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ORIGINAL RESEARCH PAPER

Designing for health: A study of architecturally oriented models of public space

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ABSTRACT

In the post-pandemic period, cities are committed to creating healthier and more healing urban environments. In high-density urban environments, urban complexes are increasingly assuming the function of enriching the external space and activating the vitality of cities, and their architecturally oriented public spaces have great potential for the promotion of residents' health. However, current research on public space and health has focused on green spaces and neighborhoods, and has not yet systematically sorted out the pathways that influence how building-oriented public space can contribute to health. In order to fill the gap, this study attempt to establish a model of health-promoting architecturally oriented public space, which can provide a reference for the similar projects.

KEYWORDS

public health, public space, architecture, high-density

1. INTRODUCTION

The onslaught of pandemic has made cities begin rethinking the evils of high-density environments [1]. However, the dynamics of high-density environments can hardly be slowed down with urbanization. It is expected that by 2050, more than 2/3 of the world's population will live in cities [2]. The increase in urban population and the strain on land resources will inevitably bring about further deterioration of the urban environment, which will ultimately jeopardize the health of the residents. Under this premise, how to create active, open, and healing public spaces in limited urban land becomes particularly important. With the development of Healthy City theory, public space is considered as an important carrier for urban life and recreation, which not only meets the increasing demand of residents for outdoor activities and social interactions, but also has a significant effect on healing emotions and relieving stress [3].

However, most of the current research on public space and health focuses on city-level parks, green spaces, and settlements [4]. In high-density cities, however, there is often not enough land to accommodate large-scale public space development. On the other hand, mixed-use buildings are springing up as a result of the wave of urbanization. As products of typical high-density urban environments, these urban complexes are becoming larger and larger, more and more functional, more and more "city-like" than the city itself, providing one-stop services for residents. The courtyards, plazas, and streets inside the buildings are gradually intermingling with the urban space, and are beginning to take on the function of urban public space to meet the needs of the society [5]. Therefore, in the process of

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urbanization, the articulation of the inner space of the city and the outdoor space of the building is an inevitable trend in the evolution of urban complexes, which has great potential in the future development. Yet, little research has been done on this kind of building-oriented public spaces, and the ways in which it promotes the health of residents and the factors that influence it are not clear.

To fill the gap, this study attempt to explore the main factors of architecturally oriented public space affecting residents' health, and build up a model of health-promoting building-oriented public space by combining theoretical and practical approach.

2. MATERIAL AND METHOD

The Wuchang Government Center, the study site for this case, is quite an example as described above. Located on the shore of Wuhan's Neisha Lake, it is adjacent to the city's subway line, and has an excellent location with public resources including elementary school, shopping malls, and the Workers' Cultural Palace. The project covers a wide range of functions of governmental affairs hall, community medical care, institutional office, and big data research center. The huge volume of the project with a net land area of 24,000 square meters and a total building area of 140,000 square meters creates conditions for the development of public space. The 16-story space is divided into four segments, 1–4, 5–8, 9–11 and 12–16 (see in Fig. 1).

The explore of architecturally oriented public space model that promotes health in the high-density environment by using Wuchang Government Center as an example has six phases.

- Sorting out the influencing factors of possible building-oriented health-promoting public space based on literature review;
- Analyzing and evaluating the current use of the study site through field survey;
- Examining and re-validating the main factors affecting health in building-oriented public spaces within the plots through interviews and questionnaires;
- Combining site research, questionnaires and interviews to summarize and model architecturally oriented public spaces for health promotion;
- Embedding the model into the case site to target remodeling strategies and interventions;

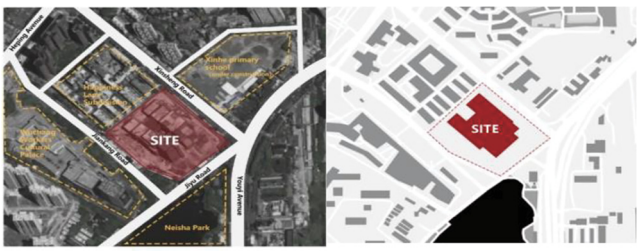

Fig. 1. Site map (plotted by Author)

- Re-validating the effectiveness of the model by comparing the residents' satisfaction ratings before and after, summarizing the lessons that can be learned from the same type of architecturally oriented public space projects.

