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The Improving of Sky Gardens' Environmental Quality from a Health Promotion Perspective

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Abstract: The quality of landscape space directly influences public health behaviors, making public assessments of the qualities of the sky garden landscape crucial for optimizing it. This article focuses on three types of typical high-rise building sky garden (plaza-park, rest-stay, and move-pass type) and establishes an evaluation framework for their health promotion characteristics (24 indicators in 7 dimensions) based on existing restorative environment research. Then, questionnaires (354 valid responses) and quantitative calculations were employed to assess the public's perception of demand in health behaviors and the spatial supply of different sky garden types. Ultimately, the data were processed to propose targeted interventions and recommendations to enhance health benefits using the comprehensive importance-performance analysis method. The results show the following: (1) The public seems to have widely accepted sky gardens in the context of high-density urban environments (near 6.92, below the mean of 7.09). They place greater emphasis on spatial indicators that cater to relaxation activities and show heightened sensitivity toward public facilities (7.32–8.00) that contribute to physical and mental health-related activities. (2) The health promotion performance of different types of sky garden shows significant variation, with the rest-stay sky gardens at the embodied scale demonstrating the greatest competitive advantage. (3) The development of sky gardens has significant potential, and different types of sky garden need to specifically lever-age their characteristics as complementary public spaces.

Keywords: sky gardens; health promotion; importance-performance analysis; high-density environment; sustainable healthy living environment

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1. Introduction

1.1. Background of the Study

Urbanization is an evolutionary process in which human beings seek survival and development and expand the use of space. The high density of the urban environment is the result of population explosion and realistic choice under urbanization [1]. A large number of studies have confirmed that natural landscapes and open spaces have health promotion effects such as relieving stress, improving mood, and enhancing cognitive abilities [2,3]. However, high-density urban spaces greatly limit the exposure of urban residents to ground-level green environments [4–6]. Therefore, exploring the complex relationship between the spatial environment and the public's physical and psychological health in a high-density urban environment is one of the important issues facing current research and practice in high-rise buildings. Sky gardens, as important natural environments in high-rise buildings, have become potential resources for nature-based solutions in urban environments [7], and it is important to explore their health promotion.

Sky gardens are the contemporary interpretation of Le Corbusier's concept of "streets in the sky" [8] and are one of the most important components of urban green infrastructures [9]. Existing studies confirm the sustainability value of sky gardens and the role of

complementing ground-level green spaces [10–12] by integrating the public realm, natural landscapes, and community facilities in high-rise buildings [13]. Compared to parks, green spaces, and other public spaces, sky gardens are mostly privately owned public spaces [6], and it is relatively difficult to measure and evaluate the difference between the supply and demand of their spatial health quality. However, there is some consistency in health-promoting environmental factors, and restorative environment research provides a feasible angle for studying the relationship between sky gardens and human well-being [14].

Schröpfer Thomas et al. systematically investigated the integration of green spaces in buildings among contemporary architecture and urban design practice through a series of international in-depth case studies, producing new typologies for high-density environments that include public spaces, sky terraces, sky bridges, vertical parks, roof gardens, and other 'green' components [15]. Notwithstanding, it is evident that most studies concerning people's satisfaction with health promotion in sky gardens are usually conducted in more advanced countries, especially Singapore [8,16,17]. Again, such studies have extensively reported the environmental, social, urban, architectural, and economic benefits of large-scale, urban-iconic sky gardens, such as rooftop gardens and podium gardens [4,5,8,10,17–21]. To a certain extent, the small-scale and other functions of sky gardens scattered in high-rise buildings, such as sky courtyards, sky terraces, and sky-bridges, have been neglected. Therefore, for policymakers and planners, it is necessary to accurately understand the public demand for different types of sky garden in order to propose targeted health-promoting planning and design strategies to better meet the public's cognition and demand preferences for sky gardens, especially for sky gardens that are widely scattered within high-rise buildings and at small-to-medium scales.

Importance-performance analysis (IPA) is a measure that has been gradually introduced into the management of natural and built environments to understand the difference between public expectations and their experience [22]. The method is based on the collected survey data and the calculation and comparison of performance and importance scores of different variables to discover the potential strengths and weaknesses of the services and to prioritize their development [23]. Studying public perceptions of health promotion in sky gardens can help policymakers and planners to properly understand the relationship between people and the environment, rather than separately studying human activities or environmental factors [24]. In turn, a better understanding and experience of sky gardens can encourage people to support and participate in various public affairs related to sky gardens [8,17].

1.2. Literature Review

1.2.1. Trends and Transformations

Design with nature is a classic topic in the field of urban design [25]. Since the 1960s, massive urban renewal movements have attracted much attention and reflection, and urbanists, landscape architects, and others have begun to explore the construction of urban habitats centered on human experience and perception [26–31]. The concept of "natural environmental health promotion" can be traced back to Ian McHarg's *The Place of Nature in The City of Man* [26], which suggests the need to critically examine the place of nature in the city, and fully utilize it to provide well-being benefits for city dwellers and improve the qualities of the urban environment. It echoes previous thinkers concerned with urban issues, such as Ebenezer Howard's garden cities of tomorrow [29], Frederick Law Olmsted's city park movement [30], and Patrick Geddes's comprehensive vision of nature in urban planning [31].

European countries began to explore the development path of green urbanism in the 1990s, influenced by urban issues and diseases caused by urbanization and industrialization, and by the ideas and methods of ecologism that design with nature. Vertical green spaces, such as rooftop greening, living gardens, sky terraces, green walls, and urban farms [32] have become important extensions of urban green infrastructures, and their proportion in cities has been gradually increasing by space flexibility and healthiness,

the closeness with people's daily lives, and the iconicity in spatial form [33]. Recently, researchers and scholars have found that vertical green spaces have great potential for physical and psychological health promotion [14]. They have also called for associating wellness environments with people's daily lives in order to promote more social interaction and enhance the belonging of space [8,17], thus reaching harmonious coexistence between high-density and green environments [15]. Green urbanism is one of the ideal models to alleviate urban problems, promote public health, improve urban ecology, and achieve sustainable urban development [34]. Green urbanism in highly dense urban environments has more important reality and practicability.

Compact cities and high-intensity development and construction have intensified, and the densification of the urban environment has accelerated the shift of public space from the ground to the sky. Sky gardens, as part of the urban green infrastructure in densified cities [5,35], are gradually forming a paradigm of compact open green spaces with a mix of density and natural and social spaces [15]. Sky gardens have become transitional and social spaces in high-rise buildings with the characteristics of spatial flexibility, functional diversity, and composite value [36]. This not only vertically divides the different vertical areas of high-rise buildings [37] but also meets the increasing demand for public space and the health promotion of users [8]. In high-density urban environments, sky gardens have gradually attracted attention and are widely established [7,38]. It has become the key element in building livable and resilient urban environments through reducing harm (e.g., air pollution, noise), restoring capacities (e.g., attention restoration, physiological stress relief), and building capacities (e.g., physical activity, social cohesion) [39]. Sky gardens have grown exponentially with the incentives of sustainable development and privately open public spaces (POPS), and with the strong promotion of architects they have shown various potential in compact urban environments [40]. Also, the lack of urban green space due to different drivers, such as urban intensification, has accelerated the process of implementing sky gardens and other vertical green spaces [41]. Indeed, the greening of buildings through vertical green spaces might well develop into one of the major architectural movements of the twenty-first century, and, in times to come, become a norm rather than a trend [32].

1.2.2. Spatial Features for Health Promotion

Health promotion research in built environments has been receiving academic attention for a long time, and spatial features have been extensively studied from multiple perspectives, including physiological, psychological, emotional, and cognitive ones. To understand the key elements of sky gardens for health promotion, this study takes reference from the dominant theories of restorative environment research—the attention restoration theory (ART) and the stress reduction theory (SRT) of restorative environment research [42,43]. The specific restorative factors are key to the fulfillment of restorative effects [44]. The restorative properties in different dimensions are fulfilled by stimulating positive emotions, reducing stress and distraction, and providing social support [33,39]. In addition, preference is strongly associated with judgments of restoration likelihood [45]. Therefore, the literature on preferences for built environments can guide the identification of physical attributes that affect restorative experience.

Humans have innate or evolved preferences for nature [46], which is one of the basic psychological demands of human beings [47]. The positive restorative effects of green vegetation on emotions, cognition, and mental health were already confirmed in the 1970s [48–50]. Natural elements relieve human physiological stress through visual–emotional responses [51], and viewing greenery alone also has positive effects on mood and performance [52], helping to alleviate visual fatigue in workspaces. Water features are also seen as a positive restorative component, and people prefer to be in water-rich areas to relieve stress [53], which positively affects their emotional status [54]. In addition to natural and water elements, other recreational infrastructures are also important for the public in relation to psychological restoration: sport facilities and pathways, playgrounds, sitting

features, lighting, drinking fountains and swimming areas, and silence and tranquility areas [55,56]. Furthermore, spatial forms have an important influence on spatial preferences, such as void-to-solid ratio (VSR), the scale of green space. There is an inverted U-shaped relationship between preference and the spatial VSR [57]; large-scale green spaces have visually broad views [58] and city residents are also willing to pay for housing with more green space [59]. Therefore, natural elements, water features and landscapes, public facilities, and form features are important dimensions to explore the health-promoting effects of the internal environment in sky gardens.

Some scholars have further explored the external supportive effects that influence the health-promoting experience of spatial environments. Studies have found that sky gardens are widely distributed in urban centers [16]. Central urban areas have high inclusiveness, overtime openness, and physical and visual accessibility [60], which provide activity support for the health-promoting experiences of accessing sky gardens. High-quality urban environments are more likely to attract the public to visit the adjacent public space, with increased accessibility, activity numbers, duration, and range of use [61], thus further enhancing the health promotion potential of sky gardens. Skyscape is one of the external environmental features perceived by the public in the internal environment of sky gardens [16], and distant skyscapes positively influence emotional states [62]. Skyscape-evoked restorative ratings are like those for ground-level spaces with street trees, but the most restorative and popular are those with the most sky [63]. High-rise buildings are an important carrier for the development of sky gardens in high-density cities [4,5,40], and there are potential impacts on the performance of sky gardens' health benefits. In contrast, people expect more open space in high-rise buildings with high floor area ratio (FAR) to satisfy their needs for rest and recreation [6]. Building height, outlines [64], spatial configuration, and layout [65] can also affect the fulfillment of health promotion, especially for stressed individuals. Therefore, the skyscape is an extension of the internal environment, the high-rise building is the carrier of sky gardens, and the surrounding urban environment encourages participation in activities that support accessing the health-promoting experience in sky gardens; these are important dimensions for exploring the analysis of the external environment of sky gardens for public health promotion.

1.3. Aim and Research Questions

The quality of landscape space directly influences public health behaviors, and sky garden spatial characteristics fulfill certain aspects of the public's health needs in high-density cities. Health perception assessments from the public, who experience the sky garden landscape, are crucial for optimizing the qualities of sky gardens. Numerous studies have extensively investigated the possibilities of health promotion in natural environments and urban public spaces [48–50]. However, most of the studies on sky gardens focus on only one or two dimensions [8,17,18,66] and lack a comprehensive framework to integrate people's multidimensional perceptions to assess the difference between the supply of and the demand for the health promotion qualities of sky gardens.

