Environment and Social Psychology (2024) Volume 9 Issue 9
doi: 10.59429/esp.v9i9.2980

RESEARCH ARTICLE

Opportunity in lost spaces: Exploring the potential of edible landscapes in viaduct underpasses

Huihua Yang, Mohd Kher Bin Hussein*, Roziya Binti Ibrahim, Qianda Zhuang

Department of Landscape Architecture, Universiti Putra Malaysia, Serdang, Selangor, 43400, Malaysia

*** Corresponding author:** Mohd Kher Bin Hussein, mohdkher@upm.edu.my

ABSTRACT

This paper introduces the concept of edible landscapes to underutilized spaces in viaduct underpasses to explore their untapped potential. Using a case study approach that involves on-site observations, questionnaires, and photographic documentation, this study will document the characteristics of 29 space nodes beneath 18 viaducts and along their routes in Guangzhou's Tianhe District. It analyzes user behavior and aspirations to activate the underutilized spaces of the viaduct underpass, optimizing their residual space, and enhancing their interactive potential. Furthermore, the paper proposes targeted design strategies for the rejuvenation and sustainable management of these underappreciated urban lost spaces. This study has two primary contributions. Firstly, it enhances the conceptual understanding of the lost spaces located in the viaduct underpass. Secondly, it investigates potential approaches and the benefits of utilizing these spaces for edible landscape development within the urban environment of Tianhe district in Guangzhou city.

Keywords: viaduct underpass; edible landscape development; lost space

1. Introduction

The viaduct underpass studied in this paper refers to the space below the orthographic projection of pedestrian and vehicular bridges on urban municipal roads, which mainly consists of the top plate, columns, and the three-dimensional space under the vertical projection and is a unique overhead open space[1]. Besides, this paper explores the potential and suggests possible usage of the often-overlooked lost spaces under the highway that are the byproduct of viaducts. The tension between human activity and land usage has become more acute in high-density urban contexts. As urbanization continues to accelerate, so does the need for more transportation infrastructure. Urban viaducts ease traffic and improve the intensive use of land. Still, at the same time, they cause negative impacts such as blockage of urban space, obstruction of pedestrian traffic, single-landscape vegetation, and abandonment. Thus, the development of elevated highways has resulted in the formation of empty and leftover spaces[2]. These issues lead to spatial fragmentation and a disrupted pedestrian space network, ultimately creating "lost space" that is challenging to utilize and has a detrimental impact on its condition.

In general, there have been numerous studies on the overall advantages of green infrastructure, urban

ARTICLE INFO
Received: 19 July 2024 | Accepted: 13 September 2024 | Available online: 9 October 2024

CITATION
Huihua Y, Hussein AKB, Ibrahim RB et al. Opportunity in Lost Spaces: Exploring the Potential of Edible Landscapes in Viaduct Underpasses. *Environment and Social Psychology* 2024; 9(9): 2983. doi: 10.59429/esp.v9i9.2980

agriculture, and edible landscapes. However, there is a limited amount of research on its benefits concerning vacant or lost space utilization[3]. This is largely attributed to the fact that few studies have comprehensively explored how different types of lost spaces collectively contribute to the sustainability of the city as a whole[4]. The lack of attention given to the design, planning, and management of the underutilized area beneath the viaduct further demonstrates that it has been neglected as a valuable resource. Based on this perspective, this study will highlight the issues of under-utilization, under-management, under-design, and low accessibility to the space beneath the viaducts in Tianhe District and identify potential landscape design interventions.

In terms of urban planning, it is advisable to employ resilient intervention and coordinated planning by governmental entities. This involves implementing integrated development and management techniques from a professional perspective, while also actively engaging locals in the utilization of open spaces of the viaduct underpass through a top-down approach. Conceptually, this study adopts flexible and elastic landscape design means to give urban agricultural production function to the lost space of the viaduct underpass to realize the function, vitality, and economic regeneration of the lost space in the city.

1.1. Lost space under the viaduct

In the context of urbanization, American urban planner Roger Trancik was among the first to introduce the concept of "lost space." He asserted that the presence of lost spaces, which refer to unattractive and unoccupied areas, necessitates a process of redesign to provide beneficial contributions to the surrounding community[5]. Future cities will confront limited urban spaces and resources. Accordingly, vacant land as Trancik called them "lost spaces" can be seen as an opportunity for green urban development[6].

Lost spaces are perceived in various discourses as terrain vague, blank spaces or dead zones[7], superfluous landscapes[8], spaces of uncertainty and the margin[9], landscapes of contempt, voids of ambivalent landscapes[10], and the urban interstices[11]. Furthermore, some scholars have introduced similar concepts, including "negative space", "gray space" and "leftover space". Research on "negative space" has highlighted "lost space" characteristics from both a spatial and functional perspective: unclear boundaries, low connectivity of landscape nodes, disconnection from the city, and poor spatial quality. "Gray space" and "leftover space" all emphasize the underutilized nature of the lost space (**Figure 1**). Underutilized negative spaces are scattered throughout various corners of the urban landscape. They have failed to adjust to contemporary demands or undergo necessary functioning modifications. Frequently, these areas were not given sufficient consideration about the pace of urban development, and the viaduct underpass serves as a typical illustration of urban lost spaces.