3. THEORETICAL FRAME

Currently, according to the WHO definition of "health", Healthy City research focuses on the holistic health of residents in cities, including physical, mental and social health [6]. Thousands of cities around the world have responded to this, and some of the more mature ones include the Building Healthy Places Toolkit, Designing a Healthy LA, and Active Design Guidelines: Promoting Physical Activity and Health in Design and so on. Among them, the Active Design Guidelines [7] introduced the concept of "public health space design" for the first time, proposing to improve the possibility of daily public activities by improving the five indicators of density, diversity, design, accessibility to destinations and distance to public transportation stations. At the building level, The WELL Building Standard™ version 2 [8] is based on the principles of fairness, globality, evidence-based, high technology, user-focused and adaptability, controlling building design and operation in terms of air cleanliness, water hygiene, fitness and exercise, health systems, emergency response systems, and environmental friendliness, paying attention to the impact of the building on the natural environment and the social environment, and increasing the daily interactions of the users, relieving their stress, and ultimately enhancing their health.

The above building-related criteria are synthesized and summarized. This study divides the potential building-oriented public space into three categories: blue-green space, streets and squares, and outdoor sports grounds. The elements of the three types of public spaces are decomposed in terms of the three ways of influencing health, namely, reducing exposure to health risks, promoting healthy behaviors and improving psychological resilience (Table 1).

4. SITE ANALYSIS

In light of these influencing factors, this study conducts a comprehensive status survey of the base. Combined with field mapping, interviews, and questionnaires with the users, the results shows that the current public space in the Wuchang Government Center has obvious health risks and is lacking in promoting healthy behaviors and improving psychological resilience of the residents, which is reflected in the following three aspects (see in Fig. 2).

Blue-green space: Wuchang Government Center is east of Neisha Lake Park and Shahu Park, with tree-lined streets. However, the current design of Wuchang Government Center does not focus on the use of these landscape resources, and does not form a tandem network of slow-moving systems, greatly weakening the pedestrian

Table 1. Possible architecturally oriented public special factors under different impact pathways

Type of public space	Factors	Reducing exposure to health risks			Promoting Healthy Behavior			Improving psychological resilience
		Reducing air pollution	Reducing noise pollution	Mitigating the urban heat island	Promotion of nature experience activities	Promotion of physical activity	Promoting social interaction	
Blue-green space	B1-Plant diversity	+	+	+	+			+
	B2-Comprehensive utilization of rainwater			+				
	B3-Size area	+	+	+	+			+
	B4-Touchable plants				+			+
Streets and plazas	S1-Accessibility				+			+
	S2-Green visibility and green coverage	+	+	+	+			+
	S3-Resting facilities			+	+			
	S4-Slow-moving systems					+		
	S5-Material limitations (non-slip and safety)					+		
	S6-Gardens and planting areas	+	+	+	+		+	+
	S7-Sanitary installations						+	+
	S8-Lighting					+		
	S9-Shading or sheltering structures					+		
	S10-Water features				+			+
	S11-Regional culture and spirit of place creation						+	+
Outdoor sports grounds and facilities	O1-Activity areas and facilities for children					+	+	+
	O2-Activity space and facilities for the elderly					+	+	+
	O3-Sports facility					+	+	+

Note: + indicates positive impact effect; blanks indicate no impact effect.