The objective of this study is to investigate the demand and supply of the health promotion qualities of sky gardens in high-rise buildings. It is hypothesized that health promotion demand and supply are influenced by the type of sky garden. This study seeks to answer the following research questions:

(1) What are the perceived needs for health promotion in sky gardens by the public?
(2) What are the differences in the health promotion supply status across different types of sky garden?
(3) What are the focuses of interventions for health promotion in different types of sky garden?

2. Methodology

We developed a comprehensive quantitative framework for assessing the difference between supply and demand for health promotion qualities in sky gardens (Figure 1). For

this reason, we measure the quality of sky gardens in seven dimensions: the surrounding environment, high-rise, skyscape, geometric form, greenscape, waterscape, and public facility. The analysis content mainly includes the following four parts: (1) Identifying the types of sky garden and typical cases based on previous studies (3 types, 12 sky gardens); (2) Clarifying the environmental characteristics affecting health promotion in sky gardens and the calculation method (7 dimensions, 24 indicators); (3) Collecting data on the demand (importance) and supply (performance) characteristics of health promotion in sky gardens through questionnaire surveys (354 valid responses) and quantitative analysis (288 spatial data); (4) Importance-expression analysis to compare the differences in the demand and supply of various types of sky garden, and targeted development recommendations for the optimization of the indicators.

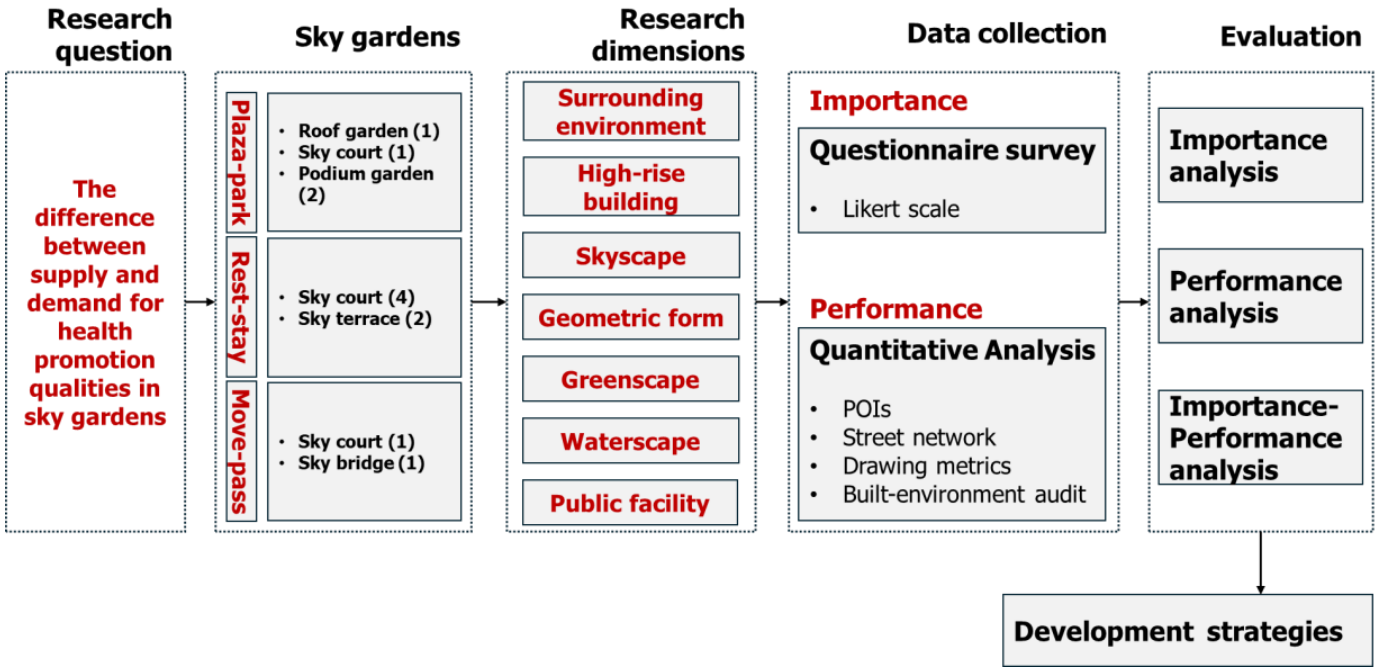
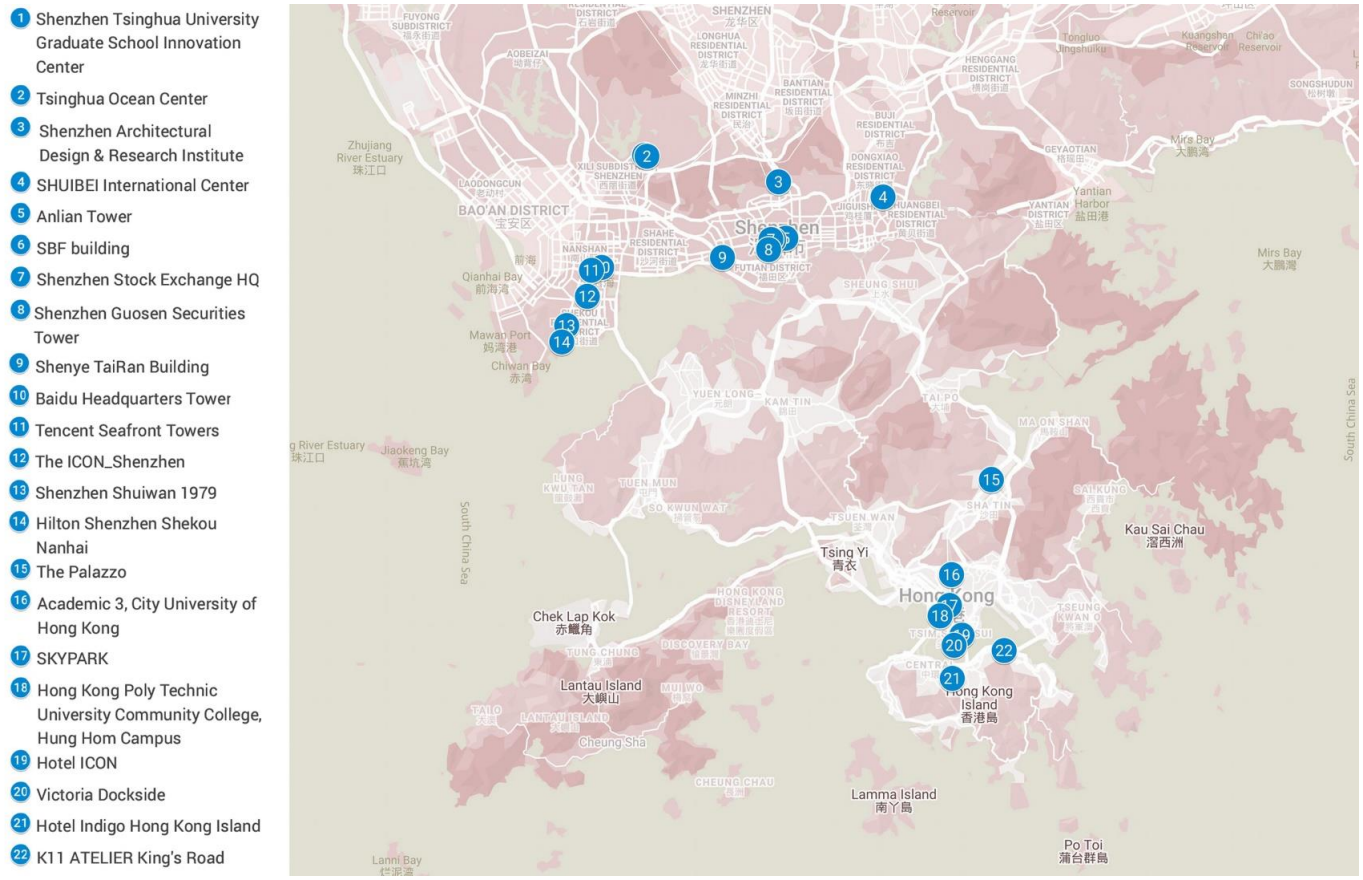


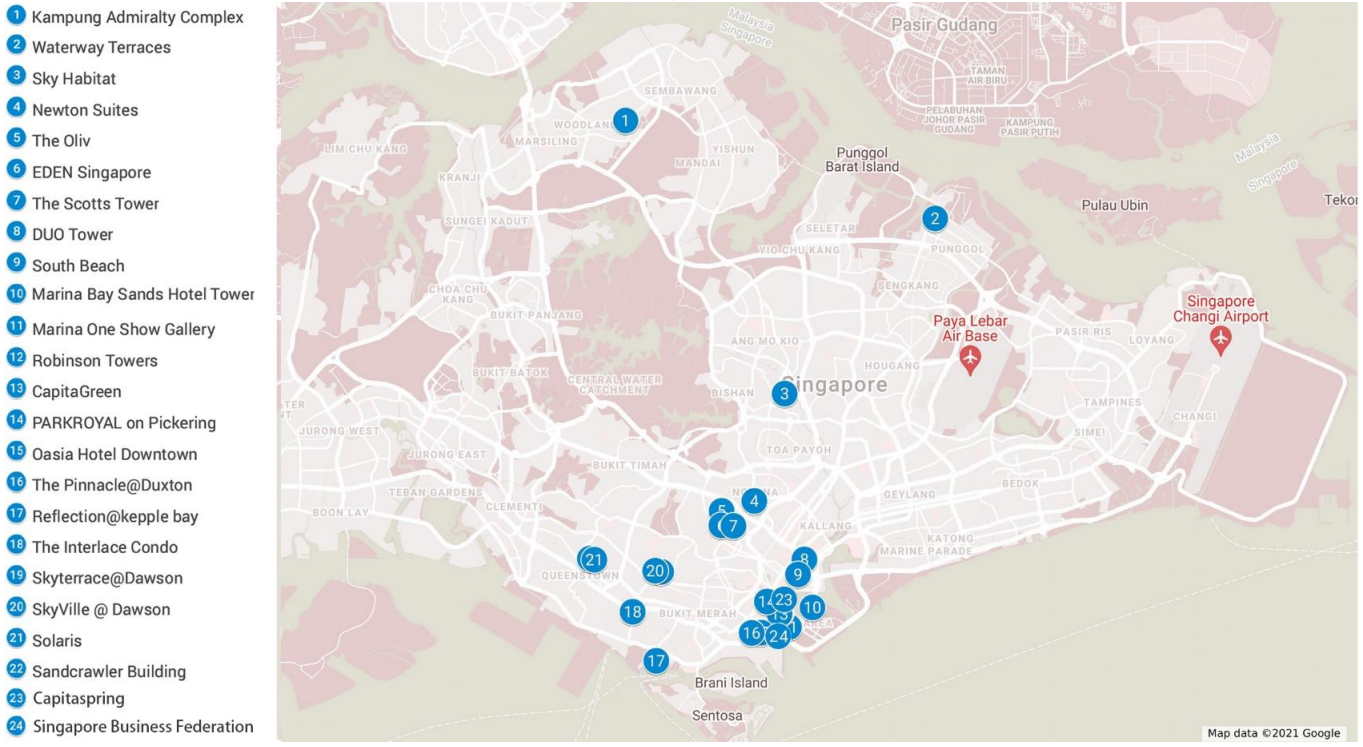
Figure 1. Analytical framework.

