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Strategy of Visual Connection with Nature Through The Building-Integrated Vegetation Approach on The Campus Environment (Case Studies: UMN Campus in Gading Serpong and Binus Campus in Alam Sutera)

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ABSTRACT

Rapid urbanization in recent decades has increasingly separated humans from nature. Campuses that have been associated with 'tiny cities' hold significant potential to promote it. This conscious effort by humans to affiliate with nature through the built environment is called biophilic design. One strategy for biophilic implementation is through visual connection with nature by integrating vegetation into the building. This study aims to explore the application of building-integrated vegetation (BIV) in urban campuses and examine the perceived sensory dimensions by users. A case study approach was employed on two urban campuses: Binus University in Alam Sutera and UMN University in Gading Serpong. The qualitative method is the place-centered mapping technique. Data were collected through physical observation, document analysis, and questionnaires. Visual and spatial data were analyzed to explore the implementation of BIV, while questionnaire data were analyzed to examine user perceptions. The findings reveal that both campuses applied vegetation to buildings through outdoor gardens, indoor gardens, and rooftop gardens. The study also found that users experienced natural ambiance, tranquility, openness, and biodiversity when visually connected to nature. These findings provide relevant insights and recommendations for campus designers to create healthier and more sustainable learning environments through the application of BIV.

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1. INTRODUCTION

In an era of rapid urbanization, many campuses around the world are faced with the challenge of creating sustainable environments that not only enhance academic activities (Zhang et al., 2024), but also support the physical (Guswaldi et al., 2019), and the mental well-being of their users (Alves et al., 2022). It is confirmed by Alshuwaikhat & Abubakar (2008) that universities have been conceptualized as 'small cities' and living laboratories to achieve such sustainability goals, collaborating on environmental, social, and economic aspects of education and research. In addition, the role and efforts of universities have been widely recognized for their responsibility regarding environmental issues (Uvalić-Trumbić, 2012 in Peters & D'Penna, 2020), being proactive towards sustainability programs (Escrigas, 2012 in Malekinezhad et al., 2020), and offering an ideal environment for exploring and practicing sustainability (Disterheft et al., 2013, as cited in Liu et al., 2018).

Within the scope of the campus, sustainability efforts are made by responding to the surrounding climate and context. This contributes to reducing ambient temperature and the urban heat island effect (Raji et al., 2015), saving building energy, activating environmental cooling, and increasing oxygen reserves (Marugg, 2019), enriching ecosystems, and increasing biodiversity (Elgizawy, 2016). Research conducted by Ratnasari & Dwisusanto (2024a) found that restoring human connection to nature through the built environment has positive benefits not only for humans, but also for buildings and the environment. Kellert & Calabrese, (2015) defined it as biophilic design, which is a conscious human effort to integrate natural processes and elements in the built environment. Browning et al., (2014) and Browning & Ryan (2020) provide a more practical approach that biophilic design can be achieved by bringing nature into the space, analogizing nature, and creating natural spaces. One of the strategies for bringing nature into space can be done through a visual connection with nature (Browning et al., 2014), which can be achieved through building-integrated vegetation (Arnold et al., 2021).

Nature integration is not only at the scale of spaces and buildings, but also landscapes and even cities. Marugg (2019) and Raji et al. (2015) define this concept as building-integrated vegetation (BIV). Vegetation is a soft element in the design of the built environment that represents nature. Its integration in the design can be done in the form of gardens inside, outside, between indoor and outdoor spaces, creeping on walls, embedded in the roof, or attached to all building components (Sugianto et al., 2024). Raji et al., (2015) reveal similarly that inner gardens, roof gardens, facades, sky gardens, and vegetated balconies are design strategies commonly applied in contemporary architecture. Considerations for the application of vegetation in these designs can be categorized based on the type and type of vegetation, growing medium, and construction method (Sheweka & Magdy, 2011). Human connection with nature through BIV provides holistic benefits to the human mind-body system, which includes human cognitive, psychological, and physiological dimensions (Ratnasari et al., 2024a). Through the integration of vegetation elements in the design, humans can experience a multi-sensory experience. Stoltz & Grahn (2021a) identified that perceived-sensory dimensions (PSDs), including naturalistic aspects, tranquility, diversity, and space, contribute to improved psychological well-being and stress reduction. In addition, Stoltz & Grahn (2021b) emphasized that built environments with natural elements can strengthen human perceptions of aesthetics and sustainability, while increasing focus, productivity, and satisfaction with the built environment.