The spaces beneath urban infrastructure such as overpasses and viaducts are often considered "lost spaces" that are dangerous, easily overlooked, and lack proper management[12]. The presence of under-viaduct spaces is the way people experience the city, as they impede the connectivity between neighborhoods, produce unattractive views, and serve as obstacles to both physical and psychological growth[5]. Furthermore, the absence of clear territorial attribution for these spaces results in land misuse, such as the dumping of garbage or becoming homes for vagrants[13]. Urban planners, designers, and scholars have pointed out that these issues are the result of a lack of integration in the planning and design processes, and the residual problem of the viaduct underpass is indeed an urgent gap that needs to be addressed. Transportation infrastructure is considered a major contributor to landscape fragmentation, impacting nearly all aspects of the landscape, including aesthetics, ecology, history, recreational quality, illegal occupation, littering, and negative social effects such as crime[14]. Therefore, addressing the issues of lost spaces beneath viaducts is a

challenging goal and a crucial aspect of urban renewal and governance, not only in China but in many countries around the world.

List of figures:

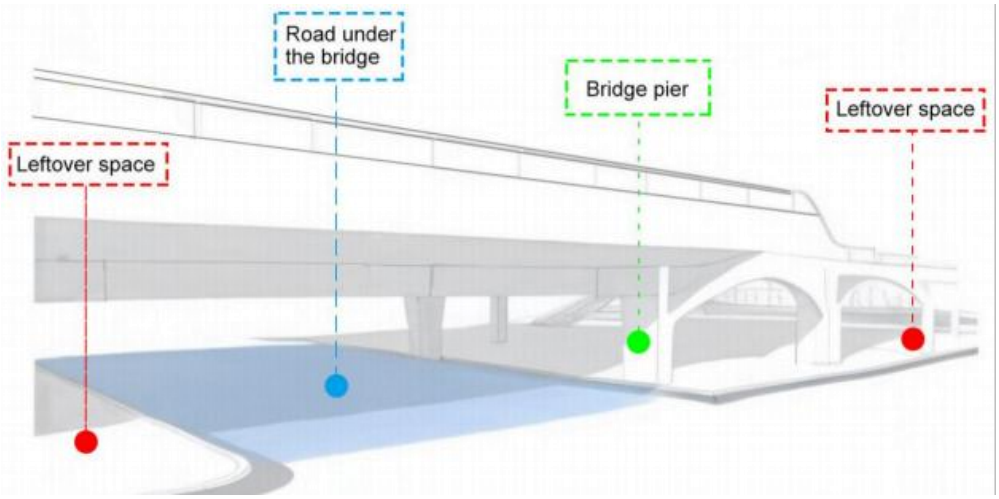

Figure. 1. Schematic diagram of the viaduct underpass

1.2. Edible landscape in lost space

In the 1980s, environmentalist Robert Kourik from the United States introduced the concept of establishing edible landscapes within urban areas. This concept was later studied in detail and put into practice by landscape architect Rosalind Creasey[15]. According to Creasey's definition, the term "edible landscaping" refers to the cultivation of edible crops inside urban fruit and agricultural gardens, employing ecological gardening methods to ensure that these gardens possess both productive and visually pleasing qualities while also contributing to ecological preservation[16].

As edible landscapes are gradually being introduced into various urban landscape designs, there is a growing body of research evidence that the development of edible landscapes has significant benefits for urban leftover spaces[15]. Edible landscape spaces play an important role in urban planning, providing a true green infrastructure in heavily built-up areas[17], and they are also valuable resources for the recreational activities of urban residents[18]. Edible landscapes can reclaim underutilized spaces while emphasizing the role of productive landscapes in moderating the excessive consumption of urban resources[19].

Participation by the community is the driving factor behind the successful habitation of the lost spaces[20]. The viaduct on the eastern side of Yilan City in Taiwan, China, serves as a notable illustration of the integration of an edible landscape and the activation of lost space in the viaduct underpass. This transformation encompasses around 700 meters of repurposed ribbon park, now occupying the former train area beneath the viaduct.

In Yilan City, it can be observed that the designers integrated the distant rice fields into the design, incorporating entrances, paving, seats, and a signage system beneath the viaduct. This approach establishes a harmonious relationship with the surrounding environment and facilitates the natural engagement of the public with the space in the viaduct underpass. The designers planned the distant rice paddies into the design by incorporating entrances, paving, seating, and signage systems under the viaduct. This approach aimed to establish a harmonious relationship with the surrounding region and facilitate the public's engagement with the viaduct underpass. As a result, urban landscape infrastructure will give more consideration to using urban lost spaces in combination with productive landscapes[21].