2.1. Study Location

This study selected a total of 157 typical sky garden spaces in 46 high-rise buildings within Shenzhen, Hong Kong, and Singapore, which are widely known or have received professional awards (Figure 2). Most of these are concentrated in the urban center with compact space and limited land [16]. Sky gardens can be classified into three types, and the differences between the types were verified [67]: plaza-park type with podium gardens and rooftop gardens, rest-stay type with sky courts and sky terraces, and move-pass type with sky bridges. Plaza-park sky gardens have a large spatial scale, are regular in shape, and have high landscape richness; rest-stay sky gardens are distributed higher in high-rises, have moderate scales, and have high landscape richness; and move-pass sky gardens are linear in shape and are related to transport functions. Then, based on two indicators, namely the "open space ratio" (sky garden area/total floor area) and the "void-to-solid ratio" (sky garden façade area/floor façade area), 12 cases were selected from widely known or professionally awarded sky gardens (Table 1, Figure 3).



(**a**)



(**b**)

Figure 2. Distribution of 157 typical sky gardens in 46 high-rise buildings in Shenzhen, Hong Kong, and Singapore: (**a**) Shenzhen and Hong Kong; (**b**) Singapore.

Table 1. General information on the three types of 12 sky gardens.

Type	Building Name	Garden Type	OSR	VSR	FAR	Scale/m^2
Plaza-park	01—SkyVille @ Dawson	Podium garden	1.00	1.00	3.9	3659.9
	02—The Pinnacle@Duxton	Roof garden	0.63	0.87	8.4	2923.0
	03—Hilton Shenzhen Shekou Nanhai	Podium garden	0.31	0.45	2.4	2252.6
	04—Capitaspring	Sky court	0.79	0.28	12.8	1862.3
Rest-stay	05—Singapore Business Federation Center	Sky court	0.68	0.68	11.9	198.7
	06—Oasia Hotel Downtown	Sky court	0.38	0.51	8.4	1071.4
	07—Baidu Headquarters East Tower	Sky court	0.10	0.43	10.8	222.9
	08—Shuiwan1979	Sky terrace	0.01	0.13	11.0	24.7
	09—DUO Tower	Sky court	0.40	0.27	6.0	1208.7
	10—Newton Suites	Sky terrace	0.06	0.19	2.8	34.6
Move-pass	11—PARKROYAL COLLECTION Pickering	Sky court	0.15	0.47	4.3	993.1
	12—SkyTerrace @ Dawson	Sky bridge	0.26	0.32	4.7	328.2

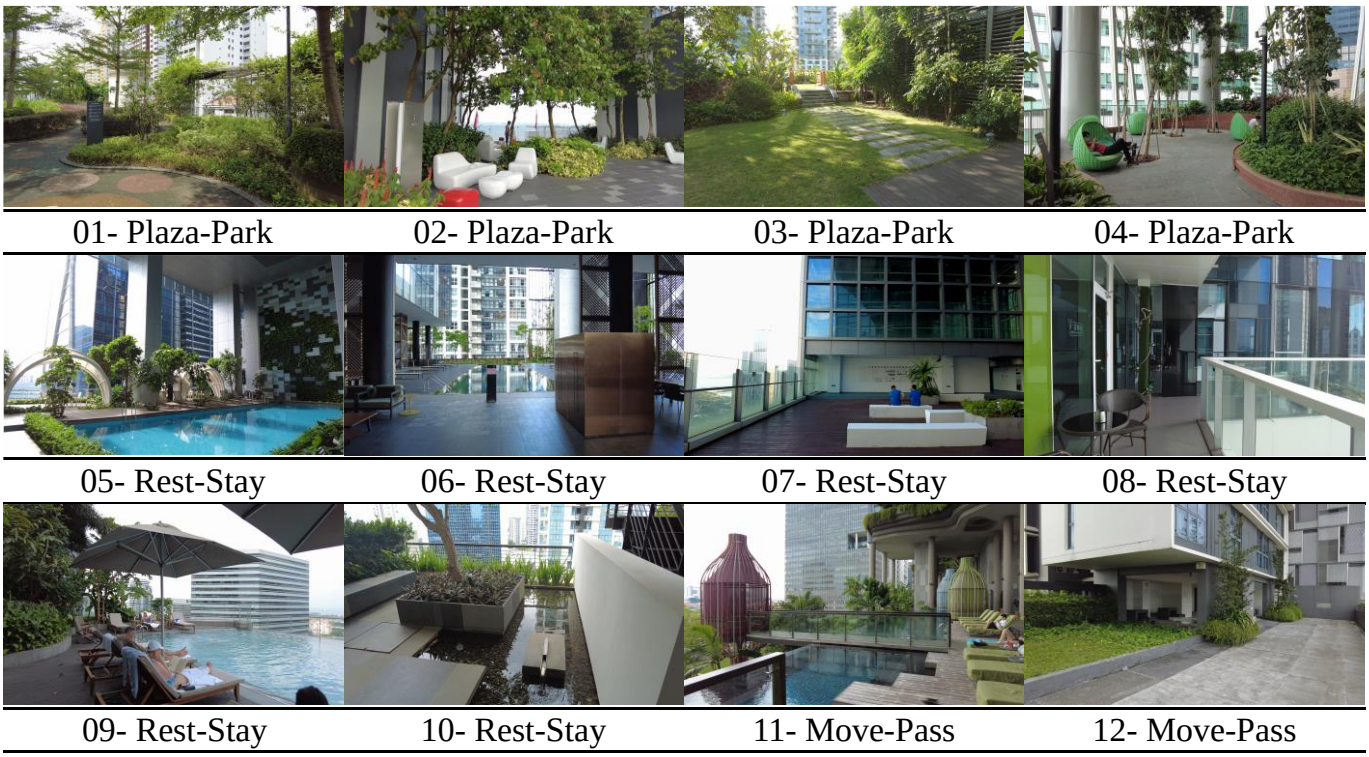


Figure 3. The three types of 12 sky garden scenarios.

2.2. Research Methods

2.2.1. Measuring Sky Garden Space Quality via Seven Dimensions

To determine the dominant spatial characteristics of health promotion to be included in the main study, an explorative pilot study was carried out in two stages.

First, spatial composition was conducted using computer vision API and manual identification of sky garden images from the internet. According to principal component analysis, the main spatial elements of sky gardens consist of seven principal components: urban landscape, skyscape, high-rise, public facility, natural landscape, waterscapes, and cultural activity [16].

Secondly, a meta-analysis of the literature was conducted, combining typical spatial elements that promote health from previous restorative environment studies. "Restorative", "healing", "health promoting", "therapeutic", "healthy", "salutogenic", "supportive environment", "environment", "landscape", and "garden" were used as keywords to search in the Web of Science and CNKI databases. Fifty-three articles, including environmental elements and indicators of health promotion, were selected. The environmental studies on health promotion focused on 19 elements, including greenery/vegetation, architecture, natural environment, waterscapes, streets/roads, public facilities, colors, rocks and mountains, environmental attributes/phenomena, people, urban/man-made natural landscapes, urban landscapes, vehicles, scale/forms, animals, sky, sounds, indoor spaces, and agricultural landscapes.

Since recreational activities mostly rely on public facilities, considering the spatial scale and form of sky gardens as the focus of this study, and following the comprehensive exploration of the two stages mentioned above, a total of seven dimensions and 24 indicators were selected. We introduced a comprehensive framework to assess the health-promoting quality of sky gardens through multidimensional perception (Figure 4), and specific indicators are detailed in the following text.

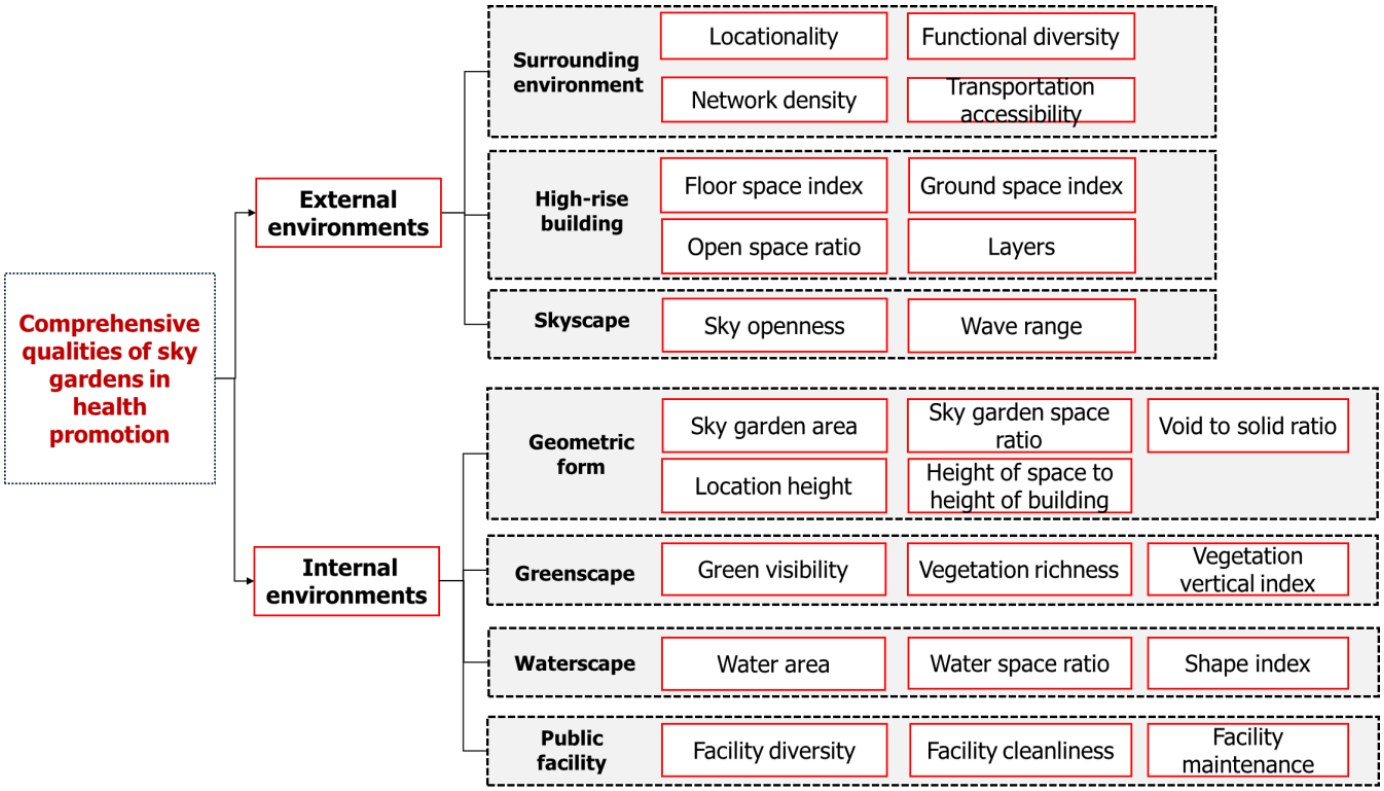


Figure 4. Twenty-four spatial indicators in the seven dimensions of health promotion in sky gardens.