Given that vegetation in the built campus environment has ecological, economic, health, cognitive, and also psychological benefits (Mangone, 2014 in Marugg, 2019), many campuses

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in Indonesia are currently integrating it as part of the design and architecture. This study aims to explore the application of building-integrated vegetation in campus environments. The UMN campus in Gading Serpong and the Binus campus in Alam Sutera were chosen as case studies because they are located in urban areas, belong to the category of small campus areas (less than 10 hectares), and integrate vegetation in design on limited land. Under these conditions, the application of building-integrated vegetation is a strategic solution to overcome the challenges of limited green space while still fulfilling aesthetic, functional, and academic aspects. Thus, this study can provide relevant insights on how urban campuses can adapt and utilize building-integrated vegetation in design to address increasingly pressing environmental and spatial issues.

2. LITERATURE REVIEW

2.1. Biophilic Design Approach

Ratnasari & Dwisusanto (2024) explain that humans have a deep symbiotic relationship with nature. The mechanism of connecting humans and nature through the built environment has an influence not only on humans but also on nature and its built environment. Kellert et al., (2008) dan Browning et al., (2014) explain that this conscious effort by humans to connect with natural processes, mechanisms, and elements in the design of the built environment is defined as biophilic design. This biophilic practice involves the application of various design strategies called experiences/patterns and attributes/elements (Kellert & Calabrese, 2015). Kellert (2018) further explained that the success of biophilic practices is highly dependent on the engagement, adaptation, attachment, interaction, and interconnection between attributes. Through the application of these design attributes, humans can have direct experience with nature, indirect experience, and also experience form and space (Kellert & Calabrese, 2015). A similar approach is described by Browning et al. (2014), presenting nature in space, symbolizing nature through analogy, and creating natural spaces will bring people to experience nature. Table 1 below details the biophilic experiences/patterns and attributes/elements.

Table 1. Patterns/experiences and attributes/elements of biophilic design

	Patterns / Experiences	**Attributes / Elements**
Browning et al., (2014)	Presenting nature in space	visual connection with nature; non-visual connection with nature; sensory stimuli; water features; diffuse & dynamic light; connection with natural systems; thermal & air variability;
	Symbolizing nature through analogy	biomorphic forms & patterns; order & complexity; material connection with nature;
	Creating space	risk/peril; mystery; prospect; refuge;
Kellert & Calabrese (2015)	Direct experience of nature	air; light; water; vegetation; weather; animals; natural ecosystems & landscapes; fire;
	Indirect experience of nature	replicas of nature; natural materials; natural colors; simulated natural light & air; natural shapes & forms; evoking nature; diversity; change of time & weather; natural geometry; biomimicry; biomorphic;
	Experience of space and form	prospect & refuge; order complexity ; compaction; mobility & wayfinding; transitional space; culture & place attachment;

Source: Browning et al., (2014) dan Kellert & Calabrese (2015)

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2.2. Building-Integrated Vegetation (BIV)

Building-Integrated Vegetation (BIV) is a design approach that integrates vegetation elements into the building structures and components (Raji et al., 2015). This approach not only serves as a decorative and aesthetic element but also becomes an integral part of the building system that provides ecological, social, and economic benefits that support the sustainability of urban architecture. The benefits of BIV implementation include: reducing the effects of urban heat, improving thermal insulation (Elgizawy, 2016), improving air quality through the absorption of carbon dioxide (CO2) and other pollutants (Marugg, 2019), providing visual and physical access to natural elements (Ratnasari et al., 2024a), reducing energy consumption for cooling, and increasing the economic value of the property through the aesthetic appearance of the building. According to Raji et al., (2015) in Marugg (2019)), the application of BIV can be in the form of green roofs, living walls, vegetated balconies, sky gardens, and inner gardens. Technically, BIV applications can be categorized based on the type of vegetation, growing medium, and construction method (Sheweka & Magdy, 2011). These BIV categories accommodate how vegetation grows hanging down, wall-climbing or modular (Othman & Sahidin, 2016).