2. Methodologies

2.1. Research methods

The present investigation employed a case study design, enabling the researchers to employ qualitative methods to examine a real-life contemporary phenomenon. Field observations and data collection in the viaduct underpass were guided by the systematic framework developed by Hauck[22]. The framework facilitates the systematic documentation of multiple elements within the study sites, including information on land use features, viaduct structures, visitor flows, urban spatial relationships, utilization, and environmental conditions of the viaduct underpass in Tianhe District. The geospatial data of the Tianhe district of Guangzhou City were deployed objectively, while non-participatory observation and questionnaire methods were adopted subjectively[23].

2.2. Questionnaire survey

The main objective of questionnaires in research is to obtain relevant information most reliably and validly[24]. As a result, from November to December 2023, the first author distributed 400 questionnaires to activists at 18 viaducts and their 29 nodes throughout their routes to better understand the existing situation, perceptions, and sense of experience in using space beneath viaducts. The sample size for this study was 385 respondents (including tourists, residents, and planners), and the answers were obtained using a questionnaire technique (a mixture of online and offline questionnaires). It was distributed randomly regardless of the users' age, race, and ethnicity.

The questionnaires were finally returned at 386, a 96% return rate, during which the authors also conducted seven web interviews, each with an average length of 25 minutes, to discuss the respondents' acceptance, values, and suggestions for the development of edible landscapes in the viaduct underpass. The respondents selected by the researcher are highly relevant to the viaduct underpass and must be able to articulate the characteristics of the viaduct in Tianhe district. Finally, the observed variables were analyzed and summarized, as depicted in (**Figure 2**), where the researchers visually mapped the spatial distribution of viaducts in Tianhe District. At present, the surrounding primary site environments include commercial, residential, and industrial land uses. It is important to note that the findings of this study are constrained by the observations made solely within the specified time.

Figure. 2. Map of the current distribution of viaducts in Tianhe District

2.3. Field observation

The study site is in the Tianhe District of Guangzhou, Guangdong Province, with the study area stretching from the south along the Pearl River, north to the Guangyuan Expressway, east starting from the Guangzhou Expressway, and west ending at the spaces beneath the viaduct of the Guangzhou Avenue. According to the statistics of Guangzhou Transport Planning Research Institute CO., LTD, the total number of municipal viaducts in Tianhe District is 58, which are divided into two categories vehicular viaducts (18 bridges) and pedestrian viaducts (40 bridges) according to size, structural form, and traffic mode (Guangzhou Urban Planning & Design Survey Research Institute - Company Profile and News, 2023). This paper used the above data for the selection of the study site, excluding inaccessible spaces due to transit-oriented roadway enclosures as well as municipal facility enclosures, and investigating 18 vehicular viaducts and a total of 29 under-viaduct space nodes along their routes (**Figure 2**). Among them, according to the function of the viaduct underpass, vehicular viaducts are divided into four categories: viaducts, cross-river bridges, ramps, and overpasses[16].

As shown in **Figure 2**, it was observed that the urban functions around the elevated bridges in Tianhe District are primarily commercial and residential areas, with a minority designated for construction or unused land. Among the viaduct underpasses,38% are in a state of disuse, remaining largely unutilized or even becoming concentrated areas for waste disposal. The overall utilization rate is 62%, but the effective utilization rate is only 42%, and usage is predominantly limited to parking lots and urban management facilities. 14% of the viaduct underpasses are used for parking, impeding the connectivity of urban spaces. 20% of the viaduct underpasses are primarily adorned with simple greenery, neglecting the landscape potential of these spaces. 17% are used for urban management facilities, commercial operations, etc., with some residents using the spaces to set up stalls for income generation, resulting in spatial disarray. 11% of the spaces are designated as passageways, making them non-reusable due to their designated functionality.

2.4. Observation of spatial features of site

By categorizing the viaduct underpass, a preliminary summary analysis was conducted regarding the relationships in three key aspects: urban relationships, viaduct structure elements (viaduct type, pier type), and visitor flow rate (**Figure 3**). This analysis further extends to the study of information on the characteristics of viaduct underpasses, their current usage, and design evaluation, as illustrated in the following (**Figure 4**). The viaduct underpasses of vehicular viaducts are categorized according to their functional types (viaducts, cross-river bridges, ramps, and overpasses) and are divided into a total of the following four types of spaces: 1. Road space under-viaduct: under-viaduct road spaces primarily serve urban motor vehicle traffic and are considered non-reusable since their functionality is already established. 2. Ramp space under-viaduct: these are spaces formed by the viaduct's connection to the ground, often with limited overhead clearance, leading to substantial restrictions on their usability. 3. Under space of support structure Viaduct: spaces beneath the viaducts formed by support structures generally offer more vertical space, making them versatile and highly usable for a variety of purposes. 4. Under space of overpass: these spaces are created by the interweaving of viaducts and are often fragmented by multiple urban roadways, resulting in relatively fragmented viaduct underpasses.