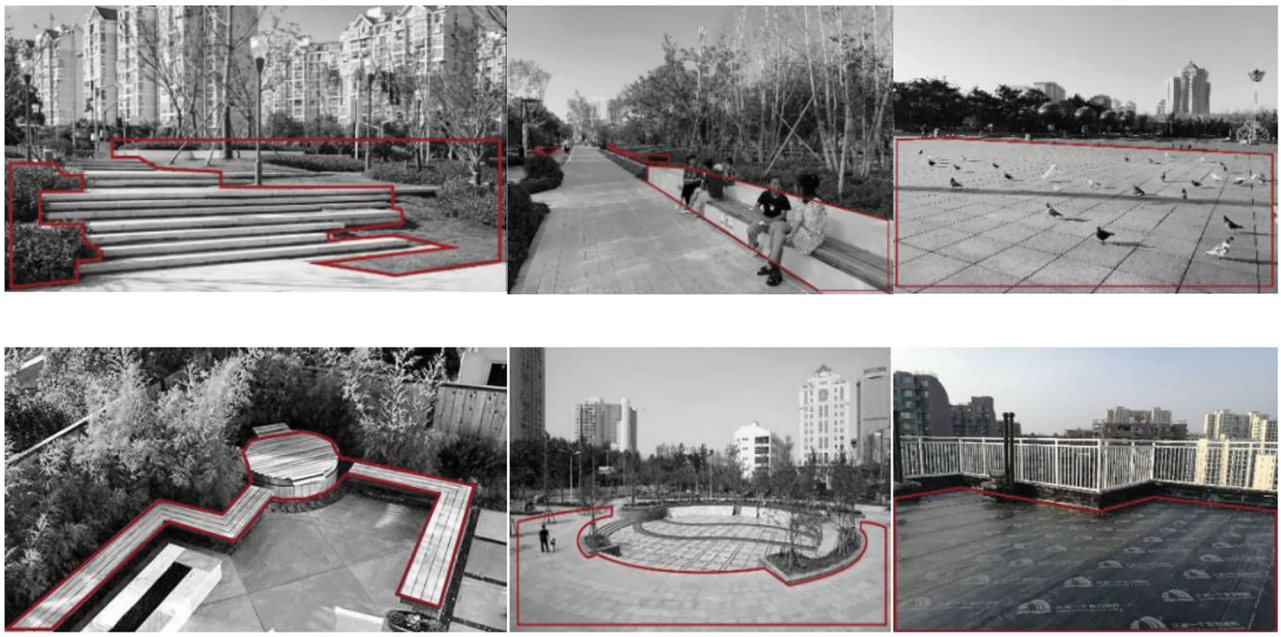

Fig. 2. Current situation of public space within the site (plotted by Author)

accessibility of the public space of the government center and the coupling strength with the blue-green space. In addition, the Wuchang Government Center has a large amount of unused space on the ground level and the roof level. The green space coverage is low and scattered, unable to form effective green space patches. Therefore, its role of purifying air, isolating noise, and alleviating the urban heat island effect is greatly minimized, posing a risk to the health of the people who use it. At the same time, the green space on the roof level is currently restricted to the use of office workers, with insufficient openness and equity. In the choice of planting mostly shrubs and small trees of solitary planting, the form of a single species, the distribution of touchable plants is less, it is difficult to form a flexible landscape to strengthen the prevention and healing of disease.

Street and squares: There are two large-scale entrance plazas in the area, and the small green space along the street is relatively abundant, which basically meets the needs of the public for gathering and dispersing. However, the area of hard paving is too large and there is a serious shortage of green visibility and shade in the squares. The distribution of public service facilities is relatively small, with only a limited number of resting seats. During the research and observation period, crowd activities within the site are relatively homogenous, dominated by small-scale conversations and walks. The internal agglomeration of the public space is not strong and does not give full play to its attribute of promoting social interaction. In addition, the choice of marble paving at entrances and exits near bus and subway stops with high foot traffic make it extremely easy for pedestrians to slip and fall. The high thermal reflectivity and poor water permeability increase the vulnerability of outdoor public spaces adapting to high temperatures and rainy weather.

Outdoor sports grounds: activity spaces are again hard-paved, and the walking paths does not use elastic shock-absorbing and non-slip materials. The distribution density of residential areas near the Wuchang Government Center is high and the population is large, but aging is serious. Residents' self-reported health conditions are generally poor, the length of daily exercise is short, the frequency of exercise is low, and there is a strong demand for exercise facilities and venues. The current public space is large in size but lacks arrangements for outdoor sports venues, which has great potential for development in the future.