Table 2. Perceived-sensory dimensions and their characteristics

Dimension	Environment Characteristics
Natural	Wild nature evolving on its own;
Serene	Tranquility, free from disturbance, sounds of nature;
Cultural	Human cultivation, historical heritage, timeline;
Spacious	Spacious whole, and cohesive;
Opennes	Open areas, vistas, views, and vistas;
Shelter	Private hideaways and safe havens
Rich in Species	Diversity of plant and animal species;
Social	Social interaction and activity;

(Source: Stoltz & Grahn, 2021a)

2.3. Perceived-Sensory Dimensions (PSD)

Ratnasari et al., (2024b) explain that interactions between humans and the environment that contribute to health and well-being can be bridged through biophilic design. However, this response is highly dependent on human sensory perception. Perceived-sensory dimensions (PSDs) are a framework used to analyze human perceptual experiences of the environment based on perceived sensory qualities. Stoltz & Grahn (2021) summarized it into 8 (eight) dimensions, namely: openness rich in species, nature, serene, social, refuge/shelter, spacious, and culture. These dimensions contribute to stress recovery in how a person understands and responds to their environment (Memari et al., 2021). On the other hand, most environmental design research utilizes PSD to explore and evaluate the effects of environmental quality (Stoltz & Grahn, 2021b) on well-being, comfort, and individual preferences. Studies show that environments designed with PSD in mind can enhance human interaction with nature and support the needs of the human mind-body system.

3. METHODS

This research uses a qualitative method with a case study approach through place-centered mapping techniques. Physical observations were conducted to explore the application of building-integrated vegetation (BIV) on two urban campuses, UMN Campus in Gading Serpong and Binus Campus in Alam Sutera, which were selected based on certain criteria. These criteria include campus location in urban areas, small land area (less than 10

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hectares), limited land conditions, and integration of vegetation in building design. The data collected consisted of visual and spatial data in the form of photographs, as well as user perception data through the distribution of digital questionnaires. Visual and spatial data were presented in the form of infographics and analyzed to explore the vegetation design strategies applied. Thematic analysis was conducted on the questionnaire results to explore user perceptions related to the sensory dimensions felt when visually connected to nature. To validate the findings, data triangulation was conducted by comparing the questionnaire results with physical observations and related documents, thus ensuring the accuracy and credibility of the data obtained.

4. RESULTS & DISCUSSION

4.1. Overview of the Case Study

1. Case Study 1: Binus Campus, Alam Sutera

Figure 1. Overview of the Binus campus, Alam Sutera
(Source: authors, 2024)

The main campus of Binus in Alam Sutera is being built in phases on an area of approximately 5 hectares. The total floor area requirement of this campus reaches around 66,000 m². In the first phase, a tower was built with a total building area of around 32,000 m², consisting of 21 floors and 1 layer of semi-basement. Meanwhile, the second phase of construction covers the remaining 34,000 m² of building area. The semi-basement floor is used for parking, building management, and utility rooms. The first floor houses the main lobby, international lounge, student services, bank, library, and several communal spaces for students. The 2nd floor is used for non-computer labs, such as Binus TV, photography studio, data center, and simulation room. Floors 3 and 4 are allocated for offices and lecture rooms, while floors 5 to 14 are used as regular classrooms, large classes, and laboratories. The building mass concept of this campus building resembles a stack of irregular vertical boxes. The use of materials such as curtain walls, aluminum composite panels, and perforated precast concrete helps maximize natural lighting and air circulation. In addition, the building's mechanical and electrical systems are controlled by a Building Automation System (BAS), which enables efficient and automated energy management.