2.5. Observation of formal features of viaducts

According to the results of the site survey (**Figure 5**), the forms of support columns of viaducts in Tianhe District, Guangzhou City, are categorized into T-column type (central single-column type), Y-column type (central double-column type), and double-column type (double-column type on both sides), and the heights of abutments are generally less than 5M (for ramps), 5-6M (for flyovers), and 7-10 meters (for river-

crossing bridges and viaducts). All three forms of viaducts are prevalent within the Tianhe District, and the architectural form of the viaduct support columns is highly dependent on the spatial characteristics of the site underneath the viaduct. Cross-river bridges, viaducts, and ramps are predominantly two-column viaducts, while overpasses contain both single-column and Y-column forms. A comparison of viaducts with different column forms reveals that the form of the piers influences potential the utilization of the space under them, which is discussed in the following section. T-column type (central single-column type) Viaducts upheld by T-shaped columns typically feature a relatively narrow roadway surface, with an under-viaduct span typically ranging between 5 to 10 meters. Consequently, this configuration results in a narrow and elongated strip-like viaduct underpass. Furthermore, the presence of central pillars subdivides the viaduct underpass into distinct segments, creating inevitable spatial barriers, and thus diminishing the overall usability value. In most cases, these segmented zones are predominantly used for landscaping purposes.

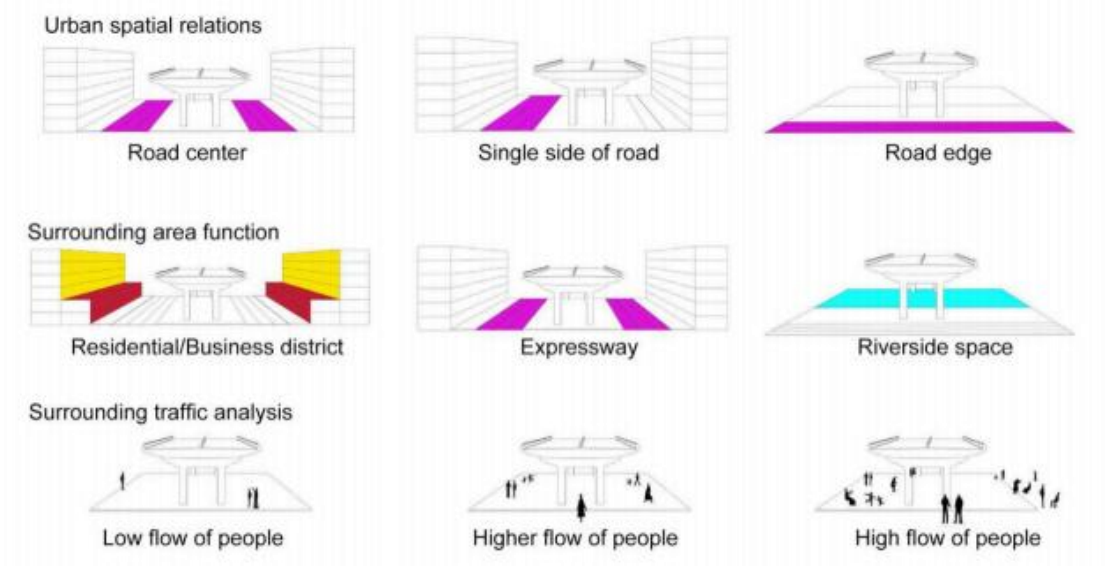

Figure 3. Analyzing the impact of urban relations, the functions of the surrounding area, and the flow of visitors on the use of the viaduct underpass