- Surrounding environment

As described in Section 1.2.2, we selected the locationality, functional diversity, network density, and transportation accessibility based on previous studies to characterize the supportive effect provided by the surrounding environment for the public to access sky gardens to serve their health values. Of these, locationality and functional diversity can influence the attractiveness and uniqueness of sky gardens, making more people likely to visit them; network density and transportation accessibility directly affect the convenience of sky gardens, attracting public access and thus supporting healthy activities. This part of the research data mainly includes street network data and POI data. Previous studies have confirmed the alternative public space value of sky gardens [16], but their service radius is slightly shorter than that of the public space in the city. Thus, regarding the service radius

of public space in residential neighborhoods (≤400–500 m), the calculation radius is set to 500 m, and POIs and street network data are selected from this region.

Locationality: the linear distance of the sky garden from the city center.

Functional Diversity: the degree of mixing the POIs types within the area where the sky garden is located.

$$\text{Functional Diversity} = -\sum_i^n (Pi \times \ln Pi) \quad (1)$$

In this equation, *Pi* represents the proportion of urban facilities belonging to the *i*-th type of functional categories, and the PoIs are categorized into eight: leisure, living, sporting, shopping and commerce, scenery, culture and education, traffic, and public facilities.

Network density: the development level of road infrastructure in the surrounding environment of sky gardens.

$$\text{Network density} = \frac{\text{L}}{\text{Area}} \quad (2)$$

In this equation, L is the total length of the road within a 500 m radius of the building where the sky garden is located (km) and Area is the total area within 500 m radius of the building where the sky garden is located (km^2).

Transportation accessibility: The linear distance between the high-rise building where the sky garden is located and the nearest metro/bus station. It is one of the important influencing factors to attract people visiting the sky garden.

- High-rise building

High-rise buildings are the important spatial composition of sky gardens [16], providing important opportunities for sky garden development [4]. To describe the density metrics of high-rise buildings where sky gardens are located, the spacemate diagram proposed by Meta Berghauser Pont and Per Haupt was used [68,69], which decomposed the density metrics into the floor space index (FSI), ground space index (GSI), open space ratio (OSR), and layers (L). The formula is as follows:

$$\text{FSI} = \frac{\text{Gross Floor Area}}{\text{Plan Area}}, \quad (3)$$

$$\text{GSI} = \frac{\text{Built Area}}{\text{Plan Area}}, \quad (4)$$

$$\text{OSR} = \frac{\text{Plan Area} - \text{Built Area}}{\text{Gross Floor Area}}, \quad (5)$$

$$\text{L} = \frac{\text{Gross Floor Area}}{\text{Built Area}}. \quad (6)$$

- Skyscape

The sky scope and shape seen by people differ due to the changes of vertical position in sky gardens. Therefore, sky openness and wave range indicators are selected in this paper to quantify the sky view in the sky garden.

Sky openness is the proportion of the sky that can be seen in a sky garden. Using the "histogram" function of Photoshop software, the ratio was calculated of the sky area pixels to the total pixels in the image. In this paper, 90 images of typical sky gardens chosen to represent the whole environment of the sky gardens are selected from subsequent field studies. The sky openness is calculated by the 90 images' mean values for the sky gardens, respectively.

$$\text{Sky openness} = \sum_i^{90} \frac{\text{PC}i(\text{Sky})}{\text{PC}i(\text{Picture})} / 90 \quad (7)$$

The sky wave range is the degree of fluctuation of the skyline [70]. The highest and lowest points of the skyline are the sky wave range. ΔL is calculated as the distance between

the lowest points based on the skylines, and then ΔH, the height difference between the lowest point and the highest point, is calculated. ΔL/ΔH indicates the sky wave range. The larger ΔL value indicates that the sky is more visible and the visual depth is farther; the larger ΔH value indicates that the sky contour lines are more diverse and pleasing to the viewers. The formula is as follows [71]:

$$\text{Wave range} = \frac{(\Delta L1 + \Delta L2)}{(\Delta H1 + \Delta H2)}, \tag{8}$$

where ΔL1 is the horizontal distance from the lowest point of the skyline to the highest point on the left, ΔL2 is the horizontal distance from the lowest point of the skyline to the highest point on the right, ΔH1 is the vertical distance from the lowest point of the skyline to the highest point on the left, and ΔH2 is the vertical distance from the lowest point of the skyline to the highest point on the right.

- Geometric form

The sky garden space supports relaxation, viewing, socializing, and other healthy behaviors within the high-rise building. Typically, the greater the spatial range of activity, the greater the health-promoting behaviors [69]; the more visible the façade void, the easier it is to be perceived [72]. In addition, different from ground-level green spaces, the vertical position of sky gardens in high-rise buildings directly affects the viewpoint from which people perceive the surroundings. Therefore, sky garden area (SGA), sky garden area ratio (SGSR), void-to-solid ratio (VRS), location height (LH), and height of space to height of building (HSB) were selected as important indicators to measure the internal geometry form of the sky garden.

$$\text{SGSR} = \frac{\text{Space Area}}{\text{Floor Area}} \tag{9}$$

$$\text{VSR} = \frac{Void}{Solid} \tag{10}$$

$$\text{HSB} = \frac{\text{Height}}{\text{Height of Building}} \tag{11}$$

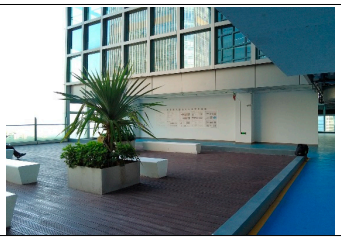
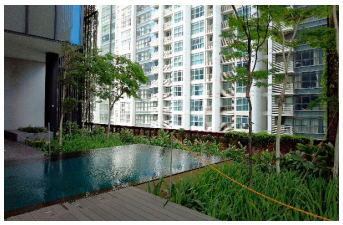
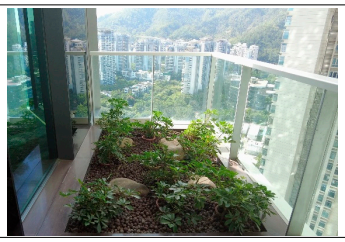
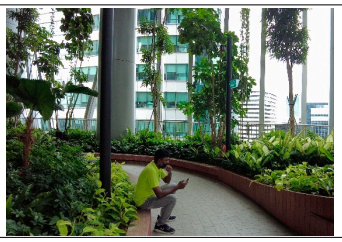
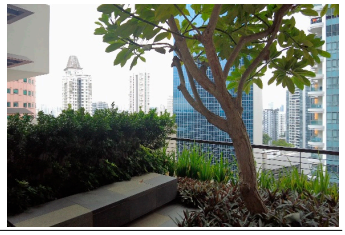
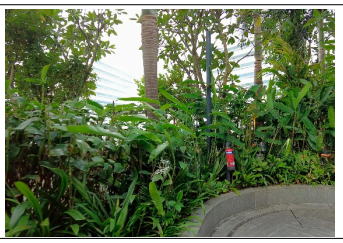
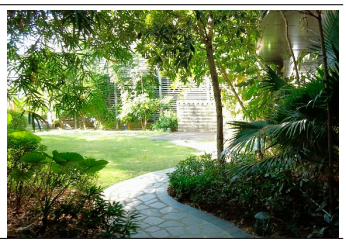
- Greenscape

We selected greenery visibility, vegetation richness, and vegetation vertical index to characterize the quality of the greenscape of the sky gardens in terms of overall greenness, vegetation species, and vertical distribution, respectively. Greenery visibility is the proportion of green vegetation in people's view. It is calculated using the same method as sky openness.

Vegetation richness is the degree of abundance and mixture. Vegetation communities are generally grouped into three categories: woodland, shrub, and herbaceous, while vegetation richness is influenced by both the plant structure and the natural attributes [73]. Therefore, nine types of vegetation communities are defined in this paper based on three levels of vegetation structural and vegetation naturalness, low, medium, and high, with corresponding scores (Table 2). Vegetation richness measurements were conducted through the virtual built-environment audit. Five auditors majoring in architecture were selected and trained in rating to reduce statistical inaccuracy. Due to the large scale of the sky gardens (>800 m^2), typical spatial joints were classified according to the morphology, and the vegetation richness of multiple joints in each sky garden was scored and averaged.

The vegetation vertical index is the difference in the vertical spatial distribution of vegetation. Vegetation outlines were drawn according to the vegetation communities, the ratio of the highest to the height of the screen was calculated as the vertical index of each community, and then the mean value of the vertical index of vegetation at each node was calculated.

Table 2. The vegetation richness: the criteria (planting structure and species character) used to define nine types and scores.

Species character similarity to natural vegetation	Structural Similarity to Natural Vegetation: Least Natural	Moderately Natural	Most Natural
Least natural			
	Simple, singer layer, isolated trees or shrubs.	Two vegetation layers, least naturalness.	Three vegetation layers, least naturalness.
	1 score	2 score	3 score
moderately natural			
	Simple, largely singer layer, intermediate naturalness.	Two vegetation layers, intermediate naturalness.	Three vegetation layers, intermediate naturalness.
	2 score	4 score	6 score
most natural			
	Simple, largely singer layer, most naturalness.	Two vegetation layers, most naturalness.	Three vegetation layers, most naturalness.
	3 score	6 score	9 score

- Waterscape

The waterscape is one of the important landscape elements to promote environmental health. Water area, water space ratio (water area/sky garden area), and shape index were selected as quantitative indicators of waterscape. The shape index of the water area mainly depends on the water area and the number of shape characterizing points (NSCP). The NSCP is an index characterizing two-dimensional geometric shapes by the minimum number of points necessary to describe their boundary. The NSCP is calculated by counting the number of a polygon's vertices. To buffer for inaccuracy of the digitizing process and to eliminate minor shape irregularities, the threshold value for valid vertex angles was set to 160°. To describe the landscape as a whole for individual study sites, the area-weighted mean was calculated as a measure of the landscape shape index. The formula is as follows [74]:

$$\text{Shape index} = \text{NSCP} * \text{Water Area} \quad (12)$$

- Public facility

Facility diversity, facility cleanliness, and facility maintenance directly affect the likelihood of people visiting the space and the stay time. Firstly, the diversity, cleanliness, and

maintenance of the 23 facilities in the six dimensions (see Appendix A for details) within the sky gardens were summarized. The five auditors scored various elements of the facility, and values were averaged in the virtual built-environment audit [75,76]. The specific steps are as follows: (1) Facility diversity: the auditor scores the facility evaluation elements in the sky garden image on dichotomous scales, which means that the presence of feature is scored as 1 and the absence is scored as 0; (2) the auditor evaluates the facility elements present in the sky garden on a scale of 1 to 5 in terms of cleanliness and maintenance according to the detailed auditing criteria; (3) the average of facility diversity, cleanliness, and maintenance for each sky garden is calculated.

