Critical Factors Affecting the Design and Use of Elevated Urban Spaces: The Sky Garden, London

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Abstract

The COVID-19 pandemic and subsequent pandemics have and will continue to have a significant impact on public spaces in cities around the World. One of the major challenges and debates for governments and professionals alike is therefore how to create enjoyable and usable environments in high-density cities, which also feel safe. Elevated urban gardens have become increasingly popular public and social spaces in large cities with their unique qualities in terms of location, accessibility, scale, intensity of experience, etc. Indeed, the past two decades have seen the re-emergence of exciting social and public places 'in the sky' which justifies the need to research these spaces in more detail.

Due to their location, searching questions can be raised with regard to the design and management of safe vibrant spaces within or on contemporary buildings. This paper focuses on analysing the Sky Garden at 20 Fenchurch Street, London using direct observation and walk-along interviews to provide qualitative and quantitative data before, during, and after the Covid pandemic. The direct observation explores how the space changed in terms of accessibility, circulation, and activities during these periods of time. The study also uses semi-structured interviews to investigate the qualitative relationship between visitors' behaviour and the design of the pace. Participants (n=23) were interviewed by the researcher while walking in the Sky Garden. This paper examines critical issues such as accessibility, circulation, activities, design obstacles, security and safety, etc., in exploring the possibilities and opportunities for the future design of elevated urban gardens. The research findings include a study of human activities, features that need improvements, design strategies, and an analysis of the potential need for new rules and regulations relating to the use of such spaces.

Keywords: *Sky Garden; vertical public realm; COVID-19; social resilience; London*

1. Introduction

A new and major challenge in creating a safe environment during the recent or any future pandemics will be spatial density (Afrin et al.,2021; Megahed &Ghoneim,2020). When we think about the future of creating public spaces, there are questions to be asked, such as who really owns the space, the number of people able to be in that space at a time, and how they should group (Martínez & Short, 2021; Geary et al.,2021). Traditional urban public spaces and their timeless values remain immensely important, however, it is becoming important to examine new ways of attaining and sustaining such values in the multi-layered cities of the future. Indeed, it is important to investigate possible new values and modes of publicness, that are crucial for vibrant cities in new high-density conditions (Zhongming et al.,2021; Lak et al., 2020).

One of the main essential components of enjoying London's cityscape is being in its public spaces. These public spaces play a major role in the quality of life, environment, economy, and tourism for both residents and visitors (Holy-Hasted & Burchell, 2022; Carmona, 2019). As cities become denser with new business and residential developments, tall building design needs to be increasingly considered in relation to its intricate urban contexts (Al-Kodmany, 2020; Oldfield, 2019). Indeed, hybrid buildings with vertical access for the public are now seen as having the potential to be regarded as a vertical extension of the public realm (Mualam, et al.,2019; Cho et al., 2015).

Vertical green social spaces are types of spaces, elevated above, or even below the ambient ground plane, but privately owned and managed are increasingly being offered as public spaces (Hadi et al., 2018; Pomeroy, 2013; Osmundson, 1999). These hybrid spaces are a new typology of public space, with characteristics and regulations quite different from the familiar models of public open space, such as city squares and parks (Oldfield, 2019; Abdelsalam, 2018; Cho et al., 2015). Many types of hybrid urban spaces are emerging, such as elevated spaces and multi-level spaces that are enhanced with nature. In our cities, we are now seeing pedestrian bridges, shopping malls and transport interchanges, which contain green spaces, and may lead people up to sky courts, sky gardens, and even sky parks (Samant, 2019; Viñoly et al., 2015).

Historically, many developers have failed to understand the importance of such spaces being used to improve amenities, well-being, good health, productivity, and social interaction, or earning hospitality revenue; and as a result they were often omitted from design proposals for cost-saving economic reasons (Triguero Mas et al., 2020; Lee & Park, 2018; Taib et al., 2010). It has been pointed out that a city government can require such spaces as a condition of planning approval for a major building, through using incentives such as greater permitted height, more parking spaces, and reduced property taxes (Pomeroy, 2013; Pomeroy, 2012). This is a requirement in Singapore, where they use the 'LUSH Index', as a way of calculating how much green private and public space, and green facade has been provided by a developer (Timm, et al., 2018). Singapore, perhaps more than anywhere else in the world, has embraced the concept of vertical urbanism (Feng, 2021; Yuen & Hien, 2005). It's now uncommon for any new Singaporean high-rise not to consider the provision of sky-gardens or vertical social communal spaces. Indeed, sky-gardens are widely spread across both public and private high-rise housing developments (Samant & Hsi-En, 2017; Bay, 2004). Also, mixed-use high-rise design that can include shopping malls, residential development, offices, entertainment, and public sky-gardens all within one building are proliferating internationally in cities across Asia, Europe, and the US (Generalova & Generalov, 2020; Oldfield, 2019).

Since the world's first underground railway network, in 1863, London has been a multi-layer city (Aleta et al., 2017; Madanipour, 2019), but it is now experiencing an evolution as a 'skyscraper city'. London in the 21st Century has witnessed an increasing trend for towers taller than 100m with some of these buildings including elevated urban spaces (Morato, 2022; Viñoly et al., 2015). This new phenomenon of elevated gardens has been designed and tested in a number of completed projects, such as the Sky Garden (indoor garden, skyscraper) at 20 Fenchurch Street, The Garden (outdoor garden, medium tall) at 120 Fenchurch Street, and Crossrail Place (semi-indoor-outdoor garden, transport interchange) at Canary Wharf. As these spaces become part of the City's public space offer, the debate continues about whether these innovative places can become vibrant and inclusive urban spaces (Wood,& Safarik, 2019; Hadi et al., 2018).

The Covid-19 pandemic caused significant social and economic uncertainty and caught the development industry off-guard (Dwijendra, et al., 2021). The temporary closure of construction sites because of the lockdown reduced the number of completions, and reduced

the revenue in projects that had reached completion (Zamani et al., 2021). Developers also hesitated to consider or invest in new projects. The confidence-shattering effect of the pandemic further emphasises the critical need for resilience and adaptability in the built environment (Lak et al.,2020). The pandemic has created numerous complex obstacles, so it is essential to take a comprehensive approach that incorporates multiple pragmatic solutions (Navaratnam et al, 2022; Mills et al., 2020).

In considering pandemic adaptability, public spaces should be able to accommodate expanded physical distancing - three to four times what is normal - between occupants during a health crisis (Afrin et al., 2021; Shroff, 2020). As the world continues to adapt post-Covid-19, it is essential for building designers and developers alike to become proactive in their design responses. This means creating strategies that reduce risk, promote hygiene habits, and also design social spaces that are flexible enough for high-levels of interaction whilst providing a safe environment (Bereitschaft & Scheller, 2020). The design and development community, therefore, needs to emerge from the defensive stage of the pandemic response to a more forward-looking approach by creating new, innovative responses (Navaratnam et al, 2022). In addition, the re-purposing of existing design tools and incorporation of new thinking around user experience design and technologies is required (He et al, 2021).

The purpose of this research study is to explore how people use elevated (vertical) green social spaces before, during, and after the Covid-19 pandemic. The specific objectives are to analyse the real-life cognitive experience of visitors to London's Sky Garden and to examine critical issues such as accessibility, circulation, activities, limitations of visitors, and social distancing. The research aims to outline solutions for designing safe and adaptable vertical social spaces that can operate effectively, and add value for developers and operators, thereby allowing premises to resume operations and adapt to a 'new normal' situation.

2. Case study - Sky Garden, London

There are a great variety of vertical social spaces in London, but this research is focused on the Sky Garden at 20 Fenchurch Street, in London. The Sky Garden was selected due to its unique typology, location, size, management approach (no entrance charge), and that it remained open, when legally permitted, during the COVID pandemic.

The Sky Garden is on the top three floors of the 'Walkie Talkie' skyscraper in the heart of London's financial district (Figure 1 and 4). The Sky Garden refers to the space on levels 35-37 as well as its dedicated entrance on the ground floor. The Sky Garden is accessible by only one access point from the ground level on Philpot Lane, on the south-west corner of the building (Figure 2 and 3). Visitors must have a valid free ticket or restaurant reservation to pass through airport-style security checks and take the elevator up to Level 35 (Sky-Garden, 2015)

The primary method for booking visits to the Sky Garden is through its website, with tickets available up to three weeks in advance on a weekly basis. However, access is not guaranteed if the maximum capacity of the space has been reached, and visitors who miss their designated entry time may be denied entry (Viñoly et al., 2015). Once maximum capacity is reached, visitors who have stayed for over one hour will be asked to leave. Re-entry to the Sky Garden is not permitted for pass holders unless granted permission, and visitors must undergo security screening again (Sky-Garden, 2015). These restrictions also applied to the researcher.

The COVID-19 pandemic has had a significant impact on the accessibility of the Sky Garden. The pandemic has resulted in a reduction of the number of visitors allowed from a maximum of 600 to a safer limit of 200, and the elevator capacity was limited to a maximum of six guests from the same household (Figure 5). Due to the limited access points and enclosed indoor environment, the Sky Garden was temporarily closed during the government lockdown restrictions in 2020.

The pandemic-induced closure of the Sky Garden also presented a significant challenge to the maintenance of its ventilation and indoor environment. The effectiveness of the ventilation and air filtration systems is crucial in providing a comfortable and healthy indoor environment for visitors. Therefore, when the space reopened to the public, it was imperative to ensure that the ventilation and air filtration systems were fully operational and capable of providing a safe and healthy indoor environment.