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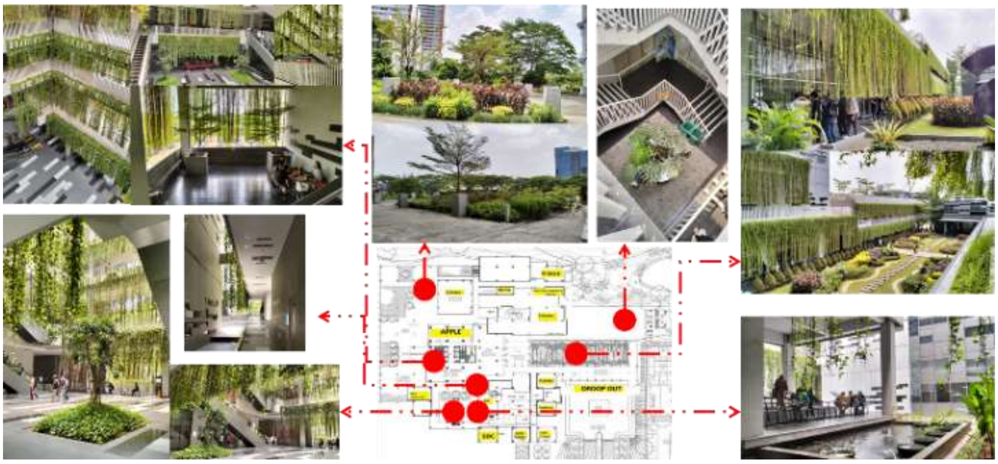

Figure 2. Implementation of integrated vegetation in the indoor spaces of the Binus campus
(Source: authors, 2024)

The integration of vegetation in the interior is also quite massive. Indoor gardens can be found in some canteen atriums, lecture halls, and even in the library. Ornamental plants that are adaptive to indoor spaces, such as monstera (*Monstera deliciosa*), were chosen because they are low-maintenance and easy to maintain. In addition, other types of vegetation, such as *Terminalia mantaly* with not-so-deep roots, small and not too dense leaves, and horizontal and layered crowns can add to the aesthetics of the space. Its shallow roots allow this type of vegetation to be planted in pots, planter boxes or directly on the planting media on the floor. The application of vertical hanging garden with dangling vegetation type can almost be found on balconies, over hangs and building atriums. The types of plants applied are *Epipremnum aureum* and lee kwan yee (*Vernonia elliptica*) with creeping and dangling characteristics. This vegetation was chosen because it can serve multiple functions, namely; providing a good aesthetic appearance, easy maintenance and care, and this type of plant is adaptive to the media and supporting structure. In addition, with a high density, these plants can become a green curtain that functions as heat and glare shading and air filters.

Figure 3. Implementation of integrated vegetation in the outdoor spaces of the Binus campus
(Source: authors, 2024)

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The irregular vertical box stack design concept allows each mass to have a roof garden and transitional spaces. These spaces are utilized as sitting areas with dry gardens. Based on considerations of building structure, maintenance, drainage systems, planting media, and vegetation types, the type of garden applied is an extensive garden. This type of garden is usually passive, only functioning as an aesthetic and a greening. The vegetation planted is limited to grasses, shrubs, and groundcover that have shallow roots or types of vegetation that can grow in pots with fairly shallow planting media. As with the hanging vertical vegetation applied to almost all building atria, the same type of plants is also applied to the building facades. This bridging vegetation not only functions in terms of aesthetics, but also as a visual barrier, sun and heat shading, CO2 filter and O2 supplier to the building.

2. Case Study 2: the UMN Campus, Gading Sepong

Figure 4. Overview of the UMN campus, Gading Serpong
(Source: authors, 2024)

Multimedia Nusantara University, also known as UMN, was established in 2006, officially moved to its permanent campus in 2009. The architectural design of the UMN campus, which integrates technology, sustainability, and aesthetics, was designed by architect Budiman Hendropurnomo, IAI. The campus design emphasizes energy efficiency and sustainability, including the implementation of a secondary skin system to dissipate heat, provide cross circulation, and reduce electricity consumption for lighting and air conditioning. The campus, located on Jl. Scientia Boulevard, Gading Serpong, stands on an 8-hectare land with a total building area of 99,500 m^2. Currently, the UMN campus consists of four main buildings: Buildings A and B (established in 2009), Building C or the New Media Tower (established in 2012), and Building D, known as the P.K. Ojong-Jakob Oetama Tower (established in 2017). Building A, which has 8 floors, is the administrative service center, admissions office, lecturer's office, and function hall, which serves as a meeting room, seminar, and other meetings. Building B consists of 5 floors and houses the library, student service center, ICT (information & communication technology) laboratory, and café. Building C consists of 1 basement floor for parking two-wheeled vehicles and 12 floors for lecture halls, international office, AI (artificial intelligence) laboratory, and business incubator through Skystar Ventures. Building D consists of 1 basement floor for parking four-wheeled vehicles and 19 floors that function as lecture halls and hospitality laboratories, collaboration hubs, and sports halls.