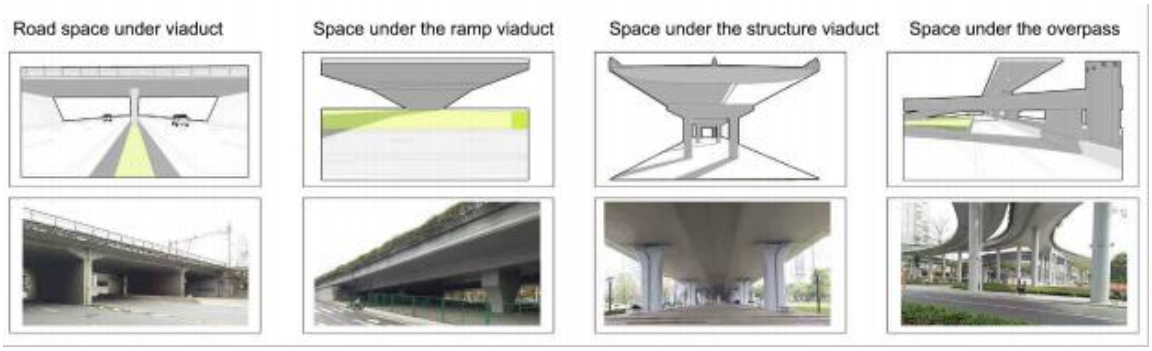

Figure 4. Classification of space under the viaduct in Tianhe District

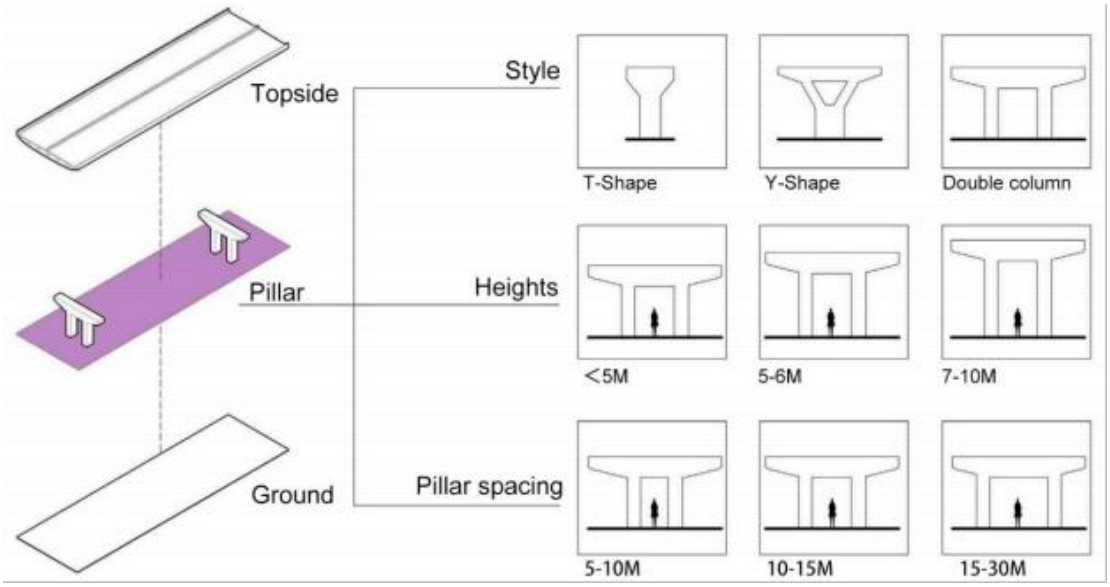

Figure 5. Tianhe District viaduct body form classification

Y-column type (central double-column type) The Y-column type design features two central pillars supporting the viaduct structure. The configuration of these pillars can either be parallel or closely spaced, creating viaduct underpasses like those of central single-pillar designs. However, the distinctive feature of Y-shaped pillar structures lies in their relatively wider viaduct underpass, typically spanning widths of 10 to 15 meters. This increased width allows for a more diverse range of utilization, often accommodating purposes such as parking facilities, administrative structures, management rooms, or access roads.

Double-column type (double-column type on both sides) The combination of two-pillar bridges is more varied, the support pillar is separated on two sides or in parallel with 4 pillars, and it forms a larger viaduct underpass, generally up to 15-30 meters in width. The increased spacing between pillars creates a substantial and contiguous usable area in the middle, allowing for seamless integration of the entire viaduct underpass. These spaces can function both as a part of the urban transportation network and provide a more flexible canvas for planning various necessary functions. Within the surveyed area, 18 viaduct nodes fall under the category of double-pillar designs, characterized by spacious, open, well-lit, and less constrictive under-bridge spaces, providing advantageous conditions for the activation of these spaces.

3. Results and discussion

3.1. Observation results

The on-site investigation results indicate that the utilization of spaces beneath the 29 viaduct nodes tends to be diverse, disorganized, and informal, serving as complementary and extended areas to the surrounding sites. Most of these viaduct underpasses remain undeveloped, with some spaces serving singular functions that do not match the needs of the surrounding environment and urban context. Vegetation and greenery are often simplistic and lacking in maintenance. A minority of spaces have the potential for reasonable utilization but lack effective spatial organization and connectivity with nearby residential and commercial areas, resulting in low accessibility. Based on the research findings, (**Figure 6**) below summarizes the current state of the lost spaces and issues facing the sites: Field observation discovers that viaduct underpasses suffer from low accessibility, space negativity, idle waste, and inappropriate use. Derelict Space: There are numerous negative spaces in viaduct underpasses characterized by poor environmental hygiene, fencing that creates barriers and enclosed environments, and a lack of urban

aesthetics. These spaces suffer from issues such as vehicle noise pollution, congregation of social wanderers, and a negative impact on street vitality.