2.2.2. Importance-Performance Analysis

- Approaches to synthesize IPA Matrix

This study employs the importance-performance analysis (IPA) method to understand the differences between the public's expectations and the actual performance of environmental characteristics in sky gardens for health promotion. The spatial characteristics of sky gardens for health promotion are measured by 24 indicators across the seven dimensions outlined earlier. The standard IPA diagram integrates the importance and expressiveness measures into two-dimensional, four-quadrant diagrams, with performance as the horizontal axis and importance as the vertical axis [23]. The first quadrant is "keep up the good work", the second quadrant is "concentrate here", the third quadrant is "low priority", and the fourth quadrant is "possible overkill". The thresholds in the IPA diagram directly influence the quadrant distribution [22,77] and may lead to inconsistent results [78]. Therefore, we used the mean value, diagonal, and coordinates-origin approaches to synthesize and discuss the spatial indicator importance and performance of the sky garden (Figure 5).

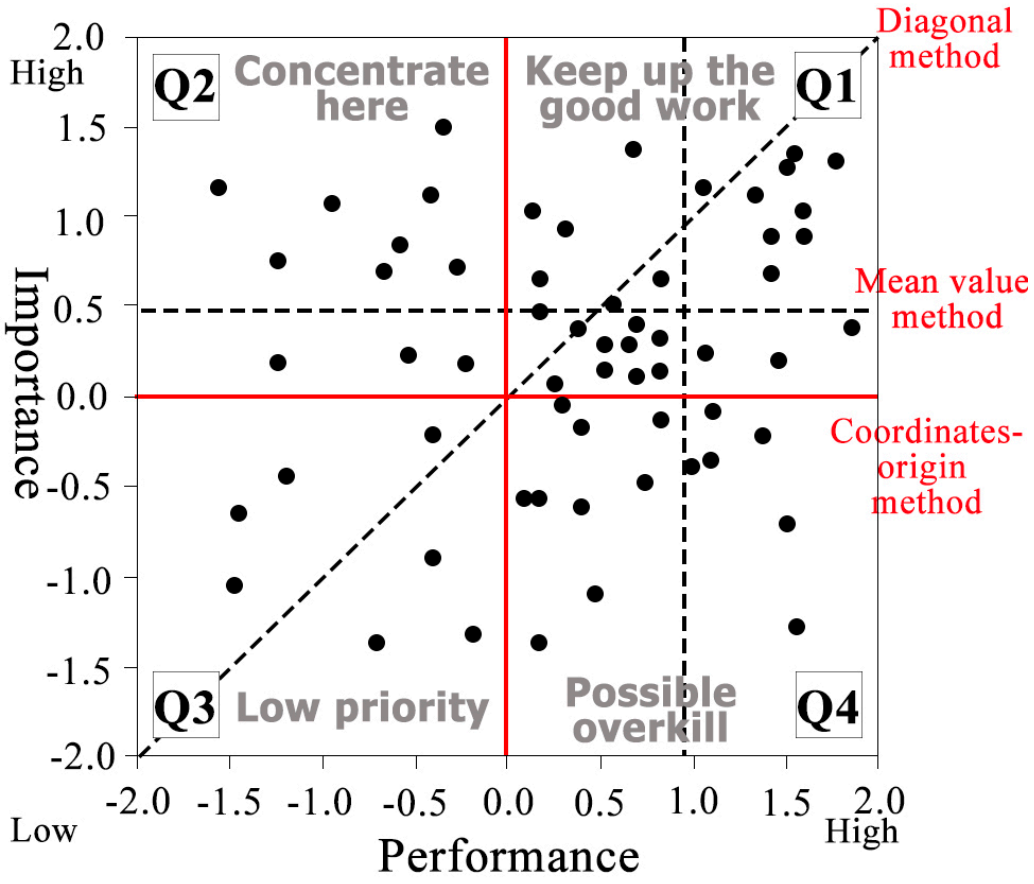


Figure 5. Graphical comparison of mean value, diagonal, and coordinates−origin approaches in identifying the IPA matrix.

- Subjects

Individual differences influence spatial preferences, while experts and relevant professionals demonstrate good consistency and discrimination in corresponding research [79]. The expert evaluation, which relies entirely on professionals, has been questioned because of some differences with the evaluation of the public. Therefore, this study combines evaluations from both experts and the public. Given that the selected cases needed to consider the typicality of various types of sky garden, which are widely distributed across cities and even countries, conducting on-site surveys was challenging. Therefore, we opted for online surveys to obtain more comprehensive data. In total, there were 375 individuals, including 170 males and 206 females (Table 3).

Table 3. The evaluation subjects.

Group	Description	Planned Participant	Actual Participant
Expert Group	Architectural design-related fields, PhD, university teachers, and professionals engaged in high-density environment, sky garden space design related work	20	27
Relevant Professional Group	Designers in architectural design	130	163
Public Group	The public and non-professionals in the field of architectural design	150	186
	Sum	300	376

- Data collection

Before the data collection commenced, a field survey was conducted to discover the activity patterns of the sky garden users. The data collection for this study includes two parts: perception data from the public regarding the importance of health promotion in sky gardens and spatial performance data related to the health promotion of sky gardens. (1) Importance data of health promotion in sky gardens. In the questionnaire design phase, a pre-survey was conducted to test the applicability of the questionnaire. Based on the results, adjustments were made to the questionnaire text to align with respondents' reading habits and to facilitate understanding. The formal questionnaire was divided into two parts. The first part asked the subjects about their demographic characteristics and activities. The second part uses a 10-point Likert scale to ask subjects about the importance of health promotion in various dimensions of sky gardens. (2) Performance data of health promotion in sky gardens. Based on the selected sky gardens, spatial performance data representing health promotion in sky gardens were collated by calculating 24 indicators in seven dimensions in Section 2.2.

2.2.3. Questionnaire Analysis

In this research, 376 questionnaires were recalled, and 354 valid questionnaires were finally obtained by deleting incomplete and overtime-filled questionnaires. Then the reliability and validity of the questionnaire data were tested. The results (Table 4) indicate that Cronbach's alpha value is 0.96, indicating that the questionnaire's reliability was at a high level. The Kaiser–Meyer–Olkin (KMO) value is 0.93, which is located between the high scoring range (>0.9), and significance is 0.000, which is less than 0.05. In conclusion, the data reliability and internal consistency results of this questionnaire demonstrate high reliability and meet the requirements of the validity test indicators, providing support for the reliability of subsequent analyses.

Table 4. Results of questionnaire reliability and validity analysis.

Cases	Valid	354	Cronbach's alpha		0.96
	Excluded	0	Bartlett's test of sphericity	Approx Chi-Square	748.67
	Total	354		df	276
KMO of sampling adequacy		0.93		Sig.	0.000

3. Results

3.1. Subjects' Demographic Profile

From the basic information of the subjects in the first part of the valid questionnaire, 45.1% were male and 54.9% were female, which is an equal gender distribution. The age distribution ranges from 0 to over 60 years old, with 18–30 year-olds accounting for approximately 80% of the total population. Educational background is dominated by bachelor's (38.93%) and master's (39.73%) degrees, totaling more than 2/3 of the whole. In terms of the types of sky garden visited, the survey adopted a multiple-choice approach. The results show that 21.60% had not visited any sky gardens, while those who have visited two types (21.33%) and three types (22.40%) of sky gardens account for approximately half (43.73%). Among these, rooftop gardens (47.20%), podium gardens (43.20%), and sky terraces (39.47%) are the most frequently visited sky garden types. The analysis above shows that the sampled survey has good representativeness and comprehensiveness (Table 5, Figure 6).

Table 5. Subjects' basic information variable description and statistics.

Variable	Variable Description	Mean	S.D.	Variance
Gender	Male = 1, Female = 2.	1.55	0.498	0.248
Age	18–25 years = 1, 26–30 years = 2, 31–40 years = 3, 41–50 years = 4, 51–60 = 5, over 60 years = 6.	2.90	0.976	0.953
Education	PhD = 1, master = 2, bachelor = 3, college = 3, high school = 4, junior high school and below = 5.	2.42	0.880	0.774

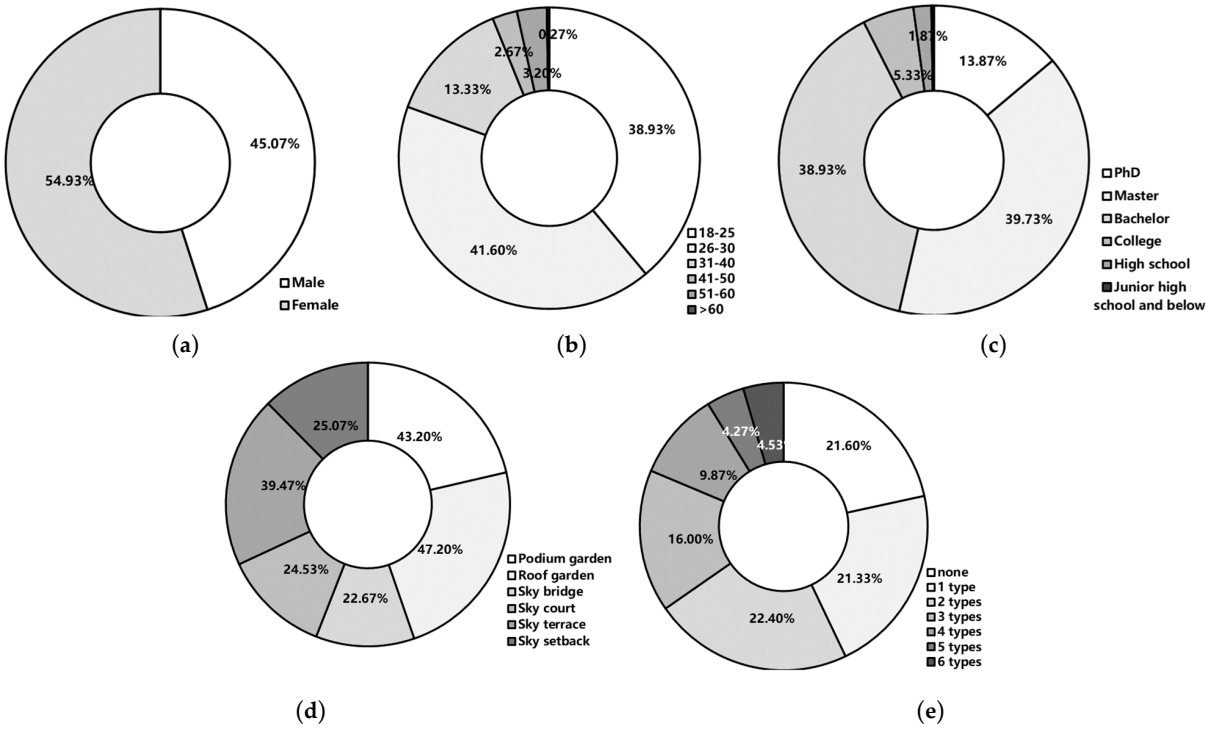


Figure 6. Subjects' demographic profile. (**a**) Gender statistics; (**b**) Age statistics; (**c**) Education statistics; (**d**) Statistics on the types of sky garden visited; (**e**) Statistics on the number of types of sky garden visited.