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Figure 5. Implementation of integrated vegetation in indoor and outdoor spaces of UMN campus
(Source: authors, 2024)

In addition to its unique design and attention to sustainability, the UMN campus creates a visual connection between its users and nature in various aspects. Pedestrian entrances from the main road are equipped with shade and vine pergolas. The types of plants commonly used are alamanda (*Allamanda cathartica*) and tiger hoof (*Mucuna bennettii*). In addition, the placement of dense trees and grass as ground cover presents a green and calm atmosphere. Between buildings A-B and buildings C-D, there is an outdoor garden planted with angsana (*Pterocarpus indicus*) and ketapang (*Terminalia catappa*) trees with mini elephant grass (*Axonopus compressus*) as ground cover, which not only provides a green element to the landscape but also helps create a more comfortable microclimate by providing shade and reducing ambient temperature. Inside the ground floor of Buildings C and D, there is an inner courtyard garden. Balinese pandanus (*Cordyline australis*) and meranti sepat banana (*Calathea lutea*) planted in planter boxes add a natural feel to the inner areas of the campus. The presence of this inner garden increases the comfort of campus users by creating a cooler and more natural atmosphere in enclosed areas.

What is interesting about the integration of vegetation in the design of this campus is the choice to maintain the existing. Several large trees are retained and integrated into the new buildings, reflecting the campus's efforts to maintain sustainability and the preservation of its natural environment. In addition, the UMN campus design also implements an intensive roof garden connecting Buildings C and D. The vegetation planted is not limited to grasses and groundcovers, but also other large plants, such as ketapang (*Terminalia catappa*) and red shoots (*Syzygium myrtifolium*). The function of this rooftop garden is not only as greenery, but also as a natural cooler for the space below, helping to reduce energy requirements for air conditioning. Another interesting feature of the integration of vegetation in the building is the sky garden applied to the New Media Tower. The sky garden on the 13th floor is a type of dry garden with vegetation planted in pots or plant boxes. King palms (Roystonea regia), which can grow up to a height of 20 meters, can grow in this garden. In addition, there are other ornamental plants, which are also planted in boxes or pots, are Balinese pandanus (*Cordyline australis*), dracena (*Dracaena reflexa sp.*), meranti sepat banana (*Calathea lutea*), and green ivory betel vine (*Epipremnum aureum*). This garden provides greenery on the 13th

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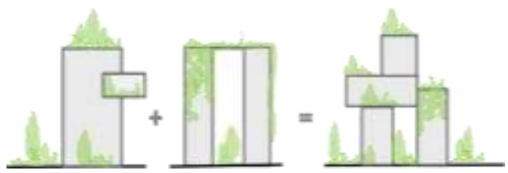
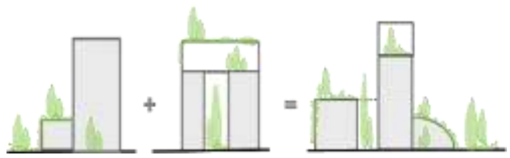
floor that can be utilized by campus users while enjoying Skylar facilities. The integrated vegetation on the UMN campus not only has an aesthetic impact but also provides significant ecological and functional benefits for its users.