Utilization situation of viaducts of Tianhe District in Guangzhou

Type	Position	Leisure activity		Transport		Management room		Green		Unuse	Evaluation
		recreation	sports	parking	passage	hoard	management	simple	composite		●reasonable ○unreasonable
River-crossing bridge	Liede Brg	●	●					●		●	●
	Guangzhou Brg		●							●	○
	Hua'nan Brg						●				○
	Pazhou Brg									●	○
	Dongpu Brg					●	●				○
Viaduct	Guangzhou Expy-ZhongShan Blvd M		●	●			●			●	●
	GuangZhou Expy-Huangpu Blvd E							●		●	●
	Guangzhou Expy-Huanxi W Rd			●						●	○
	Keyun Rd -Linjiang Blvd			●							●
	Huanan Expy(JU)			●							○
	Huanan Expy(SCNU)			●							○
	Liede Blvd-Huangpu Blvd W		●							●	○
Off-ramp	Huanan Expy-Huacheng Blvd			●			●			●	○
	Keyun Rd-Tangxia Xisha 1 Ln	●		●		●	●	●			●
	Zhongshan Blvd Mid-Tianfu Rd							●		●	○
	Guangyuan Expy-Tians Rd									●	○
	Huangpu Blvd-Chebei S Rd							●			○
	Guangyuan Expy(train station)									●	○
	Liede Blvd-Linjiang Blvd						●				○
Overpass	Guangyuan Expy-Guangzhou Expy	●		●			●			●	●
	Huanan Expy-Huangpu Blvd W			●			●	●			●
	GuangYuan Expy-Chebei Rd							●		●	○
	GuangYuan Expy-Keyun Rd				●			●			○
	Guangyuan Expy-Huanan Exp										○
	Keyun Rd-Huangpu Blvd Mid										○
	Zhongshan overpass				●				●		●
	Guangyuan Expy-GZ blvd N				●				●		●
	Huanan Expy-Zhongshan blvdW							●		●	○
	Guangyuan Expy-Yudong W Rd				●			●	●		●

Figure 6. Status quo of space utilization under viaducts in Tianhe District of Guangzhou City

Low Accessibility: The initial purpose of constructing a viaduct was to facilitate transportation and ensure the accessibility of vertical traffic while avoiding interruptions to the continuity of urban spaces caused by expressways. However, in the current state, fences and barriers are commonly placed beneath the viaducts, obstructing the development of these spaces. The traffic guidance is lacking, and linear separation zones isolate the land on both sides of the bridges, turning them into lost spaces.

Under-utilization and Waste: Most viaduct underpasses lack planning and design awareness and often remain underutilized or overgrown with weeds. Even those spaces with potential value are primarily used for recreational purposes and parking, often accompanied by basic landscaping. As urban service levels continue to improve, there is a growing demand for public service and management facilities on separate land plots. The under-utilization of viaduct underpasses results in the wastage of public land resources.

Lack of Comprehensive Planning: The fast development of urban movement infrastructures has created neglected places under viaducts, resulting in disorganized use and poor connectivity with the surrounding urban areas. Some spaces located in key spot locations viaduct underpasses receive only minimal landscaping and are enclosed by fences, thereby disrupting the visual coherence of the area. Additionally, a

significant portion of the viaduct underpass consists of extensive hard paving, leading to spontaneous and disorderly usage by dwellers, with insufficient regard for comprehensive planning and spatial design.

Lack of Management Oversight: Viaduct underpasses are not included in the planning system, which leads urban planners to automatically ignore the design of the beneath space when designing the viaduct. From the management point of view, viaduct underpasses belong to the municipal land, but the traditional urban planning system does not cover this place, and the lack of specialized control guidelines for the use of this space leads to its abandonment and idleness.

Unclear Properties rights: The utilization and management of the viaduct underpasses lack clarity, resulting in its frequent occupation by diverse units or private individuals. Consequently, this space becomes a safety oversight blind spot inside an impoverished environment.

Environmental issue: The viaduct underpass stands as one of the most heavily frequented urban domains by both pedestrians and vehicular traffic. Apart from the pervasive issues of vehicular noise and exhaust emissions, this subterranean zone typically serves as a focal point for numerous vendors engaged in commercial endeavors, resulting in challenges related to traffic conflicts and 266 environmental pollution.

3.2. Questionnaire results

Survey data show that most people who use the viaduct underpass are retirees or elderly people from the surrounding neighborhoods, with those older than 60 years old accounting for 44.7% and those aged 40-60 years old accounting for 31.82%, who use the viaduct underpass frequently and for an extended period and have a strong reliance on it. Furthermore, the survey (**Figure 7**) shows that the longer residents have lived here, the more willing they are to contribute to the development and maintenance of the viaduct underpass, whereas most of the residents who have lived here for less than two years expressed an unwillingness to contribute to the development of the viaduct underpass. As a result, the residents of the adjacent residential areas rely heavily on the government's allocation of management funds, posing challenges in their collective ability to contribute to the expenses associated with the upkeep of the viaduct underpass. According to the poll (**Figure 8**), the landscape objects beneath the viaduct that are most important to different types of users vary.