3.2. Importance Analysis of Public Perceptions on Health Promotion in Sky Gardens

The evaluation results of the importance of each spatial indicator of the sky garden were statistics, and the bar graph of the indicator importance was drawn (Figure 7). The results indicate that the public evaluated the importance of sky gardens the highest in terms of the indicators for facility cleanliness and maintenance, green visibility and vegetation

richness in the greenscape dimension, and sky openness in the skyscape dimension. The traffic accessibility in the dimension of the surrounding environment, open space ratio in the dimension of high-rise buildings, sky garden area, sky garden area ratio and location height in the dimension of geometric form, and vegetation vertical index in the dimension of greenscape were evaluated highly.

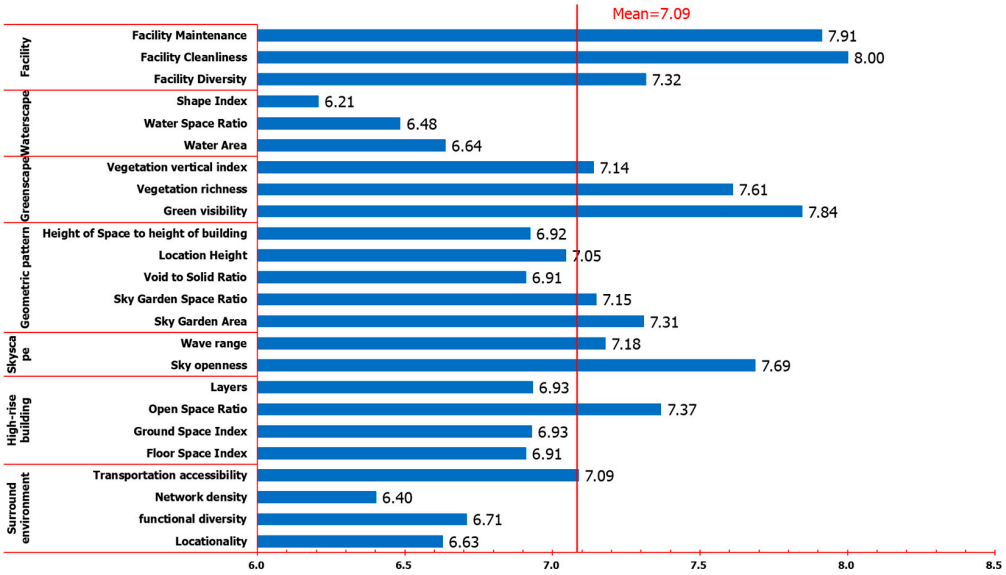


Figure 7. Importance values of 24 indicators of sky gardens.

Considering the above results, transportation accessibility, public facilities, greenscape, and skyscape are the most crucial dimensions affecting the public's engagement in health behaviors. Convenient transportation plays a crucial role in encouraging the public to visit nearby sky gardens, providing essential support for enhancing the health promotion experience associated with accessing these spaces. Public facilities serve as the crucial material foundation for highlighting health promotion attributes, solidifying the recreational environment status, and enhancing the vitality of shared spaces in sky gardens. The expansive skyscape with its distant, peaceful attributes, can alleviate people's physical and mental stress and help them to quickly recover to better states. Waterscape has not been listed in the public requirements for sky gardens, while spatial scale and greenery are in high demand for sky gardens. It is widely accepted that sky gardens are within the urban habitat context of high-density cities; density indicators associated with high-rise buildings have a relatively low impact on health promotion, such as FSI, GSI, L, and location height, which refers to the height of the space relative to the height of the building. Overall, the public places greater emphasis on spatial indicators that cater to activities such as relaxation, being close to nature, and enjoying panoramic views in sky gardens. Furthermore, there is greater sensitivity towards public facilities that contribute to activities related to physical and mental health.

3.3. Performance Analysis of Public Perceptions on Health Promotion in Sky Gardens

According to the comprehensive quantitative framework of health benefits for sky gardens, the data of spatial indicators were calculated and normalized over the same range (0, 1). Subsequently, radar diagrams were drawn to compare and analyze the similarities and differences in the performance of three types of sky garden. It is noted that the differences in performance between internal and external spatial indicators are more significant within each type of sky garden (Figure 8). The three types of sky garden show relatively consistent performance in external environmental indicators such as locationality, transportation accessibility, sky wave range, floor space index, and open space ratio. This indicates a certain convergence in the external environmental characteristics of sky gardens, suggesting the distribution in densely populated, compact urban environments. As for the

internal environmental indicators, plaza-park sky gardens have excellent performance in scale size, green visibility, vegetation richness, and vegetation vertical index. Rest-stay sky gardens perform well in vegetation richness, water space ratio, and facility cleanliness and maintenance. Move-pass type sky gardens have outstanding performance in sky garden area ratio and void-to-solid ratio indicators.

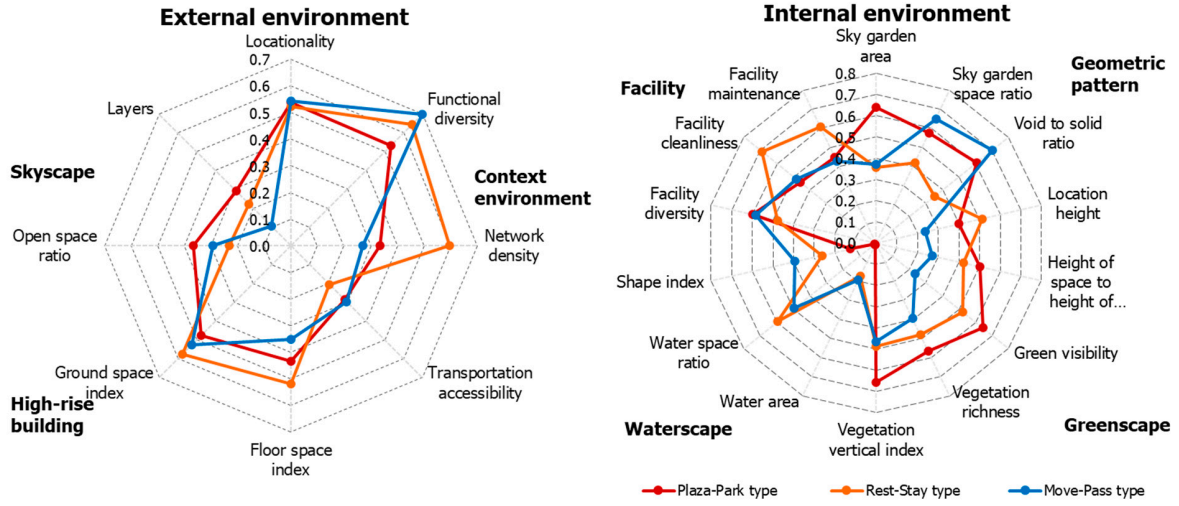


Figure 8. Performance radar diagrams of three sky garden spatial indicators.

Based on the performance of spatial indicators that ranked in the top 25%, it is evident that various types of sky garden display distinct characteristic tendencies (Figure 9). Plaza-park sky gardens with high-performance indicators are mainly focused on geometric form, greenscape, and public facility dimensions, which can satisfy people's diversified behavioral needs in sky gardens. Rest-stay sky gardens are concentrated in public facilities, waterscape scenery, and greenscape dimensions. Due to their limited spatial area and surrounding dense environment, differentiation in internal natural landscapes and public facilities is the focus of their spatial creation. Move-pass sky gardens focus on geometric form, surrounding environment, and public facility dimensions. Despite their relatively small size, these sky gardens have high spatial openness and visibility that play a positive role in spatial identification and perception. Additionally, neither the sky openness nor the wave range were included in the top 25% of indicators for all types of sky garden. This may be related to obstruction of the sky views by surrounding high-rise buildings, internal vegetation, and facilities, resulting in a relatively poor performance of these indicators.

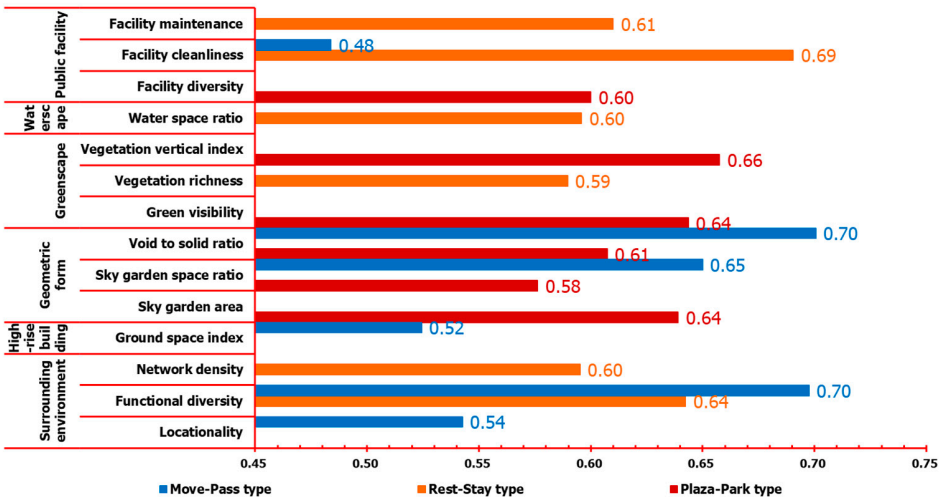


Figure 9. Top 25% spatial indicators of performance in health promotion in three types of sky garden.

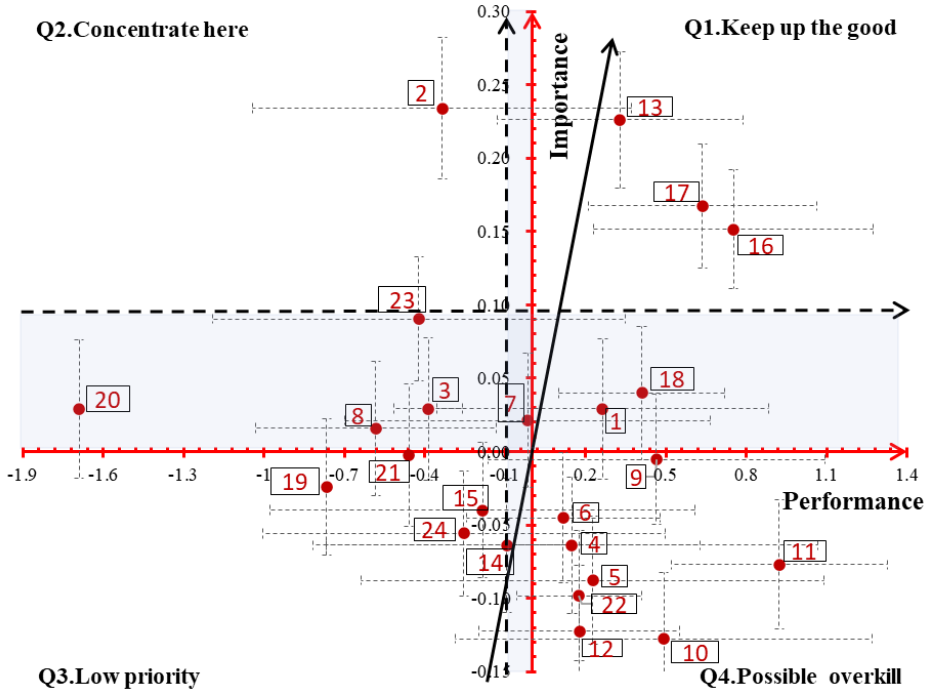
3.4. Importance-Performance Analysis Matrix on Health Promotion in Sky Gardens

Standardized spatial indicator performance and importance data affecting health promotion in sky gardens, using the mean value, diagonal, coordinates-origin methods, to generate IPA matrix and discuss the spatial indicators for each dimension to the status of different types of sky garden (Figure 10). The specific steps are as follows: first, determine the approximate distribution of the indicator quadrants through the mean value, diagonal, and coordinates-origin methods, respectively. Then, the high threshold of the quadrant is used as a baseline to determine the indicator's position. For areas with differences between the quadrant division of the mean value and coordinates-origin, the priorities for their development are further clarified by considering the standard errors of the indicators and the actual status of the sky gardens. Taking facility cleanliness of plaza-park sky gardens as an example, the point is on the second and third quadrants in the coordinates-origin method and mean value method analyses, and above the 45° line in the diagonal method, indicating the indicator belongs to "concentrate here", "low priority". Then, consider the standard error line of the facility cleanliness indicator, which can be in the first and second quadrants of the coordinates-origin method and mean value method analyses, and above the 45° line in the diagonal method. Based on the facility cleanliness of the plaza-park sky gardens, the point was finally placed in the second quadrant, which is the "concentrate here" indicator. Continuing with the analysis, the spatial indicator placement areas for each type of sky garden are analyzed individually, and the results are as follows (Table 6):

Table 6. Table of corrected attributes of spatial indicators for three types of sky garden.

