of demand (Bertram and Rehdanz 2015). For example, a planting design with more naturalness may make some people feel less safe (Qiu et al. 2013). In that case, landscape designers could try to achieve both naturalistic vegetation and "safe feeling" through a suitable spatial arrangement and choice of plants (Jorgensen et al. 2002). Alternatively, a range of small UGS with different designs could cater to a range of specific needs. By the same token, a large park could be demarcated into landscape portions to embrace a broad range of features (Bjerke et al. 2006, Whiting et al. 2017).

Considering compact cities like Hong Kong, landscape designers and UGS managers could consider a dualistic zonation with different attributes in the large urban parks. A core zone filled with a suitable assemblage of native plants or plants with high ecological and conservation value (e.g., certain spiny plant species) could be planted. Sites with naturalistic or ecological design could be established and managed successfully with minimal horticultural management inputs. The peripheral zone that can tackle heavy visitor traffic could emphasize a broad range of recreational facilities and more intensive management, accompanied by a general horticultural design with less ecological-naturalistic elements. Meanwhile, different small UGS in a given district could be equipped with different design features and serve the wide range of resident demands without long-distance travel.

Limitations of the study

We obtained our questionnaire results from the general population and did not evaluate the actual UGS visitorship. Therefore, we could not differentiate the possible discrepancies in the evaluation among frequent users, less frequent users, and non-users. As our questionnaire survey was conducted online, we received a rather low proportion (< 5%) of elderly respondents (> 60 years old) and, therefore, did not have adequate data to study this group's view. Meanwhile, the effect of sampling bias could be partly disclosed by the association of socio-demographic variables with respondents' views. Besides, the somewhat skewed distribution toward females might lead to a bias of strong evaluation of the utility factor and harmlessness of plant species. Like many studies focusing on a single city, the linkage between socioeconomic variables and public evaluations might not always apply to other cities with different geographical, climatic, and cultural backgrounds (Ostoić 2017). Nevertheless, the findings could provide a reference for similar studies.

CONCLUSION

Our findings provided insights into respondents' evaluation and perception to inform the design and management of UGS and

Table 6. Relationship between views towards plant species selection strategy and evaluations of plant species features of respondents.

Variable	By PC score†			By cluster‡		
	Harmlessness	Conservation value	Landscaping value	Conservation supporters	All-round perfectionists	Safety defenders
It is fine to plant whatever plant species in urban green spaces	r = 0.173, p = 0.000	r = -0.325, p = 0.000	r = 0.000, p = 0.990	2.3 c	2.8 b	3.2 a
It appears to me the species planted in urban parks and other green spaces are all the same	r = -0.033 p = 0.341	r = 0.153, p = 0.000	r = 0.088, p = 0.011	3.8 a	3.7 ab	3.6 b
I am satisfied with the plant composition and selection strategy in public greenery	r = 0.210, p = 0.000	r = -0.001, p = 0.979	r = 0.2043, p = 0.212	2.7 c	3.2 a	3.0 b

† r = Spearman's correlation coefficient.
‡ Different letters denote significant differences by Pairwise Wilcoxon Rank Sum Tests (Bonferroni correction).

species selection strategy. Cluster analysis allowed a more accurate differentiation of the respondents' evaluation profile on UGS attributes and plant species features. We classified the respondents into three groups based on their evaluation of UGS attributes, namely the "ecological users," "eclectic users," and "pragmatic users." Another three groups were demarcated based on the importance attached to plant species features, namely the "conservation supporters," "all-round perfectionists," and "safety defenders."

Plant species knowledge and gender were the two main factors associated with respondents' evaluation characteristics. Females and those with less plant species knowledge showed a higher concern for utility and safety. A positive association was found between plant species knowledge with the concern toward the spiritual and ecological aspects. Also, the evaluations of UGS attributes and plant species selection criteria were significantly linked.

Different respondent groups expressed a common view that the plant species in different UGS were very similar. Respondents with stronger evaluations of ecological and conservation issues tended to be less satisfied with the plant species selection strategy and more concerned about species selection. Understanding the diverse evaluation profile of public UGS users could inform decision-makers to modify the existing thinking mode and steer toward providing UGS that can satisfy the spectrum of user expectations.

Author Contributions:

Caroline M. Y. Law: conceptualization, methodology, formal analysis, investigation, writing - original draft; writing - review and editing, project supervision. L. C. Hui: methodology, formal analysis, data curation, writing - original draft; writing - review and editing. C. Y. Jim: writing - review and editing.

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Data Availability:

The data that support the findings of this study are available on request from the corresponding author (Caroline M.Y. Law). Ethical approval for this research study was granted by The Human Subjects Ethics Sub-committee of Technological and Higher Education Institute of Hong Kong.

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Appendix 1. The online survey questionnaire.

Aspect	No.	Question	Answer	Related references for setting the questions
Knowledge	A1	How many plant species you can recognize in public urban green spaces ?	0; 1–3; 4–8; 9–15; 16–30; >30	
UGS attributes	B1	How do you rate the importance of the following considerations in public urban greenery (individually rate each factor from 1—Least important to 5—Most important)	7 factors: Spatial design; Adequacy of facility (playground, chairs); Plant species richness (collection of variety); Natural scenery; Nurturing wildlife; Safety; Eco-friendly practice (water, fertilizer, manpower)	Goodness et al. 2016; Atiqul et al. 2021
Plant species selection	C1	How do you rate the importance of the following considerations when selecting plant species in urban public green spaces of Hong Kong (individually rate each factor from 1—Least important to 5—Most important)	(1) Appealing appearance (seasonal variation, attractive and colorful blossom, foliage, fruits) and fragrant (2) Pest and disease-resistant (3) Evergreen / in bloom throughout the year (4) Nuisance-free (allergenic substances and litters, e.g., debris of ripped fruits, seeds of cotton tree, pollens) (5) Safety (non-toxic/spiny) (6) Will not attract pest and dangerous insects (7) Provide food and habitats for wildlife (8) Native plant species (9) Cultural and historical significance	Lo and Jim 2010, 2012; Goodness et al. 2016; Ostoić et al. 2017

	C2	To what extent you agree/disagree on the statements? (Individually rate each statement from 1—Strongly disagree to 5—Strongly agree)	(a) It is fine to plant whatever plant species in urban green spaces. (b) It appears to me the species planted in urban parks and other green spaces are all the same. (c) I am satisfied with the plant composition and selection strategy in public greenery.	Ostoić et al. 2017
Personal traits	D1	What is your gender?	Male; Female	
	D2	How old are you?	18–30; 31–40; 41–50; 51–60; >60 or above; Undisclosed	
	D3	How much is your current monthly salary (include double pay, bonus, etc.)?	<HKD$10,000; $10,000–$20,000; $20,000–$40,000; $40,000–$60,000; >$60,000; Undisclosed	
	D4	What is your education level?	Primary or below/Secondary/Upper Secondary; Tertiary (degree level)/Tertiary (non-degree level); Master/Doctor; Undisclosed	
	D6	Which is your residence location?	Hong Kong Island; Kowloon; New Territories; Undisclosed	