4.2. Discussion

1. Application of Integrated Vegetation in the Study Case

Table 3. The comparison of case studies

Case Study	Building-Integrated Vegetation (BIV) Implementation	Schematic Graphic
Binus Campus, Alam Sutera	Innercourt (Raji et al., 2015); Hanging down vegetation (Sheweka & Magdy, 2011); Outdoor garden (Pradono, 2019) (Sugianto et al., 2024); Extensive roof garden In between exterior-interior (Pradono, 2019);	
UMN Campus, Gading Serpong	Outdoor garden (Pradono, 2019) (Sugianto et al., 2024); Intensive roof garden Sky garden (Raji et al., 2015); Wall climbing vegetation (Sheweka & Magdy, 2011);	

Source: authors, 2024

Based on physical observations of the two campus environments that became the object of study above, the Binus campus and UMN campus apply exterior gardens, inner/court gardens, and roof gardens. Although the technical implementation is different, aesthetically the existence of inner and outer gardens can present a ‘green’ and natural impression and provide a calm, fresh, and cool ambience. Ecologically, this garden can function as a green lung, cooling the environment and space, filtering CO2, and producing O2. From a legal aspect, the outer garden can be a perimeter of land boundaries, functional zoning boundaries, and separators between buildings. Although not as big as Binus' inner court, UMN's inner court is unique and special. The planter box design, which is also a sitting area, serves as a planting medium for ornamental plants that facilitate care and maintenance. Combined with the diffuse light generated from the skylights, it allows these ornamental gardens to grow despite being indoors. Meanwhile, the inner court on the Binus campus is dominated by hanging vegetation that dangles from the floor above and uses balcony boxes, greening systems (Arnold et al., 2021). which function not only as greening but also as heat shading and light, and wind filters. Both campuses also implement rooftop gardens, but with different types and characteristics. Both types of gardens function as greenery, but the extensive roof gardens applied to the flat roofs and balconies of the Binus campus are more decorative, while the UMN campus intensive roof gardens can function as building insulation against solar radiation penetration and other ecological functions, such as; supporting the creation of a microclimate, environmental cooling, air filters and habitat for certain types of birds. In addition, one of the UMN campus towers also has a sky garden with an extensive roof garden. Table 3 above describes the two campus environments and the integration of vegetation in the building design.

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2. User's Sensory Dimensions of the Case Study

The research findings represent that the sensory dimensions that users feel when visually connecting with nature are dominated by aspects such as natural ambience (23.2%), tranquility (17.7%), openness (15.4%), and diversity (14.9%), compared to other dimensions such as culture, space, social, or protection. Natural ambience refers to experiences that reflect characteristics of the natural environment, such as green colors, plant textures, and vegetation patterns that provide a sense of closeness to nature. Tranquility arises as an emotional response to visual interaction with vegetation, which can reduce stress and have a restorative effect on users. Openness reflects the feeling of relief that results from the design of spaces that provide expansive views and visual access to natural elements. Meanwhile, diversity in the landscape creates a rich sensory experience through the variety of colors, shapes, and textures of plants. Significantly, these dimensions demonstrate the superiority of biophilic design in creating sensory experiences that are not only physical in nature but also emotionally and psychologically deep.

5. CONCLUSION

The campus environment that has been conceptualized as a 'small city' must be able to support the learning and working activities of all campus residents. In the context of urban campuses such as the Binus campus in Alam Sutera and the UMN campus in Gading Serpong, which have limited land, a conscious effort to integrate natural elements through vegetation in building design is proven to provide aesthetic, ecological, and sensory benefits. Presenting building-integrated vegetation, through innercourt gardens, outdoor gardens, in-between interior-exterior, sky gardens, roof gardens, and vertical greenery are strategies that can be applied to the campus environment. The type of vegetation, planting media, propagation structure, irrigation and drainage systems, as well as care and maintenance, are certainly the main considerations for its application. The sensory dimension that users feel when visually connected to nature is dominated by aspects of natural atmosphere, tranquility, openness, and biodiversity. This experience reflects the characteristics of natural environments that bring emotional closeness to nature, restorative effects, and feelings of relief through visual access to natural elements. The superiority of this sensory dimension suggests that biophilic design not only provides aesthetic benefits but also improves the quality of users' emotional and psychological experiences. Furthermore, this study recommends a post-occupancy evaluation (PoE) to better understand users' perceptions of the thermal comfort and ecological functions of campus greening. Future studies are expected to enrich the insights of urban campus adaptation strategies in integrating vegetation as a solution to the limited green space and improve the sustainability of the campus environment.

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