Comparison of the user survey with the literature study shows that most of the factors affecting health summarized in the literature coincide with residents' wishes. And the effects of plant diversity (B1), size area (B3), touchable plants (B4), accessibility (S1), green visibility and green coverage (S2), resting facilities (S3), slow-moving systems (S4), material limitations (non-slip and safety) (S5), gardens and planting areas (S6), water features (S10), activity areas and facilities for children (O1), activity space and facilities for the elderly (O2), sports facility (O3) and facility maintenance status (O4) with residents' self-reported health levels are the most prominent. It is also found in the questionnaire statistics that connectivity to blue-green space, barrier-free facilities, walkability, site orientation, openness for all, artworks and environmental installations and facilities maintenance status play important roles in their self-reported level of health when using architecturally oriented public spaces. In addition, the results of the questionnaire reflect the residents' needs to be close to nature and their peers in a limited range of daily activities, which is very strong at the present time considering the context of special prevention and control measures during the pandemic, including large-scale quarantine and lockdown.

Summarizing the current situation, the main factors affecting the health of the public space in Wuchang Government Center are low pedestrian accessibility and openness, air and noise pollution caused by the lack of green space, safety hazards caused by the large area of hard pavement, single facilities and activities that greatly reduce the opportunities for physical activity as well as social interaction, and lack of attention to vulnerable groups. Despite all these problems, Wuchang Government Center has obvious advantages: firstly, its location adjacent to the blue-green spaces helps to build a landscape ecological network, and secondly, its large-scale ground floor and retreating roof space provides the possibility to promote the physical activities and interactions of the citizens, and to increase the opportunities for nature contact.

5. RENEWAL STRATEGY

Under the guidance of the healthy city theory and methodology [9], in order to compensate for the shortcomings of the current public space in terms of ecology, openness, accessibility and vitality, the focus will be on the introduction of health-promoting architecturally oriented public space systems, which include biodiversity conservation, increasing corridors to blue-green space, storm water management and urban heat adaptation, community-friendly slow-moving systems, clear guidance system, community engagement and community support, special considerations to vulnerable groups, increasing number and scale of outdoor facilities, all-age friendly event space and diversified life scenarios to enhance the quality and attractiveness of public spaces and encourage social cohesion, thereby greatly contributing to the health of the population (Fig. 3).

As the first phase of the pilot project, four plots, A-1, B-1, C-1, and C-2, with three dimensions: ground level plaza (A), sunken courtyard (B), and rooftop garden (C), are selected for the renewal design of the health system (Fig. 4). By implanting the health tool module into the vertical space from the ground level to the rooftop, it is going to create a urban connected, vibrant, and environmentally friendly public space.

5.1. A-1

Plot A-1 to the east of the ground level serves as the main entrance for motorized vehicles and is currently covered by large areas of hard paving, making it a negative site.