The ventilation system at the Sky Garden employs a combination of natural and mechanical ventilation to achieve a comfortable and healthy indoor environment. Natural ventilation is achieved through the use of vents and louvers, while mechanical ventilation includes air

handling and heat recovery units to circulate fresh air and extract stale air. Additionally, the Sky Garden uses a sophisticated air filtration system to eliminate pollutants and airborne particles, ensuring a clean indoor atmosphere (Schoenefeldt, 2016; Sky-Garden, 2015).

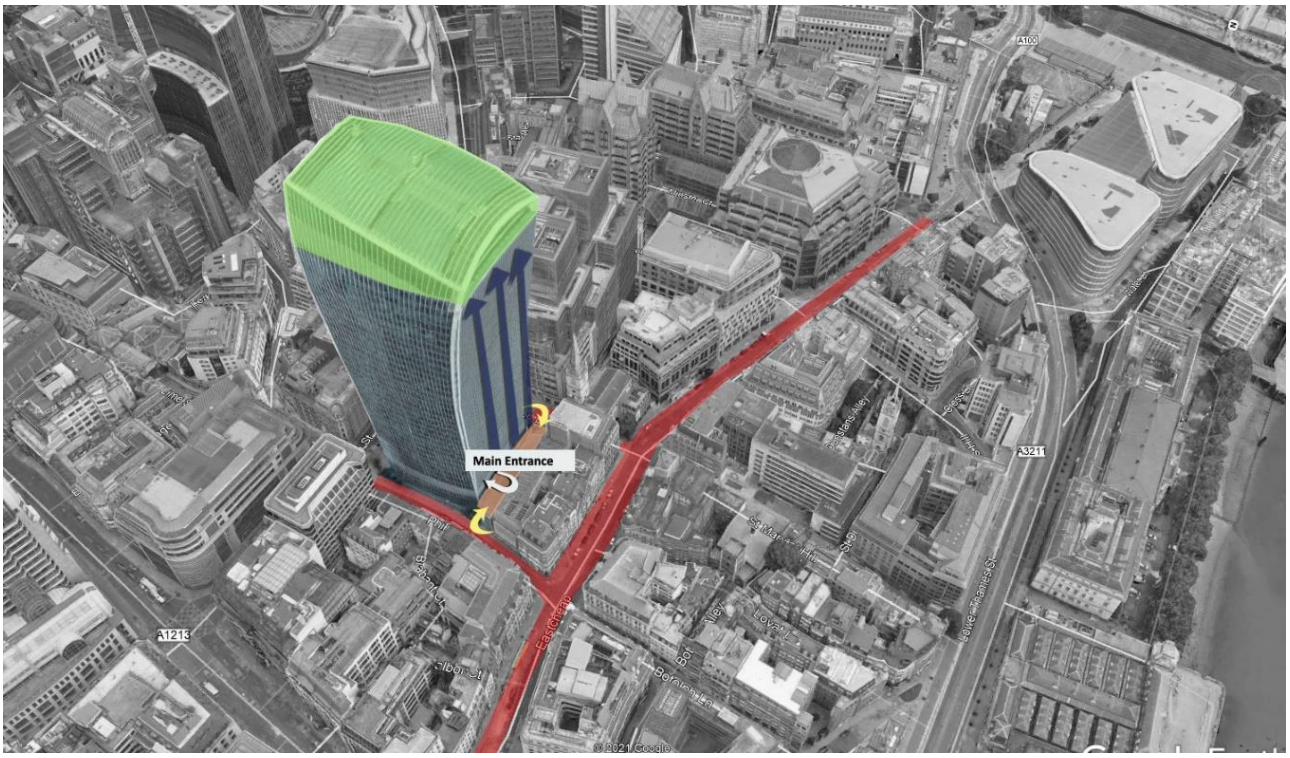

Figure 1. Accessibility from the street level., Source: Author.

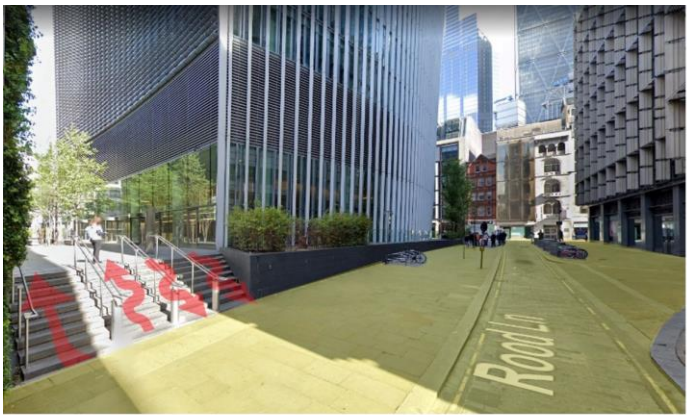

Figure 2. Access from Philpot Lane., Source: Author.

Figure 3. Entrance security checks, Sky Garden Source: Author.

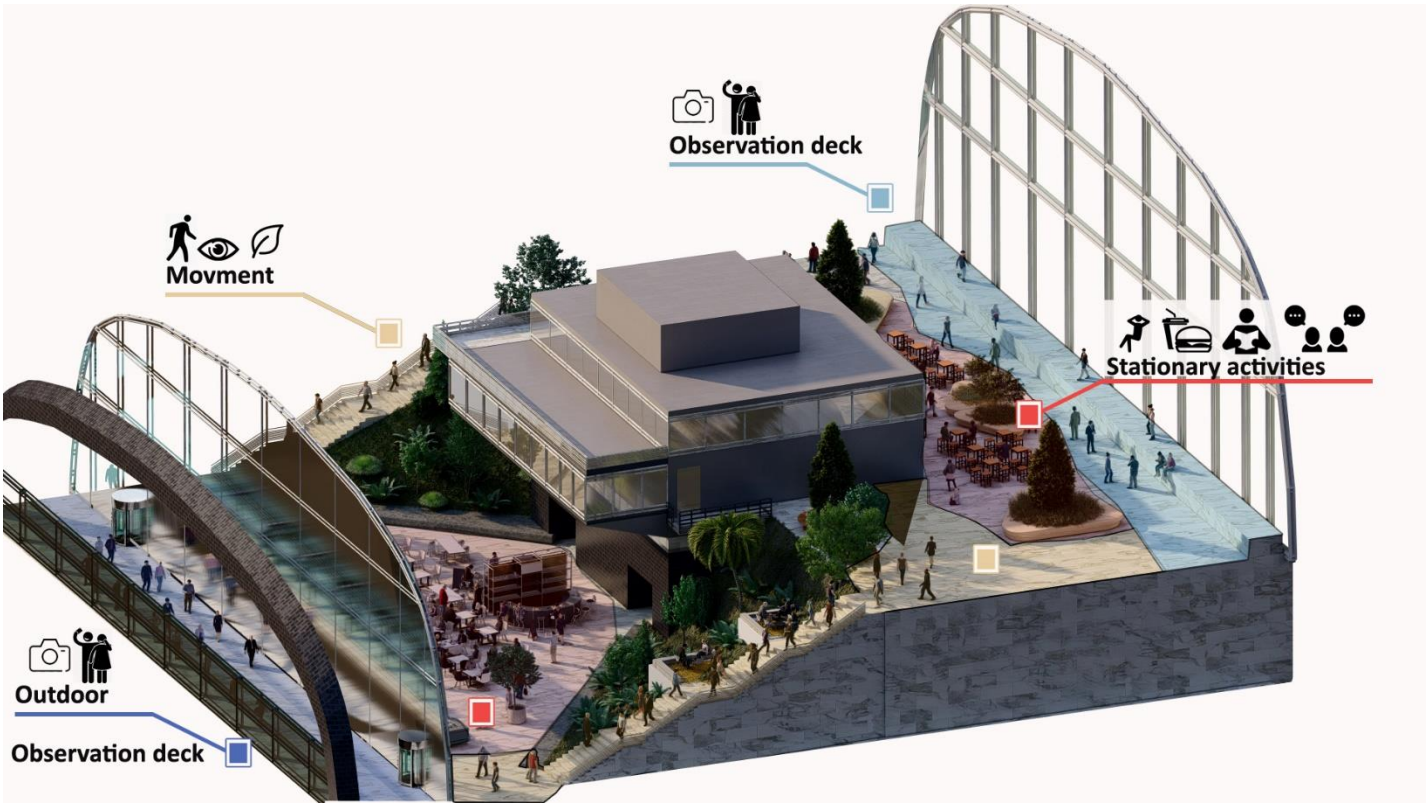

Figure 4. Three-D plan of the different activities and functions, Sky Garden, Source model: Author.

Figure.5. London Sky Garden, 20 Fenchurch Street, London, Source: Author.

3. Methodology

There were two main research methods utilised in this research: (i) direct observation; and (ii) semi-structured walk-along interviews.

3.1. Direct observation

The first method used in this study was direct observations at different times over three years (2019-2022). The research team visited the Sky Garden before, during, and post the Covid-19 pandemic for data collection, pertaining to the movement and legibility of the space, and to observe people's activities within the space. The manual methods used for measuring the public life interaction in the space involved counting, mapping (collecting subject locations), tracing (drawing people's movement), and tracking (shadowing or following people) (Gehl & Svarre, 2013). The original research intention was to observe human behaviour and design factors in elevated public garden spaces. The research proposal found a whole new direction at the start of 2020 with the effect of a pandemic, limiting freedom of movement and social mixing.

There are various tools for analysing and registering people's behaviours in public spaces. The observation tools described are primarily manual tools which can be replaced by automated registration. The crucial difference is that human registration presents more than 'cold facts' as details from the site area, which might have a significant influence on the study analysis (Hanzl & Ledwon, 2017).

The fieldwork of the 'before and after' was essential for data collection to gather an understanding of how the space was experienced and how it then changed in terms of accessibility, circulation, and activities. This method required observation and data collection during 2019, and then to apply the method during and after the conditions caused by the pandemic. There were also many subsequent visits during the gradual relaxation of regulations throughout 2022. The author visited the Sky Garden to observe the layout and the users visiting the spaces (see dates and times in Table 1).