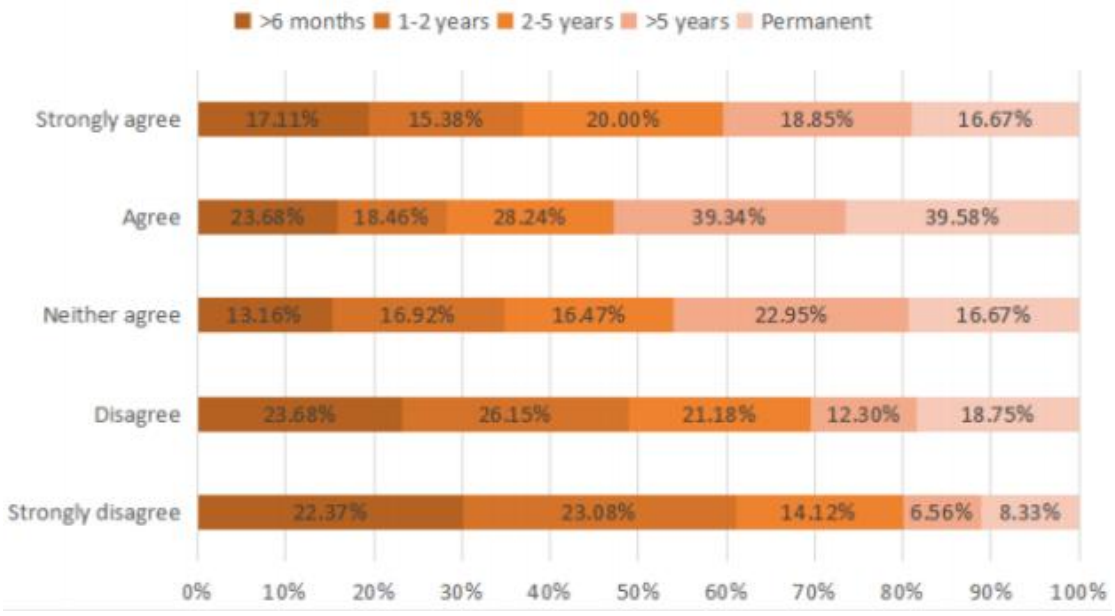

Figure 7. The overall willingness of different occupants to raise funds for the development and maintenance of the space under the viaduct

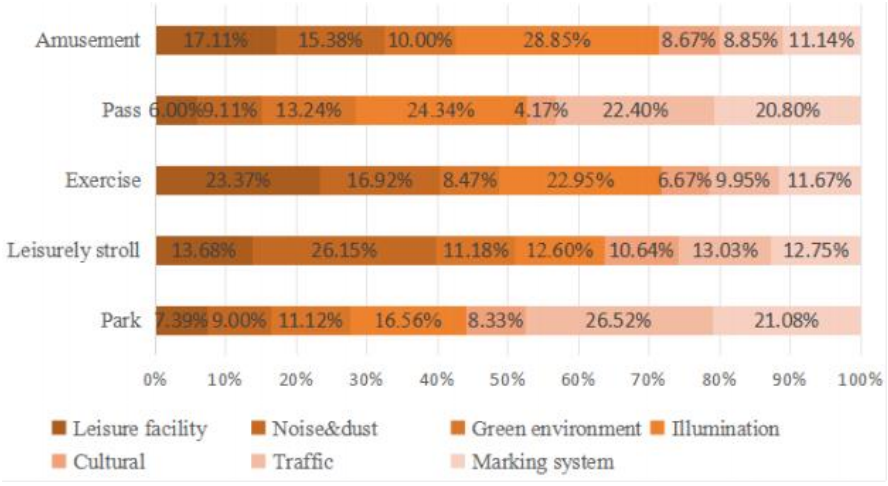

Figure 8. Statistical chart of items of most interest to users with different purposes

For example, parking users wanted improved signs and traffic conditions, whereas recreational walking users were more concerned about noise and dust in the viaduct underpass. In general, all users would like to see further improvements in lighting, traffic conditions, and signage infrastructure. The integration of necessary public service amenities, such as garbage bins, public toilets, bicycle parking lots, and tool rooms, within the landscape environment optimization of the viaduct underpass, is by the spatial layout, thus catering to the functional environment. Adapt to local conditions, set up spatial functions according to the urban spatial relationship of the viaduct as well as its location attributes, and improve the comprehensive utilization rate of the viaduct underpass while solving traffic problems. The primary purposes of users utilizing the viaduct underpasses are engaging in physical activity (34.39%), engaging in recreational activities (23.78%), taking leisurely walks (18.04%), utilizing parking facilities (14.25%), and traversing over the underpasses (9.54%). The study commenced by categorizing users into various age groups and identifying their respective purposes for utilizing the surveyed area. The findings revealed that users who primarily utilized the area for parking and fitness activities exhibited negative attitudes toward the implementation of edible landscapes. Among the various user groups, individuals falling within the age range of 40 to 60 years and those surpassing the age of 60 showed a favorable disposition towards the implementation of edible landscaping under the viaduct underpass (**Figure 9**).