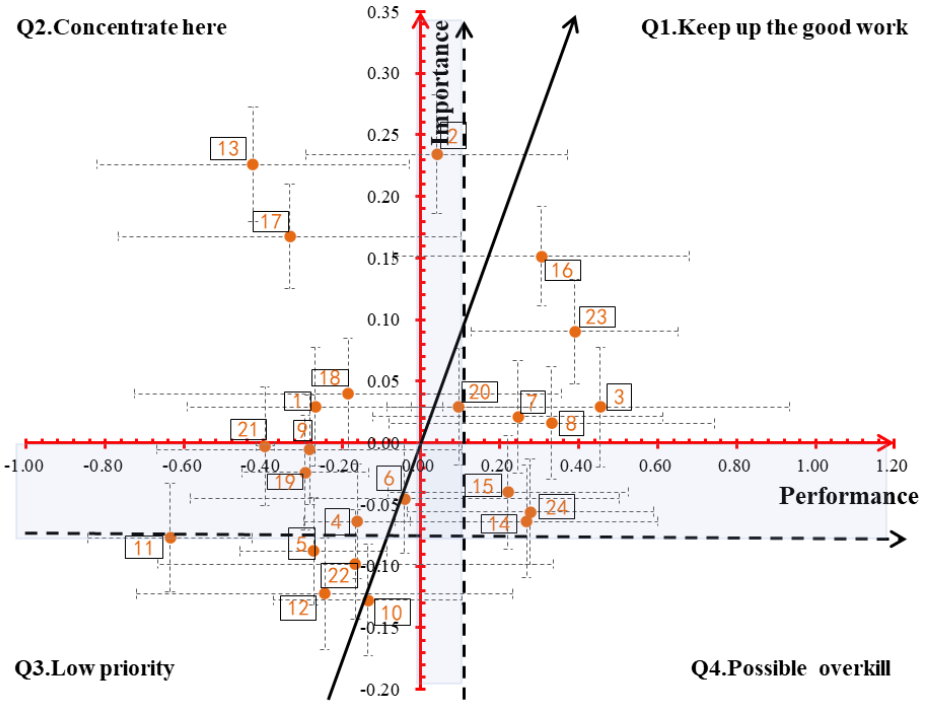
	Plaza-Park Sky Gardens	Rest-Stay Sky Gardens	Move-Pass Sky Gardens
Q1 Keep up the good work	13, 16, 17, (1), (18)	3, 7, 8, 16, 23, (20)	2, 13, (1), (20)
Q2 Concentrate here	2, 23	1, 13, 17, 18, 21, (2), (9)	16, 17, (18), (23)
Q3 Low priority	14, 15, 19, 21, 24, (3), (8), (20)	5, 10, 11, 12, 22, (4), (19), (24)	6, 9, 10, 14, 15, 24, (3), (7), (11), (22)
Q4 Possible overkill	4, 5, 6, 9, 10, 11, 12, 22, (7)	(6), (14), (15)	4, 5, 12, 19, 21, (8)

Note: The numbers have the same meanings as in Figure 10. Indicators in parentheses represent the comprehensive consideration of standard error lines and the specific spatial status of sky gardens.

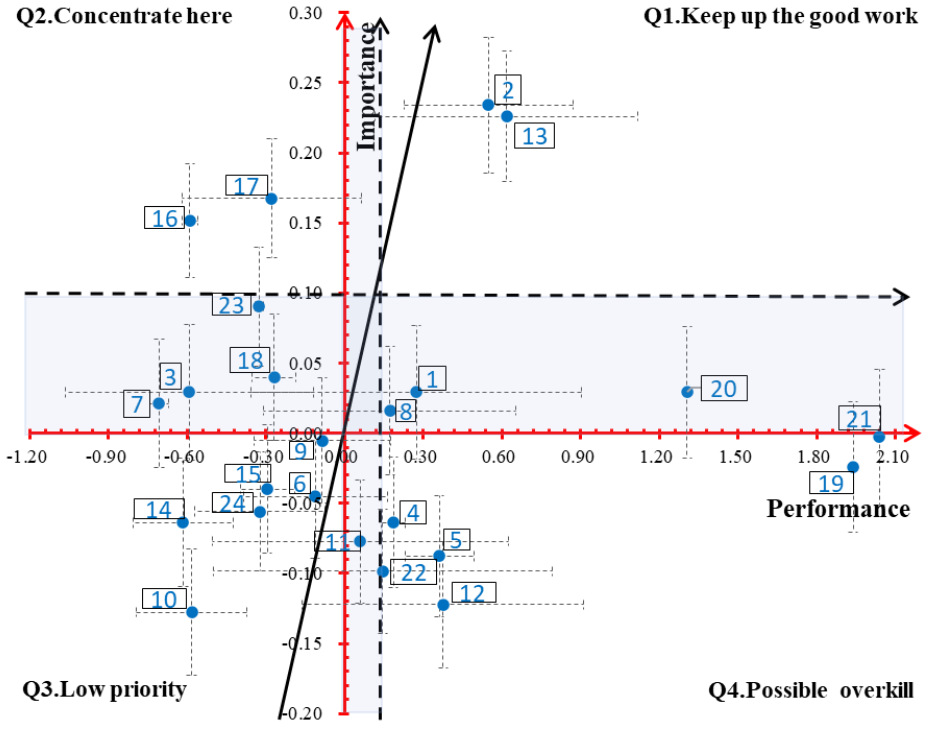


(**a**)

Figure 10. *Cont.*



(**b**)



(**c**)

Figure 10. IPA matrix of 24 spatial indicators for three types of sky garden. (**a**) Plaza-park sky gardens; (**b**) Rest-stay sky gardens; (**c**) Move-pass sky gardens. Notes: 1 = Locationality, 2 = Functional diversity, 3 = Network density, 4 = Transportation accessibility, 5 = Sky openness, 6 = Wave range, 7 = Floor space index, 8 = Ground space index, 9 = Open space ratio, 10 = Layers, 11 = Sky garden area, 12 = Sky garden space ratio, 13 = Void-to-solid ratio, 14 = Location height, 15 = Height of space to height of building, 16 = Green visibility, 17 = Vegetation richness, 18 = Vegetation vertical index, 19 = Water area, 20 = Water space ratio, 21 = Shape index, 22 = Facility diversity, 23 = Facility cleanliness, 24 = Facility maintenance.

(1) "Keep up the good work" area. These indicators represent the major strengths and potential competitive advantages of sky gardens. The results indicate that the indicators of void-to-solid ratio, green visibility, vegetation richness, and vegetation vertical index for plaza-park sky gardens; the network density, green visibility, facility cleanliness, and water space ratio for rest-stay sky gardens; and the function diversity, void-to-solid ratio, and water space ratio for move-pass sky gardens, all fall within this area.

(2) "Concentrate here" area. These indicators play crucial roles in promoting public health, but their spatial performance is relatively low and urgently needs improvement and enhancement. The function diversity and facility cleanliness of plaza-park sky gardens, the void-to-solid ratio, vegetation richness, vegetation vertical index, and waterscape shape index of rest-stay sky gardens, and the greenscape indicators and facility cleanliness of move-pass sky gardens are in urgent need of optimization and improvement. Therefore, plaza-park sky gardens need to prioritize improving the facility cleanliness, rest-stay sky gardens need to enhance spatial permeability and the hierarchy of green landscape, while move-pass sky gardens need to increase the greenscape richness and facility cleanliness.

(3) "Low priority" area. The attributes that fall into this quadrant are not performing exceptionally well but are relatively unimportant to the public; they represent minor weaknesses and poor performance is not a major problem. Compared to that, the vertical location height and waterscape demand of plaza-park sky gardens, facility diversity and skyscape of rest-stay sky gardens, and location height and height of space to height of building of move-pass sky gardens are within this area.

(4) "Possible overkill" area. Attributes are of low importance but perform strongly, indicating that limited resources may be a waste and are inefficiently used and can be reallocated. The plaza-park sky gardens in terms of transportation accessibility, skyscape, high-rise buildings (open space ratio, layers), and geometric form (sky garden area, sky garden space ratio); the indicators of height of space to height of building in rest-stay sky gardens; and transportation accessibility, sky openness, water area, and waterscape shape index of move-pass sky gardens fall into this quadrant.

In summary: (1) Transportation accessibility is good for all types of sky garden in their locations. This indicator is "possible overkill" in plaza-park and move-pass sky gardens, while it is a "low priority" improvement for rest-stay sky gardens. (2) Rest-stay sky gardens' public facilities are optimal. In plaza-park sky gardens, the facility diversity is "possible overkill", facility cleanliness falls into the "concentrate here" area, and facility maintenance is a "low priority" attribute. In rest-stay sky gardens, facility cleanliness serves as "keep up the good work" indicator, facility diversity and maintenance belong to the "low priority" area. In move-pass sky gardens, facility cleanliness has the "concentrate here" attribute, while facility diversity and maintenance are "low priority" for health promotion. (3) Plaza-park sky gardens have the highest quality in greenscape. All greenscape indicators in plaza-park sky gardens fall into the "keep up the good work" area. In rest-stay sky gardens, green visibility is the "keep up the good work" indicator, while the vegetation richness and vegetation vertical index need improvement. In move-pass sky gardens, all three indicators need enhancement. (4) Skyscape shows varying degrees of overkill in different types of sky garden. Plaza-park sky gardens of sky openness and wave range are overkill indicators. For rest-stay sky gardens, sky openness is a "low priority" attribute, while sky wave range is an overkill indicator. the situation is the opposite for the move-pass and the rest-stay sky gardens. Overall, rest-stay sky gardens have the greatest competitive advantage, which is possibly due to their embodied scale, but their spatial permeability and interface openness need to be raised. Plaza-park sky gardens, while large in scale, still have certain gaps in richness, diversity, and alignment with public demands, such as vegetation richness, waterscapes, and facility cleanliness. It may also cause some emotional barriers to people due to the increase of vertigo or agoraphobia at greater heights [17]. Move-pass sky gardens are limited by their transportation function, resulting in moderate levels of both public demand and supply.