The author of this study developed a detailed, digital computer model of the Sky Garden using Building Information Modelling (BIM) software, Autodesk *Revit 2022*, to map and analyse the data collected during site observation visits (Ehab & Heath, 2023). This model was utilised to illustrate and simulate the changes in users' activities and movements over time. To analyse

the controlling 'pinch points' within the space, the research employed *depthmapX*, which enabled the assessment of visual accessibility through the production of ‘point isovists’ and ‘isovist paths’.

Point isovists are polygons that represent the visually accessible area from a specific location, while isovist paths depict how the view changes when moving through the space. Moreover, *depthmapX* facilitated the simulation of different types of pedestrian behaviour by providing various ways for an agent to choose where to walk, such as towards larger spaces, along lines of sight, or occluded areas of their view. The development team of *depthmapX* have highlighted the versatility of the software in enabling the analysis of pedestrian behaviour in complex environments (depthmapX development team, 2017). Overall, the use of BIM software and *depthmapX* served to enable the author to conduct a comprehensive analysis of the Sky Garden's spatial qualities and user behaviour.

The observational studies were conducted during weekends and weekdays to allow the direct and equal comparison with three different conditions: ‘pre-pandemic’; ‘during pandemic’; and ‘post-pandemic’. The observations were held in hourly-based intervals both on weekends and weekdays. During the official ‘lockdown’ period, the Sky Garden was totally closed and there was therefore no observation or data collection. The period of time referred to as ‘during pandemic’ in this study is post-lockdown, when not everybody had been vaccinated, but limited degrees of relaxation for exercise, social meeting, and travel were permitted. ‘Post-pandemic’ is after the date that the UK government announced the relaxation of all regulations. The author, in conducting the observations, faced the same problems as the visitors of the public. These included being confined to set times which had to be booked in advance, limiting the population within a timeslot (to optimise social distancing), not being permitted to stay more than two hours, and not permitted to visit twice in one day.

Table 1: Data collection date and time.

Sky Garden (direct observation field study)		
Date	Time	Regulations
Monday, 23/12/2019	15:00- 17:30	Pre-Pandemic
Friday, 27/12/2019	9:30- 12:00	Pre-Pandemic
Saturday, 11/07/2020	14:00- 15:30	New rules with COVID 19
Monday. 19/10/2020	12:30- 14:00	New rules with COVID 19
Friday 21/05/2021	23:00- 00:30	New rules with COVID 19
Monday 24/05/2021	13:15- 15:00	New rules with COVID 19
Thursday, 11/11/2021	11:00-13:00	Post- Pandemic
Thursday, 31/12/2021	18:00-20:30	Post- Pandemic
Saturday, 03/07/2022	15:00-17:00	Post- Pandemic
Monday, 05/07/2022	9:30- 12:00	Post- Pandemic

3.2. Semi-structured walk-along interviews

Walk-along interviews in the Sky Garden were used to explore the physical experience of the space users and how this can impact the types of social interaction and activities (Carpiano, 2009). The semi-structured interviews were conducted with people from different age groups with all of the participants aged 18 and above. Twenty-three (n=23) interviews were conducted and analysed (n=23) with visitors to Sky Garden. The duration of interviews took around 20 minutes each. The participants were recruited on the site, with an explanation of the purpose and duration of their contribution, plus their signature on an ethics consent form.

The author conducted a theme-based analysis using various qualitative data sets. Data were analysed using content analysis, which is an effective method for the descriptive aims (Schreier, 2014), guided by a summative approach (Hsieh & Shannon, 2005). This strategy was used to examine the ideas that make up the theme and sub-theme and how they interact with each other. The final stage was to investigate the evidence of relationships between the

overarching themes, identifying the quotes that were initially hard to classify and fit into the themes and sub-themes. Sub-themes fit under the major themes in the write-up (Table 2).

3.2.1. Qualitative data analysis

A total of 23 interviews were completed in June 2021; 39.1% (9) were males and 61.9% (14) were females. The average age of participants was 28.2 years. Around 34.7% of the interviewees lived in London, 39.1% lived elsewhere in the UK, and 26.08% were overseas tourists visiting London. The analysis of the interviews highlights five overarching themes: the purpose of the visit; activities; accessibility; design concerns; suggestions for design features and activities.

Table 2: Displaying the main themes and subthemes

Themes	Sub-themes
The Choice of the space & the purpose of the visit	free to visit
	Exploring the city
	Meeting a friend
	Good attraction to show a visitor
	Social media
Activities	Checking the views
	Taking pictures
	Relaxation
	Food & Beverage
Accessibility	Online Booking
	Accessibility from the ground level
	One-way circulation system
	Security
	Publicness
Design concerns	Seating spaces
	Stairs
	Plants
	Open Space (Terrace)
	Restaurant Design
Suggestions for design Features and activities	Features that improve the design quality of the space
	Features that encourage the physical activity
	Features that encourage the social interaction.

4. Results

4.1. Observation study results

According to the Sky Garden management team, the theoretical maximum occupancy of the space is 600 visitors. The pre-pandemic analysis showed that the average occupancy per hour during the hourly intervals did not exceed an average of 310 visitors (51.6 % of the maximum) on weekends and 260 visitors (43.3%) on weekdays (Figure 15). Many people of different age group were visiting the space, such as tourists, families, elderly people, and youth. The observation study reported six different optional and social activities taking place in the roof garden (figure 6). Walking was the major activity taking place; around 190 visitors were moving around the Sky Garden levels taking pictures of the city views and enjoying the green environment. The study showed an average number of 82 visitors were on stationary activities such as sitting, eating, relaxing, reading, watching, and listening to others. The most dominant activity that stimulated social interaction in the garden was on the outdoor observation platform where visitors were taking pictures (Figure 6 and 7).

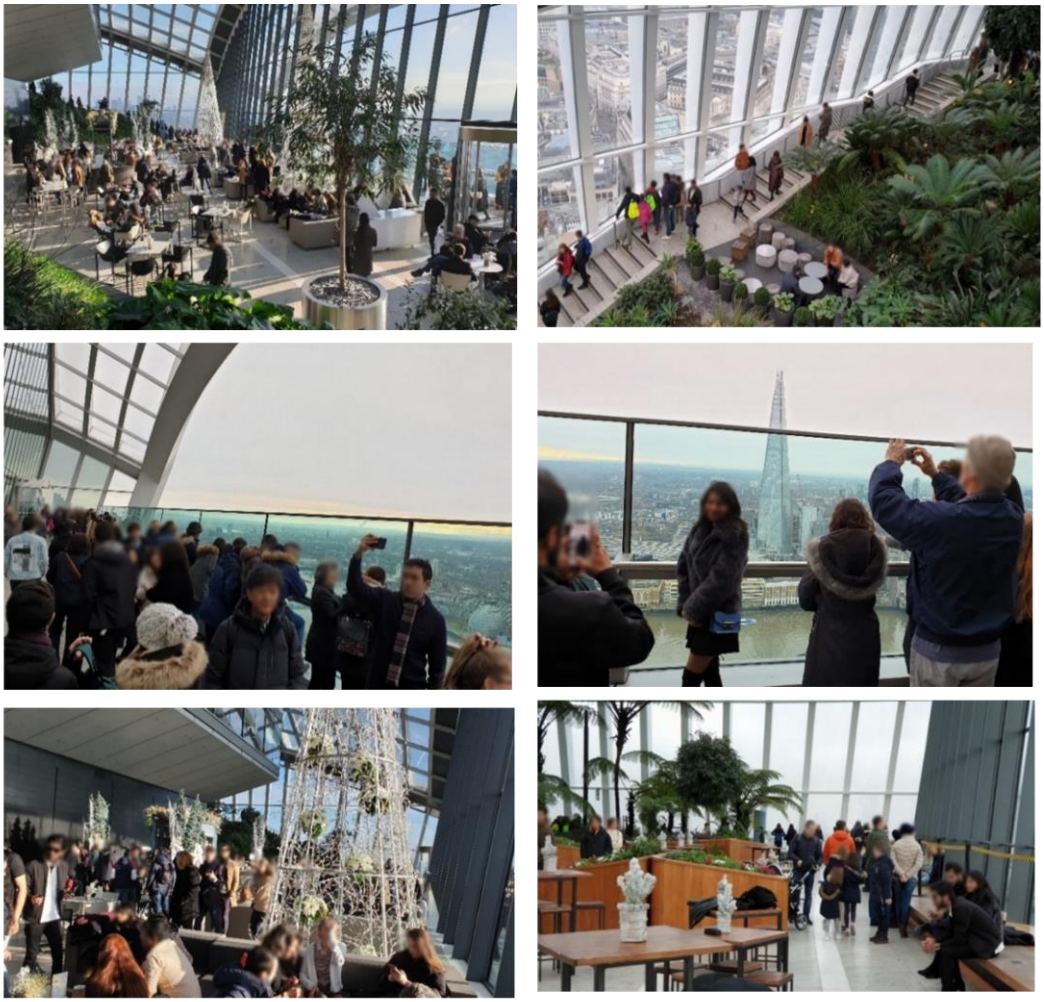

Figure. 6. The visitor's activities pre-pandemic, Sky Garden, London, Source: Author.