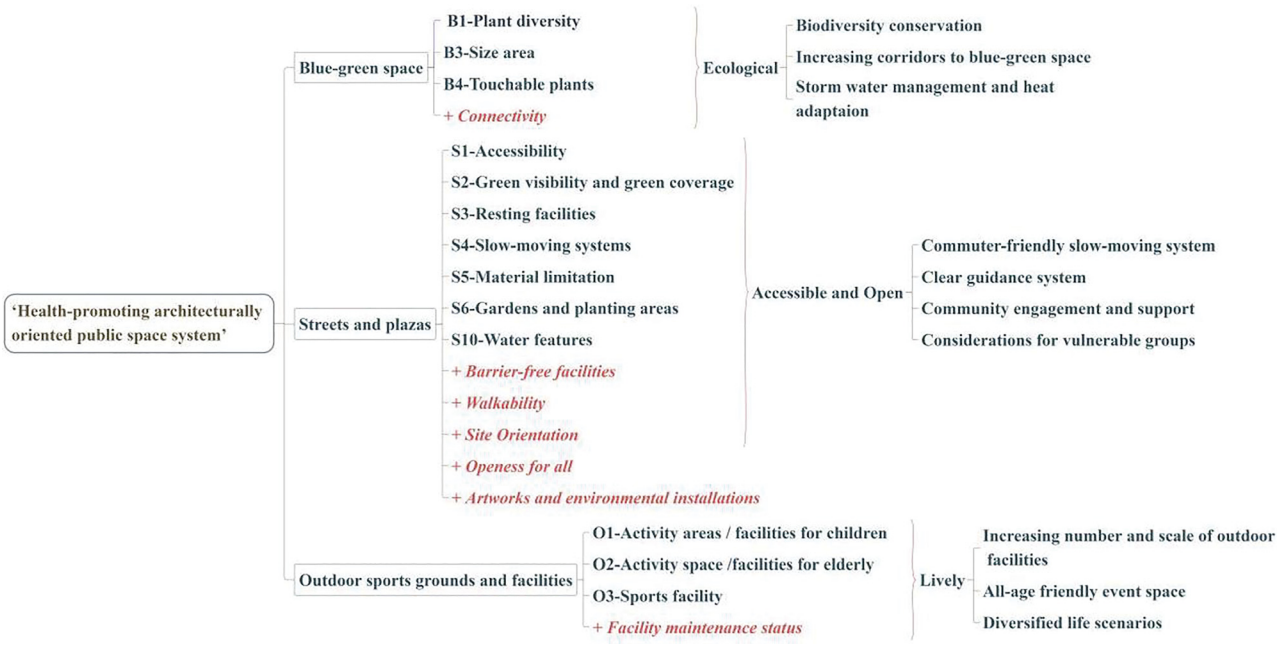

Fig. 3. Health-promoting architecturally oriented public space model (plotted by Author)

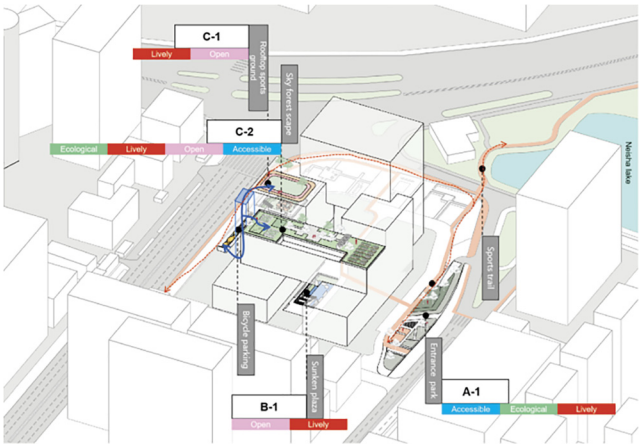

Fig. 4. Implantation renewal program for multidimensional health systems (plotted by Author)

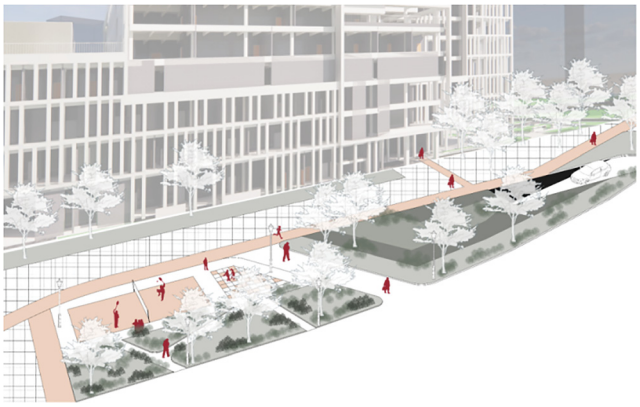

Fig. 5. Entrance garden (south-east) renovation (plotted by Author)

In order to revitalize this space, it is planned to extend the north Neshahu Lake walk all the way south to connect with the southeast main entrance and around the Wuchang Government Center to the west direction where the residential area is densely populated (see Figs 4 and 5). This will enhance the pedestrian accessibility of the public space at ground level, reinforce its coupling strength with the blue-green space, and increase the opportunities for citizens to engage with nature. An outdoor sports ground is embedded on the side close to the slow walking trail to further satisfy the public's demand for outdoor sports.