4. Discussion

4.1. Opportunities and Strategies for Sky Garden Development

High-density cities have many opportunities to realize the potential of sky gardens. The previous texts confirm that there are already significant foundations in public awareness regarding the positive values of sky gardens for public physical and mental health and social interaction. Additionally, government policies have attempted to encourage the development of the roof and podium greening of high-rise buildings in order to tackle the inadequate ground-level open spaces [80], expand the green network [5,81], and promote carbon peaking and carbon neutrality action [82,83]. Additionally, research and demonstration projects on sky gardens provide the objective and scientific basis for multiple benefits [84–86]. Research findings on materials, techniques, and maintenance of vertical greening have been disseminated to the public through popular science methods. Recently, the pilot implementation of the research and demonstration of vertical garden green ecological architecture has begun. This plan specifies the inclusion of sky garden (green space) plants and facilities, the use of vertical open spaces, and related management and services in property service contracts [87]. Sky garden development has taken root in high-density environments, with expectations of a significant emergence of new sky gardens in due course.

To foster the systematic development of sky gardens, the following broad strategies could be adopted: (1) governments could incentivize construction through reward policies and establish an accreditation system to ensure delivery quality; (2) strict standards and regulations for sky garden materials and methods should be promptly instituted to ensure quality and durability. For sky garden construction, the following should be applied: (1) More attention could be paid to high-density, compact urban environments. On one hand, this study found that people are accepting sky gardens in the context of high-density urban environments. On the other hand, the scarcity of ground-level green spaces in these areas underscores the importance of utilizing sky gardens as supplementary public spaces [8], thereby enhancing users' spatial experiences and overall well-being. (2) In practical application, precedence could be afforded to the development of rest-stay sky gardens. These spaces offer significant health-promoting advantages, come with relatively lower construction costs, and provide convenient spots for the occupants of high-rise buildings for daily relaxation and work breaks [8,17].

4.2. Utilizing the Qualities of Complementary Public Spaces

Population growth and migration towards urban centers, along with the resulting urbanization process, have accelerated the density, scale, and functional diversity of high-rise building development [36]. This also inevitably demands more open spaces within high-rise buildings, and sky gardens serve as practical significance and operability solutions to complement public spaces as pocket parks in dense urban environments [17]. The previous studies indicate that the public places greater emphasis on activities in sky gardens, such as relaxation, being close to nature, and enjoying panoramic views, and they are more sensitive to public facilities that promote physical and mental well-being. Rich natural landscapes [51,52], expansive sky views [62], waterscapes [53], and diverse public facilities [55,56] all have positive effects on mental and physical well-being. Sky gardens play a significant role in promoting public health, especially in high-density urban areas, as supported by empirical evidence.

Different types of sky garden exhibit distinct disparities in their health-promoting effects, which can be reinforced by leveraging their spatial attributes to enhance their qualities as complementary public spaces. Plaza-park sky gardens have high similarity in attributes with ground-level public spaces [17]. These gardens are more likely to benefit from landscape typologies, functions, and facility selections and combinations, and they are best positioned to cater to the diverse and abundant health needs of the public. Thus, plaza-park sky gardens could focus on the overall quality of vegetation types, layout, and public facilities, aiming to enhance visitor initiative and prolong exposure to natural environments by increasing landscape complexity. Rest-stay sky gardens primarily cater to the daily relaxation needs of

high-rise building occupants [36]. Therefore, they can fully utilize their small size and flexible usage characteristics by being distributed throughout high-rise buildings. In terms of spatial interface permeability, rest-stay sky gardens need enhancement. By reducing view-blocking materials and controlling vegetation density, they can provide natural environments while effectively promoting social interactions. The first two types of sky garden mainly cater to static leisure activities, while move-pass sky gardens primarily support dynamic viewing activities. Their spatial form is predominantly linear [66], and they also serve a transportation function. The public's attention to its health promotion and its performance are both low. To improve this, rest areas can be appropriately incorporated into their transportation function, enriching spatial usability and attracting public engagement.

To further enhance the characteristics of sky gardens as complementary public spaces, it is necessary to specifically increase the utilization frequency. Research has confirmed that high-quality urban environments are more likely to attract the public to visit the adjacent open space, with increased accessibility, activity numbers, duration, and range of use [61]. To enhance the health-promoting potential of sky gardens, the supportive role of the surrounding environment can be amplified by the following: (1) By improving transportation accessibility, the frequency of sky garden usage can be increased; (2) By enhancing the functional diversity of the surrounding environment, "accidentally visit" can be attracted from other functional spaces; (3) By improving the openness of sky gardens in high-rise buildings, both physically and socially, the visitation rate of the public to sky gardens can be increased through higher spatial visibility.

5. Conclusions

This study aims to emphasize the differences in the multidimensional spatial characteristics of different types of sky garden by selecting representative, diverse, and typical cases. The research results provide a general understanding of the public's health promotion needs and supplies in different types of sky garden. The results show the following: (1) The public seems to have widely accepted sky gardens in the context of high-density urban environments (near 6.92, below the mean of 7.09). They place greater emphasis on spatial indicators that cater to relaxation activities and show heightened sensitivity toward public facilities (7.32–8.00) that contribute to physical and mental health-related activities. (2) The health promotion performance of different types of sky garden shows significant variation, with the rest-stay sky gardens at the embodied scale demonstrating the greatest competitive advantage. (3) The development of sky gardens has significant potential, and different types of sky garden need to specifically leverage their characteristics as complementary public spaces. Since the primary purpose of this study was to explore the overall demand of the public for health promotion in sky gardens, we did not categorize the sky gardens in the importance analysis. In future research, we will further clarify the different health experience needs of sky gardens and consider incorporating longitudinal assessments to evaluate the long-term effects of regular exposure to sky gardens on physiological and psychological well-being. Furthermore, health benefit analysis of landscape spaces could be conducted by more rigorous evidence-based studies using technologies such as virtual reality and wearable biosensors. Meanwhile, textual, image, and video data from social media platforms can provide insights into people's perceptions and feedback regarding landscape spaces. It helps to assess people's feelings and evaluations from a humanistic perspective, thus adding another dimension to the assessment of landscape space optimization.

Author Contributions: Y.L., conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, visualization, writing—original draft, writing—review and editing; H.D., conceptualization, methodology, validation, writing—review and editing, supervision, funding acquisition. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: Data are contained within the article.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. Examples of Virtual Built-Environment Audit on Facility Diversity, Tidiness, and Maintenance of Sky Garden

Table A1. Facility diversity virtual built-environment audit.

General Information	Building Name	PARKROYAL COLLECTION Pickering					
	Sky Garden Type	Rest-Stay Sky Garden					
	Sky Garden NO.	11					
	Auditor NO.	01	02	03	04	05	Mean
Basic facility	Hard seat						
	Soft seat	1	1	1	1	1	1
	Table	1	1	1	1	1	1
	Trash bin	1	1	1	1	1	1
	Deck chair	1	1	1	1	1	1
Athletic facility	Fitness equipment (outdoor)						
	Fitness equipment (indoor)	1	1	1	1	1	1
	Swimming pool	1	1	1	1	1	1
	Shower zone						
	Public facility for children						
Access for disabled	Handrail			1	1		1
	Ramp						
Safety facility	Envelope (railing/glass/bush)	1	1	1	1	1	1
	Fire hydrant	1	1	1		1	1
	Indication signage	1	1	1	1	1	1
	Lifesaving appliance	1	1	1	1	1	1
Shading facility	Beach umbrella						
	Sunshade tent						
	Empty space	1	1	1	1	1	1
Landscape facility	Sculpture	1	1	1		1	1
	Decoration pendant						
	Landmark	1	1	1	1		1
	Pool	1	1	1			1

Note: Facility diversity: 1—present, 0 or null—not present.

Table A2. Facility cleanliness virtual built-environment audit.

General Information	Building Name	PARKROYAL COLLECTION Pickering					
	Sky Garden Type	Rest-Stay Sky Garden					
	Sky Garden NO.	11					
	Auditor NO.	01	02	03	04	05	Mean

Table A2. *Cont.*

Basic facility	Hard seat						
	Soft seat	5	4	5	5	4	4.6
	Table	5	4	3	5	5	4.4
	Trash bin	5	4	3	5	5	4.4
	Deck chair	5	3	4	5	4	4.2
Athletic facility	Fitness equipment (outdoor)						
	Fitness equipment (indoor)	5	4	4	5	5	4.6
	Swimming pool	5	4	5	5	5	4.8
	Shower zone						
	Public facility for children						
Access for disabled	Handrail			3	4		3.5
	Ramp						
Safety facility	Envelope (railing/glass/bush)	5	4	4	4	5	4.4
	Fire hydrant	5	3	4		5	4.3
	Indication signage	5	3	4	4	5	4.2
	Lifesaving appliance	4	3	4	4	5	4.0
Shading facility	Beach umbrella						
	Sunshade tent						
	Empty space	4	4	4	5	5	4.4
Landscape facility	Sculpture	4	4	5			4.3
	Decoration pendant						
	Landmark	4	4	5	4		4.3
	Pool	3	4	3			3.3

Notes: Facility cleanliness: 5—very clean, 4—somewhat clean, 3—normal, 2—less clean, 1—dirty.

Table A3. Facility maintenance virtual built-environment audit.

General Information	Building Name	PARKROYAL COLLECTION Pickering					
	Sky Garden Type	Rest-Stay Sky Garden					
	Sky Garden NO.	11					
	Auditor NO.	01	02	03	04	05	Mean
Basic facility	Hard seat						
	Soft seat	5	4	5	5	4	4.6
	Table	5	4	4	5	5	4.6
	Trash bin	5	3	4	5	5	4.4
	Deck chair	5	3	3	5	4	4.0
Athletic facility	Fitness equipment (outdoor)						
	Fitness equipment (indoor)	5	4	4	5	5	4.6
	Swimming pool	5	4	4	5	5	4.6
	Shower zone						
	Public facility for children						
Access for disabled	Handrail			4	4		4.0
	Ramp						

Table A3. *Cont.*

Safety facility	Envelope (railing/glass/bush)	5	4	4	4	5	4.4
	Fire hydrant	5	3	3		5	4.0
	Indication signage	5	3	4	4	5	4.2
	Lifesaving appliance	5	3	4	4	5	4.2
Shading facility	Beach umbrella						
	Sunshade tent						
	Empty space	4	3	4	5	5	4.2
Landscape facility	Sculpture	4	4	5		5	4.5
	Decoration pendant						
	Landmark	4	4	5	4		4.3
	Pool	3	4	3			3.3

Note: Facility maintenance: 5—very good, 4—somewhat good, 3—normal, 2—less good, 1—bad.

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