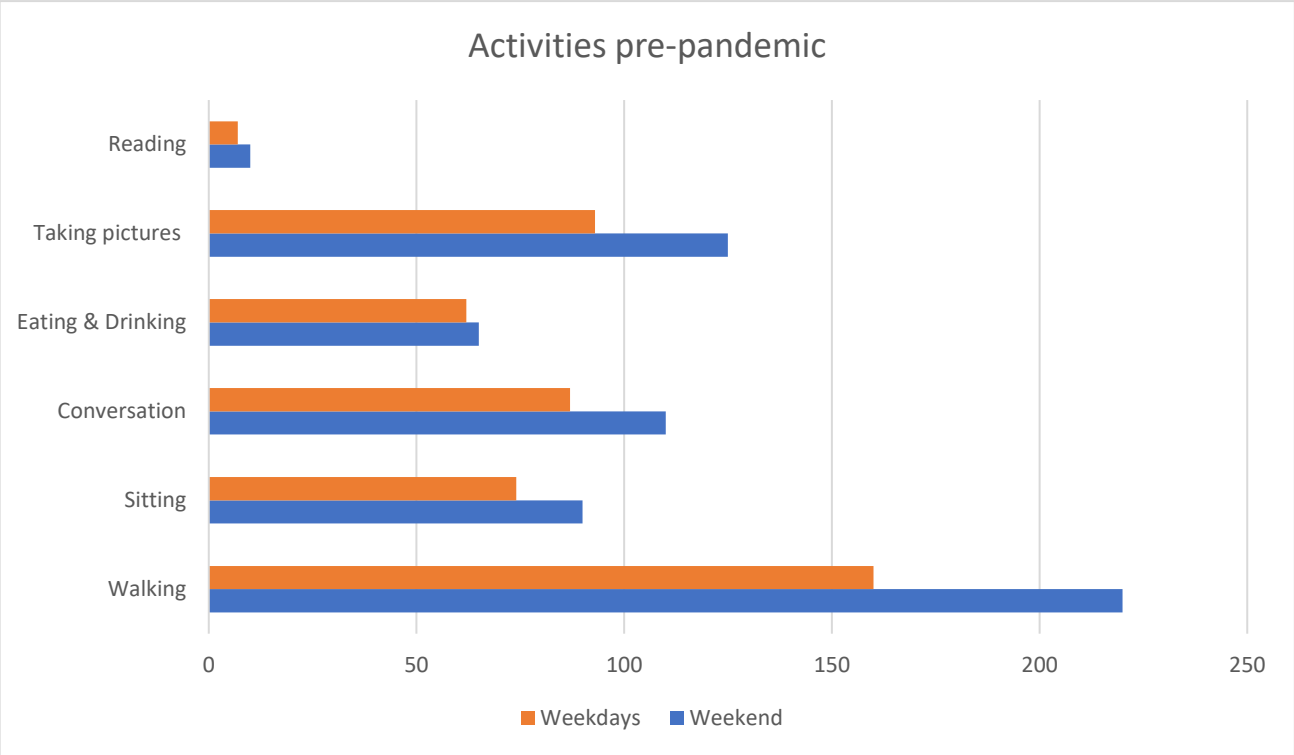

Figure. 7. The average number of visitor's activities pre-pandemic, Sky Garden, London, Source: Author.

The data collected during the pandemic showed a massive difference in terms of accessibility, circulation, activities, and the number of visitors. The analysis showed a significant decrease in the number of people visiting the Sky Garden at one time. The average occupancy per hour reached about 110 visitors (18.3 % of the maximum) on weekends and 90 visitors (15 %) on weekdays (Figure 15).

The connectivity map produced by entering the researcher's data into the application of *depthmapx* indicates that the weakest connection zones that need further management and circulation control are the entrance, the stairs, and the outdoor terrace (Figure 9). Most of the space syntax analysis aligned with the field observations, but the practical use of spaces is not fully reflected in space syntax visual graphic analysis. The circulation of the space was changed from free movement to a one-way system to manage and control the pinch points (social distancing hazard) (Figure 8). The management team reviewed all areas where a queue might occur and added markings to the ground to clearly show safe social distancing for guests to observe. The floor signage outside the toilets also helped to ensure that guests maintained their distance when waiting to use the facilities. The floor markers indicated the

direction of movement permitted for all guests around the venue and indicated the one-way circulation system.

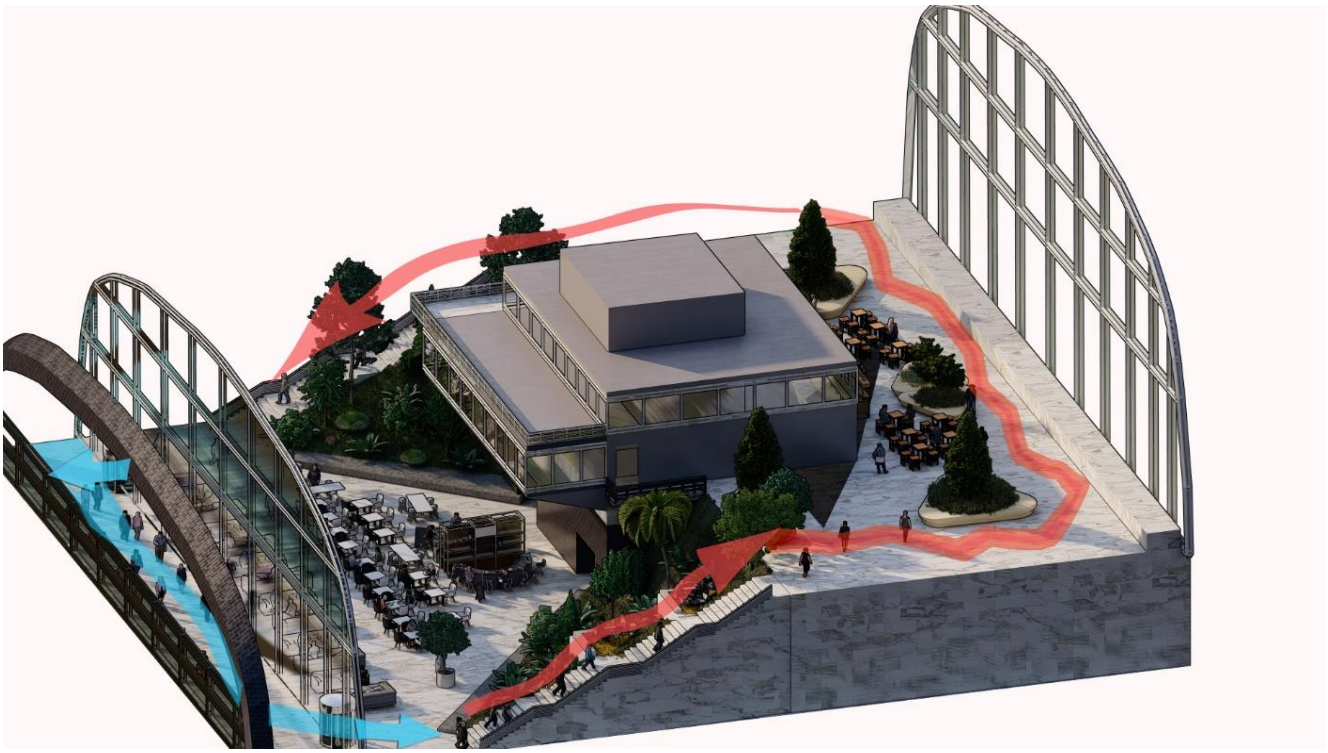

Figure. 8. One-way circulation system to maintain social distancing and control the pinch points, Sky Garden, Source of 3-D model and image: Author.

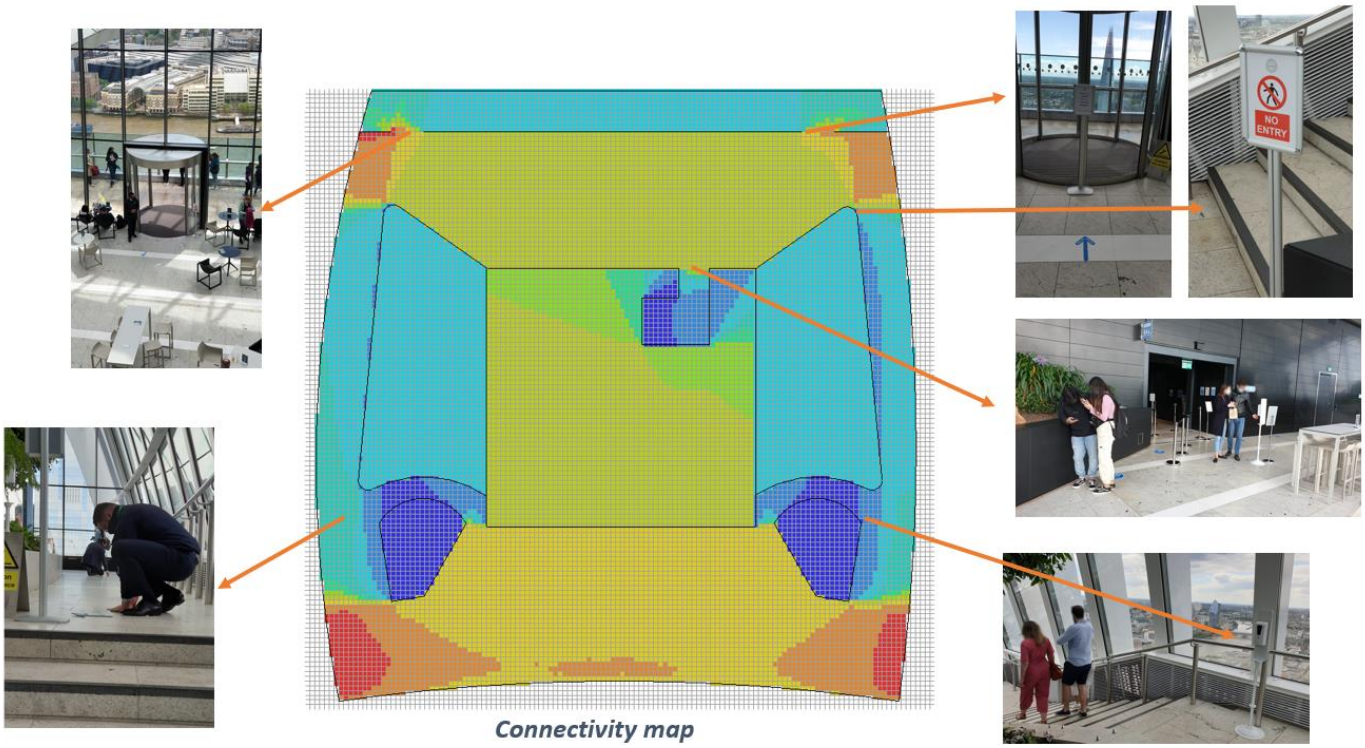

Figure.9. Connectivity map (using depthmapX). Each location is coloured according to how many other locations are visible from it . The range runs from blue, for low, through green, yellow to red for many visible locations, Source: Author.