Against the background of high construction density and insufficient public space, it is necessary to actively improve the functional mixing of the site to create multiple activity scenarios. The pre-planned underground garage entrance at the southeast corner of the project is a major challenge in landscape treatment, and the clients support the proposal in this study to remove the existing concrete entrance roof and create an earth art garden shaped by natural topography and vegetation. The garage entrance garden is envisioned to require mounding of soil on top of the garage ramp roof to shape the terrain, utilizing lightweight backfill material to ensure structural slab loading while accommodating plant growth, as well as topographic aesthetics. In this way, it helps to form effective green patches, purify the air, isolate noise, and enrich the walking experience in the outdoor space by shaping the green terrain boundary together with the walkway. At the same time, permeable pavement is retrofitted on the top slab of the basement, and grass-planted trenches are added to collect rainwater from the surrounding area and store it in underground tanks for recycling (see Fig. 6).

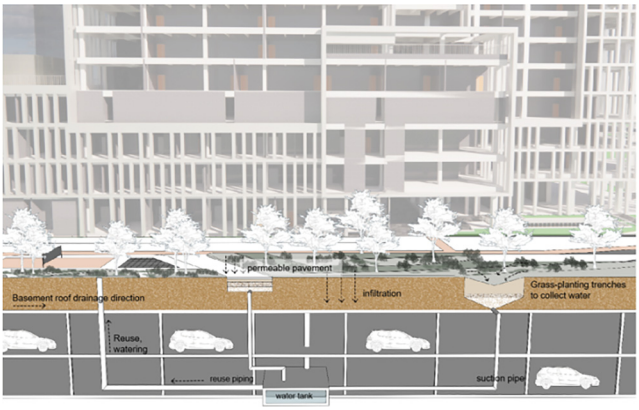

Fig. 6. Technical approach to entrance garden (south-east) (plotted by Aauthor)

5.2. B-1

In order to increase the accessibility and openness of the plot B-1, the plan changes the pedestrian movement inside the government center by adding outdoor stairs and ramps from the inner court plaza to the sunken courtyard. The width of the steps is more than 6 m, which meets the traffic demand and also serves as a place for small gatherings and rest. In terms of site arrangement, in order to not only meet the leisure needs of office workers, but also consider the needs of vulnerable groups such as the elderly and low-income earners for their daily diet, rehabilitation, and social interaction, the modular and flexible organization is used to create multi-functional open spaces. For example, a community cafeteria can be set up in conjunction with the community medical center for outdoor dining, additional activity panels can be added for health lectures and friendship talks, and small charity bazaars and art exhibitions can be held on special holidays (Fig. 7). In short, space shaping fosters community organization with the Wuchang Government Center at its core, and strengthens mutual support and collaboration among citizens.

5.3. C-1 and C-2

Rooftops, as a compensation for the limited public space on the ground floor, have great potential for development in densely built-up urban environments [10]. Currently, the roof level of the Wuchang Government Center is inefficiently utilized, with only a few areas open and limited to the use of internal staff. It is difficult for the public to access these areas from the ground floor, and even if they do find an entrance from the interior, they have to walk through the long office space. In order to improve the effectiveness and equity of the use of public space on the roof level, an outdoor vertical elevator from the ground level to the roof level is planned. By stopping at the 9th and 12th floors respectively, the renewed C-2 and C-1 plots can be reached (Fig. 8). Among them, Lot C-1 will be re-created as a rooftop sports park, which opens up a vision of future sustainable office scenarios while designing a return to nature. The introduction of a rooftop running track and badminton court, as well as fitness equipment will greatly improve the physical fitness of employees. Through researching the staff size and work characteristics of each department, the space "convention" that suits the needs of large and small departments is found - each unit module for 42 × 33.6 m (about 1,200 square meters), the axis network are used 8,400 × 8,400 mm, and then Multiple 42 × 33.6 m unit modules are combined to divide the area according to different needs. The modularization and standardization of this system provides the premise and foundation for the continuous renewal of the rooftop public space in the later stage. In the long term, it is even considered designing a three-dimensional mini-marathon loop from the ground to the roof as a fun program for outdoor sports. People walk through the platform scenery, blurring the boundaries between work and life and conveying a healthy and lively atmosphere.