The floor markers outlined a safe distance for guests; however, they hugely affected the movement patterns and limited the sense of publicness. As another safety measure, face coverings were mandatory in the Sky Garden unless visitors were seated at a restaurant table or in the bar areas.

Further analysis indicates that the one-way circulation system during the pandemic had a major impact on activities in the Sky Garden (Figure 10 and 11) The majority of the visitors (n=70 visitors) preferred to spend more time in stationary activities. The number of people involved in stationary activities, such as eating, drinking, and relaxing, increased compared to the number of people engaged in movement activities. There was a significant decline reported in the average number of people sauntering in Sky Garden at one time, which was around 42 visitors. Most of the movement activities were taking place on the outdoor terrace where people felt safer outdoors taking pictures and enjoying the view. The study reports the emergence of new activities within the Sky Garden, such as visitors use the space for working on their laptops, as well as using the newly installed chaise longues near the plants, for leisure and relaxation. These chairs lounges were introduced by the Sky Garden management during the pandemic and have proven to be popular among visitors.

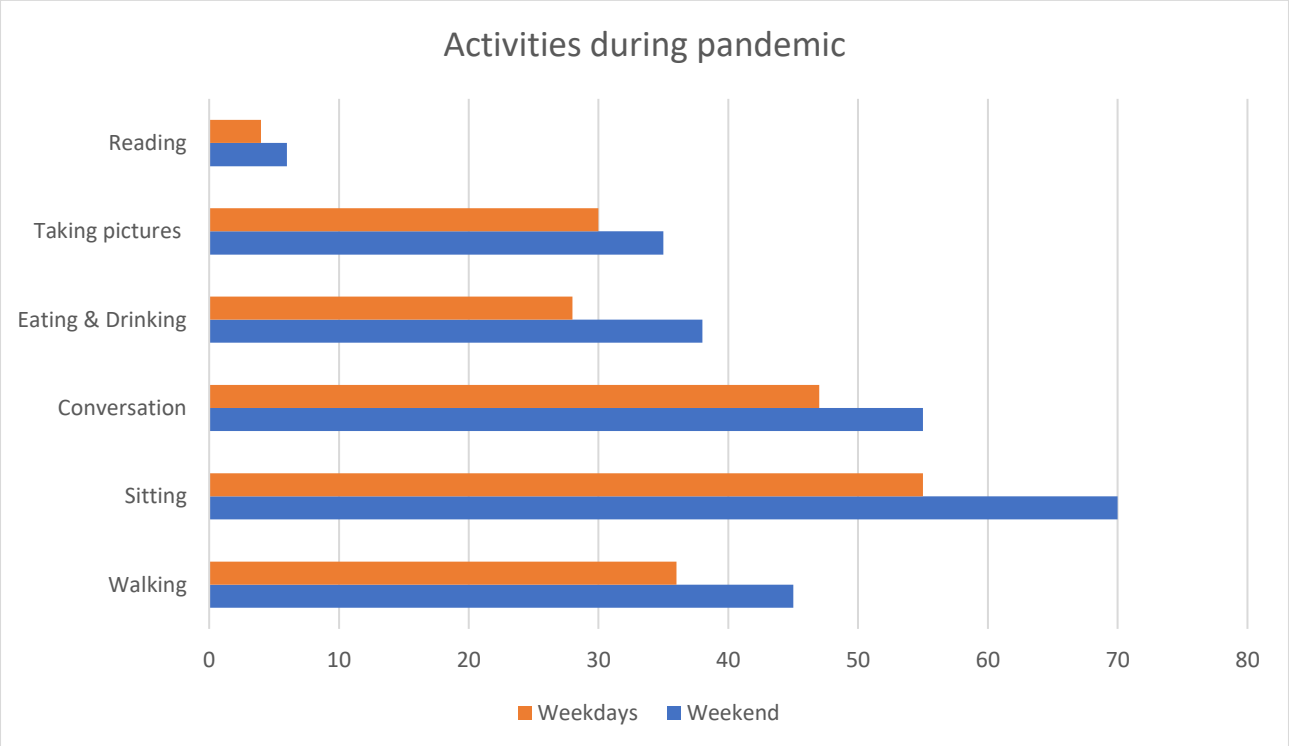

Figure. 10. The average number of visitor's activities during the pandemic, Sky Garden, London, Source: Author.

Figure. 11. The visitor's activities during the pandemic, Sky Garden, London, Sourcel: Author.

The data analysed during the post-pandemic time showed that the roof garden activities and use changed to become more active than during the pandemic time. The average occupancy per hour reached 220 visitors (36.6 % of the maximum) on weekends and 185 visitors (30.8 %) on weekdays (Figure 15) Although the Covid regulations were more relaxed visitors preferred to spend more time in stationary activities such as eating, drinking, chatting, and relaxing (Figure 12). The Sky Garden hosts a variety of special events throughout the year, catering to different interests and age groups. These events include live music performances, cultural exhibitions, fitness classes, DJ nights, Halloween parties, and New Year's Eve parties. These new themes and events of the Sky Garden were inviting and interactive for most

visitors, encouraging them to spend more time in the venue. However, most of these events were not free for the public, and visitors had to pay for valid tickets to enter the Sky Garden during the organised events (Figure 13 and 14).

Prior to the pandemic, these special events were a regular occurrence in the Sky Garden. However, during the pandemic, these events were temporarily halted to comply with the restrictions imposed by the government. As restrictions have lifted, the Sky Garden has resumed these events, which have increased in frequency to attract visitors. The events offer visitors a unique and engaging experience that ranges from sunrise yoga classes to cocktail-making workshops. The frequency of the events varies according to the season and the availability of the venue. Nonetheless, they usually occur several times per week, with an increase during peak times such as holidays and special occasions. These special events are designed to provide visitors with an unforgettable and enjoyable experience, enhancing the Sky Garden's status as a popular destination in London.

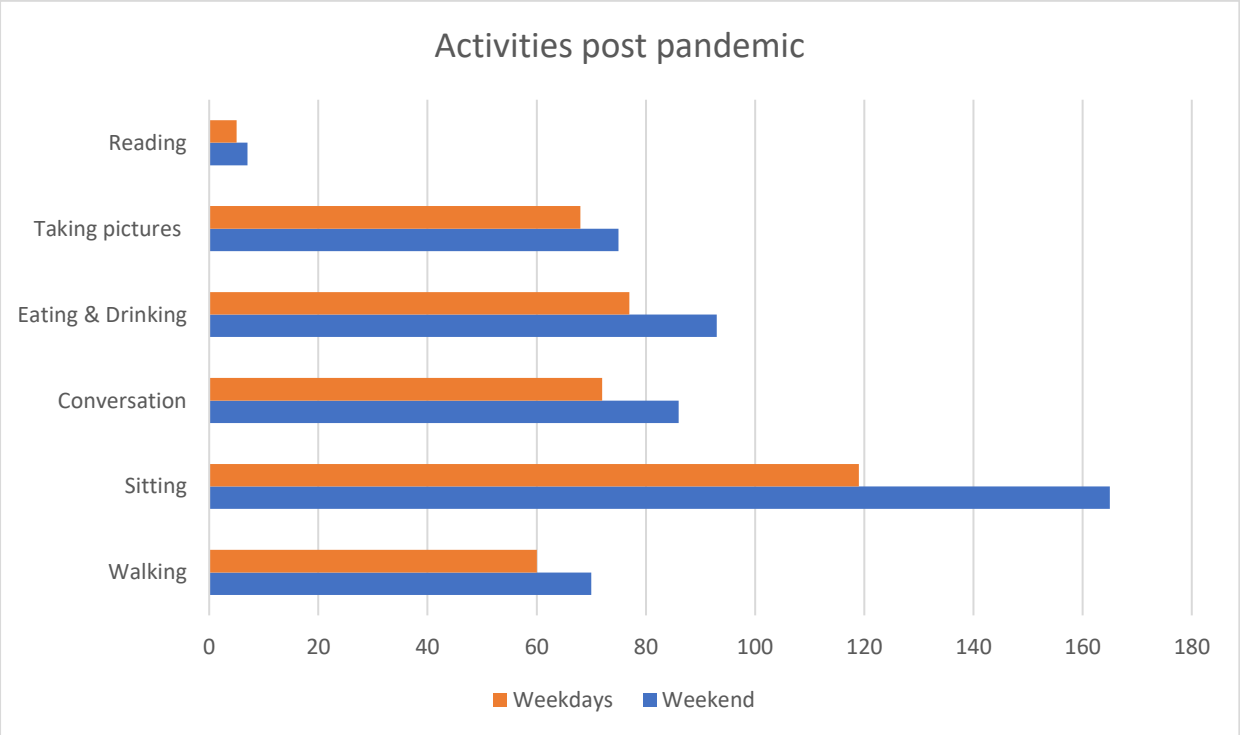

Figure. 12. The average number of visitors activities during the post-pandemic, DJ night, Sky Garden, London, Source: Author.