"Sky Forest Scape" is proposed as a renewal concept for the C-2 plot on the roof level, with the aim of providing sufficient soil depth 60 cm for greenery and creating a comfortable and cool gathering place for citizens under the local climatic conditions (long hot summers). The Sky Farm, as the main medium of activity, is divided into two planting areas, with the flower forest mystery on the east side and the farming paradise, including aquaponics, on the west side (Fig. 9). Ecology is a crucial dimension in this new scene, guiding the healthy interaction between architecture, environment, and people. In addition to green planting on the roof, the exterior of the curtain wall is updated with a vertical greening system, with through-length planting troughs and climbing zip lines, forming a second dynamic plant interface that grows and changes with the seasons. All of this contributes to the formation of a micro-environmental system in which light, heat and wind environments interact effectively. In addition, in the process of developing the Sky

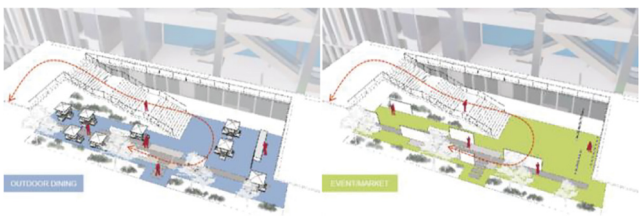

Fig. 7. Use of diversified functional space in sunken garden (plotted by Author)

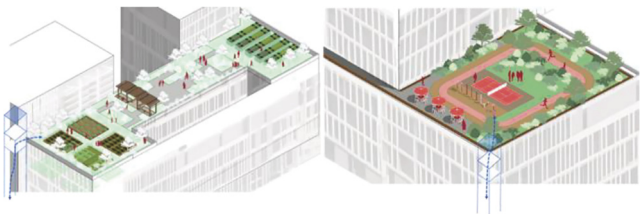

Fig. 8. Roof level space renovation (Left: C-2 Right: C-1) (plotted by Author)

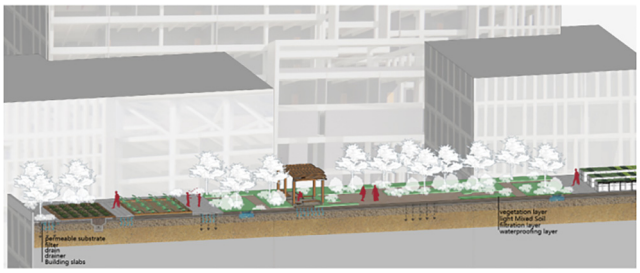

Fig. 9. Technical approach to sky forest scape (C-2) (plotted by Author)

Farm, elderly residents in the neighborhood will be recruited to join the planting work, bringing re-employment opportunities. It also promotes communication and integration between different groups in the community by organizing gardening activities on a regular basis.