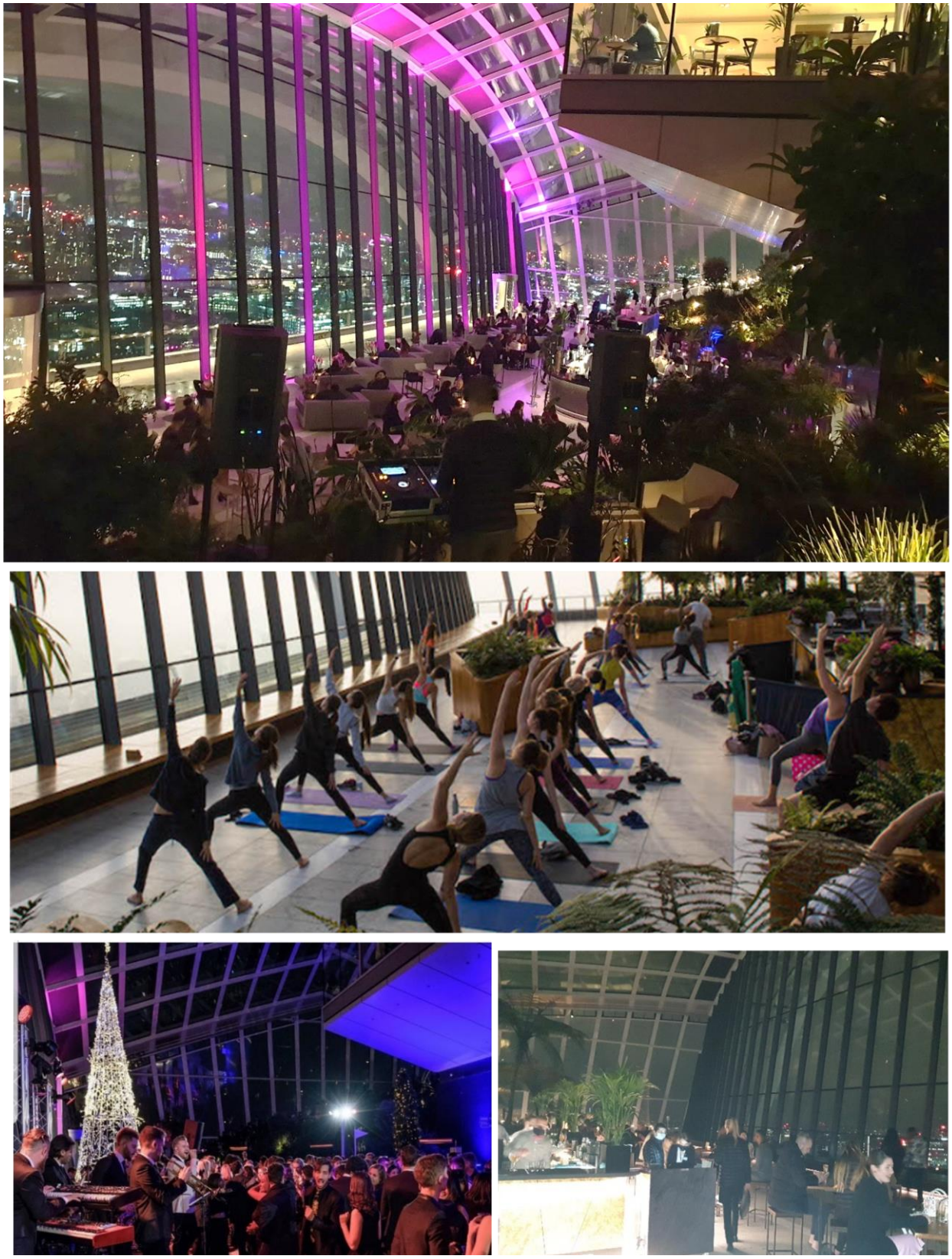

Figure. 13. The visitor's activities during the post-pandemic, DJ night & morning Yoga, Sky Garden, London, Source: Author.

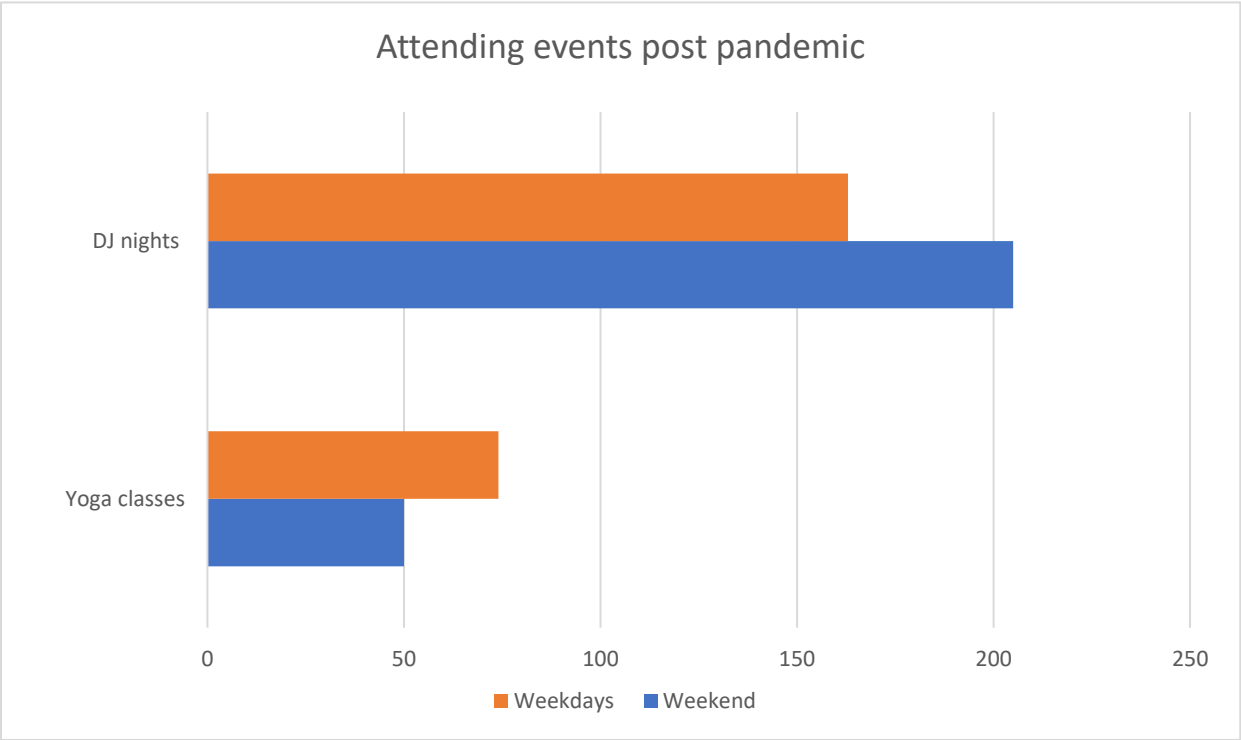

Figure. 14. The average number of visitors during the post-pandemic events, DJ night, Sky Garden, London, Source: Author.

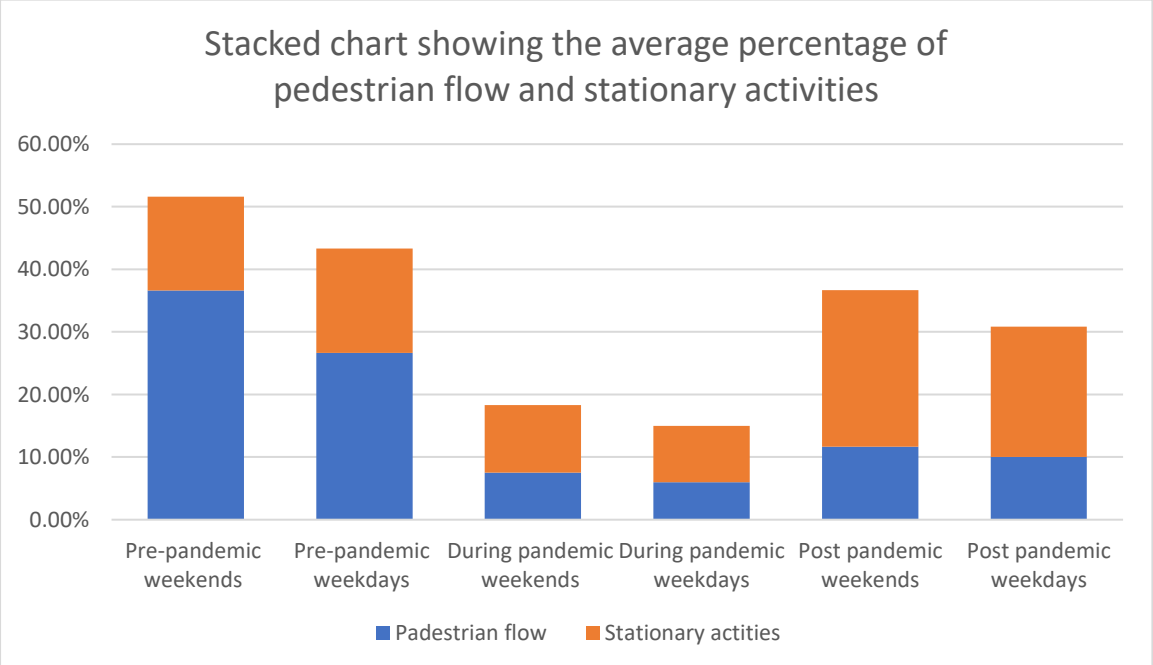

Figure.15. Stacked chart showing the average percentage of pedestrian flow and stationary activities at the Sky Garden before, during, and after the COVID-19 pandemic for both weekdays and weekends, as counted by the author's observation. Source: Author

4.2. Interview results

4.2.1. The choice and the purpose of the visit

The most common reasons for visiting the Sky Garden were: 'for the panoramic view'; 'exploring the city of London'; 'meeting a friend'; and that 'it's free to visit'. A significant number of participants referred to the fact that booking a free ticket encouraged them to visit the Sky Garden. Some participants mentioned that they knew about the Sky Garden from social media posts. Most of the participants mentioned that the views, and advertisements stating that the Sky Garden is London's highest public park were their main reasons for visiting and exploring the space.

"I have seen some pictures of it on social media, and it looks very beautiful. I am visiting London by myself, so I have just been doing random sightseeing to explore the city" (Female, aged 25 years, tourist from the USA).

"It is free to visit, and the views are very good" (Male, aged 27 years, living in London).

4.2.2. Activities

The main activities that participants undertook at the Sky Garden were: 'enjoying the views'; 'taking pictures'; 'drinking cocktails'; 'meeting a friend'; 'reading a book'; and 'eating'. The most popular two activities mentioned by the participants were 'checking the views of London', and 'taking pictures' (11 respondents; 47.8% of the interview sample). Thirty per cent of respondents (n=7) considered the outdoor terrace as the best vantage point for taking panoramic pictures of London's skyline. They also mentioned that accessing the outdoor terrace for taking pictures is limited to a certain number of people and that it depends on the weather conditions (wind, rain, temperature, visibility) (Figure 16).

"I wish we could go outside to the terrace but, we couldn't because of the weather" (Female, aged 24 years, living in the UK, restrained by security men from entering the roof terrace).

Moreover, some of the participants (6 respondents; 26% of the interview sample) mentioned that coming to the Sky Garden enabled them to relax by sitting closer to the plants and reading a book. However, a significant number of participants (11 respondents; 47.8% of the interview sample) stated that they are not encouraged to visit the Sky Garden on a regular basis due to the high prices of food and beverages. They considered that the Sky Garden

restaurants and bars were too expensive, and pointed out that visitors cannot consume their own food or beverage on site.

"It would be quite nice if you live very close to the building because it's free to come up here so you can just come to relax and read a book or just come and work and bring your laptop" (Male, aged 28 years, living in London).

"Everything is very expensive even the drink itself, I can't see myself coming here on a regular basis" (Female, aged 27 years, living in the UK).

Figure.16. Visitors activities, 34th floor, London Sky Garden, London. Photo source: Author.

4.2.3. Accessibility

Accessibility of the Sky Garden is an important factor that influences people's behaviour, activities, and interaction in the space. When the participants were asked how they found the accessibility in the light of the Covid-19 risk, four main themes emerged: 'online booking'; 'circulation'; 'security'; and 'publicness'. Nearly half of the participants (n=11) mentioned that the extra safety level was understandable, and they found it good that the Sky Garden is accessible directly from the ground level.

"The accessibility was pretty easy - it took me around 10 minutes to reach the top level. The garden wasn't busy during my visit, so I was feeling safe and not worried about social distancing" (Male, aged 25 years, living in London).

"The accessibility and the security level are understandable, especially with the current situation of the Covid-19 pandemic. I think the security guards and the management team are doing their best to make the place safe" (Male, aged 33 years, tourist from the Philippines).

4.2.3.1. Online Booking

Participants most commonly mentioned that they had concerns about the online booking system and how it always acts as a barrier to visiting the space regularly. Several participants noted that they had previously been unable to book their online tickets especially during the busier weekends. Some participants also stated that if they want to come to the Sky Garden, they have to pre-plan for their visit at least one week in advance to manage to book a free ticket.

"The accessibility is okay, but the booking phase is annoying. It would be nice to have more flexible visiting hours slots on the websites (Female, aged 26 years, tourist from Spain).

"I remember a little issue with the booking, that I tried many times to book, but it was always busy especially during the weekends" (Female, aged 45 years, living in London).

4.2.3.2. Circulation

Participants had mixed responses when asked about the Sky Garden's circulation system. Two main sub-themes were discussed: the one-way circulation system; and the different levels in the Sky Garden. The most mentioned responses regarding the one-way circulation system were that it was recognised as necessary during the current situation, but participants also stated that they were annoyed at having to go around again if they missed a particular view of the city. Some other participants reported favourably that the one-way circulation system helped them to be more purposeful on their route around the space and their enjoyment of the city views.

"if you pass something on the left and you want to see it again you must go all the way back. I guess that was a little bit annoying, so I went around a couple of times" (Male, aged 27 years, living in London).

"The one-way circulation was okay. I think it works really nice as it makes you more concentrated to look at the views and less bothered by the people walking around you" (Female, aged 33 years, living in London).

Many participants stated that they enjoyed moving between the different levels. Several participants mentioned that walking up and down the steps makes the Sky Garden design more interactive and enjoyable to explore, although it could be inaccessible and challenging for disabled and wheelchair users (Figure 17).

"It's fun to move between different levels and it helps to keep it organised" (Female, aged 23 years, living in the UK).

"I don't mind the stairs, but I suppose it might be difficult for people in wheelchairs" (Male, aged 34 years, living in London).

Figure.17. One-way circulation system, London Sky Garden, London, source: Author.

4.2.3.3. Security

Participants also spoke about how they felt safe within the Sky Garden and were asked what they think about the security system. Participants commonly reported that the security level in the building makes them feel safe during their visit . However, some of the participants (n=5) mentioned that they were disturbed at being 'watched' by the security guards in the space.

"The high-security level is necessary as it makes me feel safe inside the building" (Female, aged 26 years, living in London).

"The security level was a bit annoying, to have so many security guards in the space" (Female, aged 25 years, living in the UK).

4.2.3.4. Publicness

When asked to describe the level of publicness in the Sky Garden compared to a public park, most of the participants struggled to consider the Sky Garden as a truly public space or as a private space. Participants had mixed responses describing the garden as a 'private-public space' (n=13). The group of participants who considered the Sky Garden as a private space (n=8) mentioned specific critical factors such as the pre-booking, the security system, the Covid rules. and the use regulations. Some participants raised an issue that most of the seating spaces in the garden felt private, as most (but not all) of these seating spaces are connected to the bars, café and restaurant, implying an obligation to purchase.

"It's more like a private space, as the booking phase and the one hour permitted visiting slot puts a pressure on me although, no one asked me to leave the space before" (Female, aged 26 years, living in London).

"They offer you free entry but then there are bars around here, you can spend your money in. I guess this is how they make their profit. I found it fairly similar to most of the public spaces these days; there are always some food stalls around" (Male, aged 26 years, living in London).

"Well, the only thing that was interesting was that most of the seats were connected to the bar. There are a few spots that you could sit in that are not part of the bars and the restaurant. It felt a little bit less public than another public park, as it seems that if you want to sit you have to buy something" (Female, aged 25 years, tourist from the USA).

4.2.4. Design Concerns

Participants were asked what they liked and disliked about the design of the Sky Garden. Twenty-six per cent of the participants (n=6) reported that they are satisfied with the design of the garden and they didn't have any concerns. The presence of natural elements (plants, and trees) were enjoyed by almost all of the participants. Seventy-four per cent of the participants (n=17) reported that they had concerns about the design of the space and that improvements were needed for a better visiting experience. The most frequently mentioned themes discussed by the participants included design concerns related to the 'privacy and

positioning of seating spaces', 'lack of different tropical plants and flowers', 'stair accessibility for disabled people', 'outdoor terrace design', and the 'restaurant design'.

"I think with the name itself Sky Garden, I would like to see different kinds of flowers and roses. If they can add more green features, it will differently encourage more people to come and visit, not only for the view" (Male, aged 33 years, tourist from the Philippines).

"I don't know how it would work if you were handicapped in any way, or if you have a disability. A lot of the garden experience is on the stairs so you wouldn't be able to see any of that if you are taking the enclosed elevator" (Female, aged 25 years, tourist from the USA).

4.2.5. Design features and suggested activities

When asking the participants what design features and activities they would like to see in the Sky Garden, three main themes emerged: 'features that improve the design quality of the space'; 'features that encourage more physical activity'; and 'features that encourage more social interaction'. The most frequently suggested specific features to improve the design quality of the space were: 'adding electricity sockets'; 'providing a drinking fountain'; 'playing soft background music'; and, 'placing new relaxing seats and a quiet area near the plants'.

"The place was a bit noisy so I would like to listen to soft music in the background" (Female, aged 45 years, living in London).

"A drinking fountain just to refresh yourself a bit" (Female, aged 27 years, living in London).

"More relaxing and quiet spaces to sit, away from the bar and the café, where you can read a book or work on your laptop" (Female, aged 26 years, living in London).

The most frequently mentioned features which would encourage participants to be active in the Sky Garden were the plants and the views. Many of the participants mentioned that they would like to see more diversity and variations of plants and flowers, with name tags and information for each group of plants. Participants had also stated that a guided tour that gives information about the city's views and identifiable landmarks would be an interesting activity that would encourage walking in the space.

"If it was more like a garden space where you can walk around and see different plants, maybe like having tags of what each plant is, I think that would be interesting" (Female, aged 26 years, living in the UK).

"I think it might be worth considering having a guided tour that explains what you are seeing, and the different views and landmarks of the city" (Female, aged 26 years, tourist from Spain).

Participants had mixed responses when asked about what activities and design features would encourage them to interact with others. The most commonly mentioned responses include 'live music events' and 'placing some musical instruments such as a piano'. Some participants also suggested photograph opportunities such as 'a photo booth' and '360 viewing platform'. A few participants also mentioned other activities as events like 'table tennis area', 'kids' zone', and 'night club' during weekends.