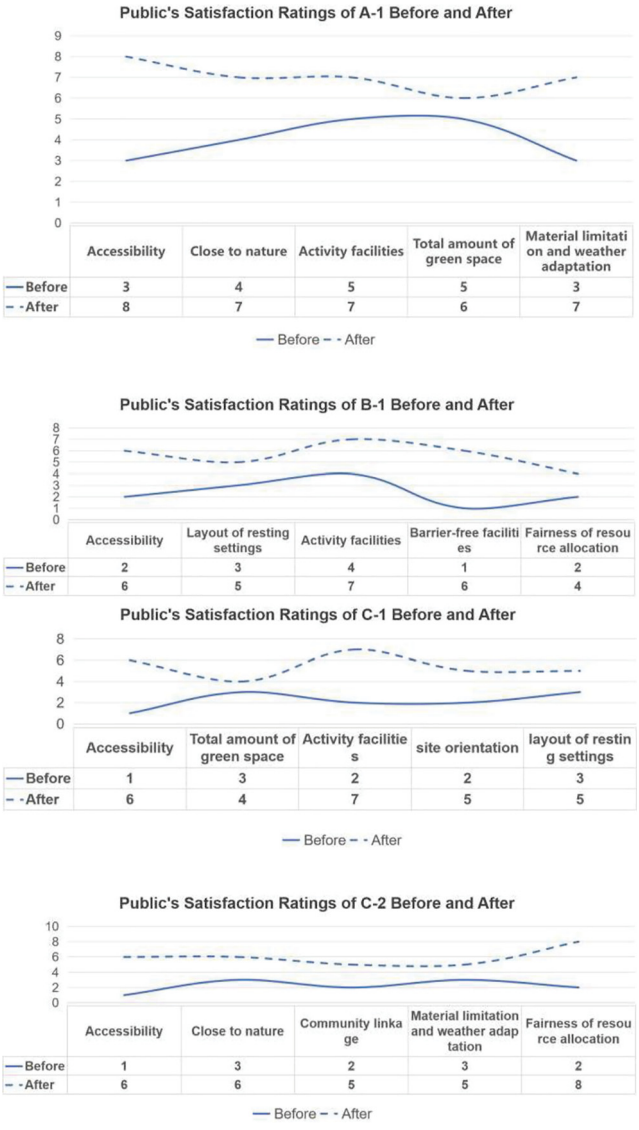

Fig. 10. Public satisfaction rating comparisons of A-1, B-1, C-1 and C-2 (plotted by Author)

Last but not the least, in the survey of satisfaction with the renovation program, the ten factors with the highest level of influence on residents' health in the former investigation were selected, which were accessibility, total amount of green space, activity facilities, material limitations and weather adaptation, close to nature, community linkage, barrier-free facilities, layout of resting settings, fairness of resource allocation, and site orientation. A side-by-side comparison of the pre- and post-renovation conditions of the four plots, A-1, B-1, C-1, and C-2, show that they are more positively impacted by the design updates. Among them, the strategies of material limitations and weather adaptation as well as accessibility in plot A-1 result in a one- to two-fold increase in resident satisfaction. B-1 has the most significant effect on accessibility improvements, while C-1 is more recognized for its activity facilities than the C-2 update. However, C-2 is better at helping residents find connections in their neighborhoods and improves equity in the distribution of public resources (see in Fig. 10). Overall, the introduction of health-promoting architecturally oriented public space systems proves to be valid.

6. CONCLUSIONS

Relying on the research of the real-world project, it is confirmed that the public space factors affecting health compiled from the literature, including accessibility, total amount of green space, and activity facilities are in line with the residents' judgments, but at the same time, it is added that factors as connectivity to blue-green space, barrier-free facilities, walkability, site orientation, openness for all, artworks and environmental installations and facilities maintenance status are also closely related to self-reported health levels. Building-oriented public space is often smaller in scale and more confined in space, it has its own qualities that distinguish it from other public spaces in terms of planning and design, such as the diversity of sites, the expansion of vertical height, the connection and interaction with the outside world, especially the natural environment, and more emphasis should be placed on inclusiveness and fairness in terms of planning principles.

In the renovation for the above factors, the accessibility of the public space was significantly improved by increasing the pedestrian access and connecting with the nearby blue and green spaces. The inclusion of activity areas, amenities, and landscaping at the ground, underground, and rooftop levels increases the potential for physical activity. Eco-technologies, including green parking lots and sky forest scape, are not only more weather-resilient, but also respond to residents' need for healing and social interaction in the post-pandemic period. This series of experiences provides a reference for similar building-oriented public spaces. Models of building-oriented public spaces that promote healthy, restorative social interactions should include:

- Building pedestrian connections to blue-green spaces (outside);

- Improving the mix of functions on limited sites;
- Increasing opportunities for natural contact within buildings by introducing necessary ecological technologies and green infrastructure;
- Plugging in sufficient activity programs or art installations that encourage community participation and interaction;
- Ensuring open access to public resources and equality for all.

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