"I think life soft music and a piano would be nice, so people could go randomly, sit down and play music" (Female, aged 35 years, tourist from France).

"Maybe something like a photo opportunity, it might be a little corner design for a photo booth or a photo frame" (Female, aged 25 years, living in the UK).

"Having music events will be quite good and it will attract more people to come" (Male, aged 27 years, living in London).

5. Discussion

The study analysed and discussed the design problems and principles that need to be considered when designing vertical urban spaces. As discussed in the Sky Garden case study there are many design aspects that could be improved in terms of accessibility, circulation, design, and management. There are nine key qualities that the study's participants most frequently referred to when describing their ideal roof garden: accessibility; provision of activities; comfort; sociability; quality of management; publicness; security; green nature; and natural ventilation.

Results from both the observation study and the interviews indicate that good pedestrian access is one of the main factors for an urban space to function well (Carmona et al, 2008; Whyte, 1980). Accessibility refers to the capability of all users to access space, regardless of any existing or potential restrictions (Persson et al, 2015). Reframing pedestrian access could

encourage logical movement and desired behaviours, while improving the level of inclusiveness (Pineo, 2020; Aelbrecht & Stevens, 2019). Carr et al. (1992) noted that three forms of physical access exist: visual; physical; and symbolic. Visual access lets people view the space before they enter it; physical access controls who can or cannot use a public area; while symbolic access indicates if the space is safe and welcoming through spatial clues (Mehta, 2014; Németh, 2009).

Although the access to the public facilities and visitor areas in the Sky Garden is free of charge and open to the public, the physical and visual accessibility remain the most significant limitations that define the publicness of the space. The Covid-19 pandemic had a major impact on Sky-Garden's accessibility. For a time it was closed altogether, and then when access was permitted there was the requirement to bring in social distancing rules. This reduced the permitted number of guests, and isolation of elevator occupants into family groups. During the pandemic, there was widely accepted advice to have good natural ventilation, but the environment at the top of a skyscraper, with a large south facing glass wall is mostly controlled by artificial environmental systems.

The pandemic has forced the managers of elevated urban spaces to rethink sightlines and wayfinding to provide good visibility in terms of horizontal and vertical directions. To ensure safety, these strategies should emphasise visibility from both inside and outside the points of the entrance and exit. A larger and more visible area allows for increased safety measures such as social distancing to be upheld while allowing pedestrians greater freedom of movement (Honey-Rosés et al., ,2020; Cho et al., 2015). An environment with a heightened sense of connectivity will not only reduce the risk of exposure, but also promote accessible routes within public spaces (Afrin et al.,2021; Pineo, 2020;).

A well-connected space is integrated with local movement and pattern systems; the movement is itself an activity that often generated other activities (Moore, 2021; Carmona et al., 2008). Legible spaces are essential for the identification of prominent activity nodes. To be effective, elevated roof gardens should provide a balanced mix and visibility to all activities; it should encourage users to engage with the environment and also have moments to pause (Pomeroy, 2013).

Seating organisation is one of the fundamental tactics to enable social activities in a vertical green space. Providing various kinds of seating in the roof gardens is therefore highly advisable. Movable chairs and benches with different orientations can improve the variety and choice of seating amenities, in terms of comfort and user experience (Huang & Franck, 2018). Seating arrangement and orientation can improve social interaction and passive activities such as people watching (Cho et al., 2015; Neto & Munakata, 2015). Interactive elements such as fountains, plants, installations, game facilities, interactive displays, pianos, swings, and public art sculptures are highly recommended to activate the roof garden design. These interactive elements bring a unique character to the roof garden while also serving as an attraction that encourages visitors to stay longer in the roof garden, or come back another time, or recommend it to friends (Milne & Pojani, 2022).

Public roof garden management should encourage inclusion through skilfully 'light-handed' regulations, rather than the hard exclusion of undesirable behaviours through restrictions on people's activities(Oldfield, 2019; Hadi et al., 2018). These new guidelines should limit the number of restrictions to essential and reasonable ones, employ plans for users' participation in the roof garden management, and regulate spatial uses and actions, rather than just confining or prohibiting them (Ehab et al., 2023).

The building industry needs new strategies to manage risk and hygiene to combat the transformation of Covid-19 and future diseases, but also new thinking on how to create resilient and vertical social spaces that allow for high-value interaction and increased health and wellness (Morawska et al.,2021). A number of possible solutions include a combination of operational, technological, and architectural inventions (Mills et al., 2020). These innovative solutions are firmly rooted in science and built upon the hierarchy of controls, a widely recognised industry standard for risk management. Safety organisations such as OSHA (U.S Occupational Safety and Health Administration) and HSE (UK Health and Safety Executive) advocate this solution to manage risks effectively (Shroff, 2020). To reduce the probability of risks in any built environment, this hierarchical system categorises design solutions or operational measures according to their effectiveness.

The inverted pyramid graphic creates a hierarchy of solutions, with those at the top considered to be more effective than the one at the bottom (Sehgal & Milton,2021; Morawska et al., 2020) (Figure 18). The use of personal protective equipment (PPE) was the initial

response to the pandemic and will continue to serve an important purpose in the short to medium-term but these are considered less effective over the long-term (Gandhi & Marr, 2021). Design and engineering solutions at the top of the pyramid are, however, more suitable long-term solutions and are considered to be more effective (Mills et al., 2020).

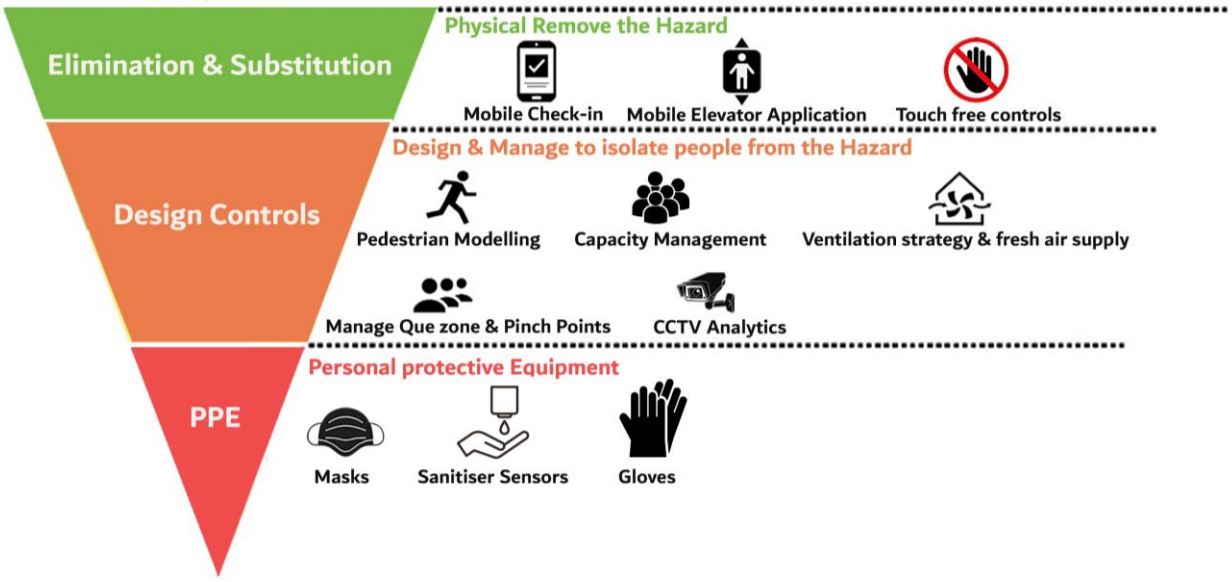

Figure. 18. The Hierarchy of controls is a commonly accepted system for reducing risk. The icons to the right represent some of the specific solutions that can be implemented in the vertical social space to effectuate each control action., Source: Author.

5. Conclusions

This paper presents a research study on the current design and management of the Sky Garden, London before, during, and post the Covid-19 pandemic. The research leveraged different methods for collecting data, including quantitative and qualitative, and a literature review to identify findings that are relevant for both industry and academia. The primary outcomes, as set by the research objectives are: (i) analysis of the design critical issues such as: accessibility from the ground level, visitor circulation, and activities occurring within the space; (ii) using space syntax analysis to examine and analyse the safe social distance for visitors; and (iii) to outline suggested solutions for designing safe and adaptable vertical social spaces.

The research also demonstrates that the evolving types and the current conditions of elevated (vertical) urban spaces in London require the re-conceptualisation and re-assessment of conventional approaches. Management and regulations are inevitable negotiating

mechanisms to determine appropriate users, uses and behaviours in intense and high density vertical social spaces, as well as to optimise the use of space over time. The range of rules and regulations needs to be carefully studied to retain a balance between safety, adaptability, and inclusiveness. If this range does not consider public perception of urban spaces, anticipating the whole experience of users, not just a few images or renders, then it will not be complete.

In response to such challenges, strategic design guidance is needed, that would work better at all levels, enabling communication among the various actors, including the public, to facilitate the decision-making process, and ultimately delivering improved outcomes (Bussell et al., 2023; Ehab et al., 2023). This requires future investigation of new efficient and flexible approaches, to understand, assess, and guide the design and management of emerging vertical urban spaces that would signify their qualities and performance. Public engagement, consultation, alternative design options, and ideas gathering are all essential before real money is spent on real buildings.

Future research being undertaken by the author and colleagues will evaluate and assess the relative merits of different types of vertical and enclosed social spaces, including innovative methods of public consultation using smart technology. Virtual Reality (VR) and augmentation of VR modelling for environments such as the indoor sky parks and outdoor open rooftop gardens is the framework for a form of consultation that can harvest public approval and design ideas, generate enthusiasm and motivation, stimulate funding and initiatives, and create better city spaces.

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