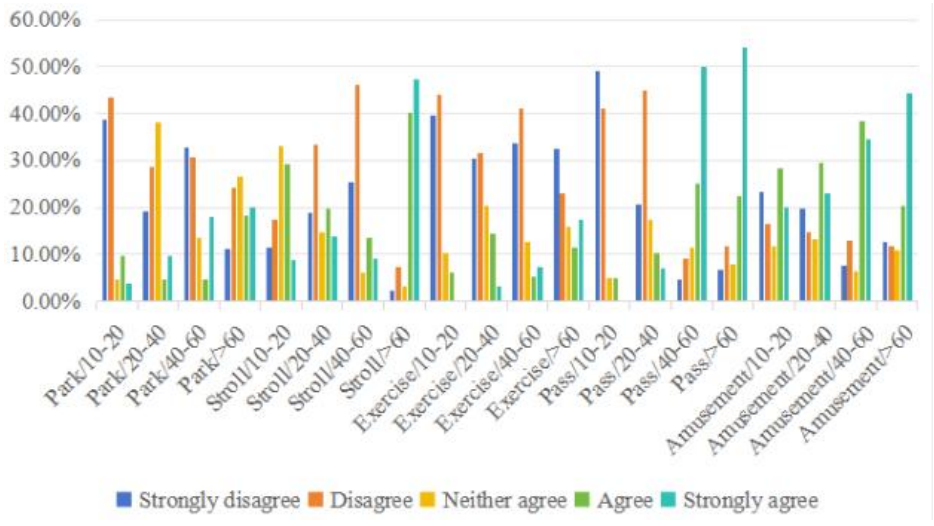

Figure 9. Perspectives of users of different age groups and for different purposes towards the development of edible landscapes in viaduct underpass

3.3. Discussion

3.3.1. Urban relations

According to the field survey and interview analysis, the urban relationship of the viaduct and the positional relationship with the road under the viaduct are two objective factors that affect the actual utilization effect. This paper presents a summary of external environmental factors that influence the utilization of the viaduct underpass in the Tianhe District. As indicated in (**Figure 10**), it is noteworthy that the utilization of reasonable viaduct underpasses accounts for only one-third of the total count. Most of these spaces are positioned within the urban nucleus, predominantly near commercial facilities and residential precincts, exemplified as the Liede Bridge or the Guangzhou Expressway-Zhongshan Avenue Medium intersection. Notably, twenty-two of the viaduct underpasses are located around residential and commercial areas with high pedestrian flow, and the space utilization pattern is mostly dominated by parking lots and simple greenery. The utilization of the viaduct underpass is unreasonable in most cases, and its spatial distribution and urban relations are more complex and diverse, but most of the viaducts are surrounded by industrial zones, warehousing land, or commercial and residential areas. The management of the viaduct underpass is more chaotic, and the utilization of the viaduct underpass does not match the actual demand (such as Guangzhou Bridge, Dongpu Special Bridge, Pazhou Bridge, etc.). In addition to a small part of the viaduct underpass in the periphery of the city, belonging to the city's rapid transit entrance, the use of the viaduct underpass is also subject to the constraints of the location. In the use of space to focus on the landscape green effect, part of the viaduct space under the large flow of people, but the use of a single form or is still in the state of undeveloped utilization, the use of its space and daily maintenance is lacking (such as the Guangyuan expressway - Chebei Avenue, Huanan expressway- Huangpu Avenue West, etc.).

External Environmental Factors Affecting the Utilization of Space under Viaducts in Tianhe District

Type	Position	Surrounding area functions			Visitor flow			Evaluation
		Residential/Commercial	Factory	Expressway	Low	Moderate	High	●reasonable ○unreasonable
River-cros	Liede Brg	●					●	●
sing	Guangzhou Brg	●					●	○
bridge	Hua'nan Brg		●			●		○
	Pazhou Brg	●				●		○
	Dongpu Brg		●		●			○
Viaduct	Guangzhou Expy-ZhongShan Blvd M	●					●	●
	GuangZhou Expy-Huangpu Blvd E	●		●	●			●
	Guangzhou Expy-Huanxi W Rd	●				●		○
	Keyun Rd -Linjiang Blvd	●		●		●		●
	Huanan Expy(JU)	●				●		○
	Huanan Expy(SCNU)	●				●		○
	Liede Blvd-Huangpu Blvd W	●					●	○
Off-ramp	Huanan Expy-Huacheng Blvd	●					●	○
	Keyun Rd-Tangxia Xisha 1 Ln	●				●		●
	Zhongshan Blvd Mid-Tianfu Rd	●		●			●	○
	Guangyuan Expy-Tianshou Rd	●		●		●		○
	Huangpu Blvd-Chebei S Rd	●		●		●		○
	Guangyuan Expy(train station)	●		●	●			○
	Liede Blvd-Linjiang Blvd	●		●			●	○
Overpass	Guangyuan Expy-Guangzhou Expy	●					●	●
	Huanan Expy Huangpu Blvd W	●					●	●
	GuangYuan Expy-Chebei Rd			●	●			○
	GuangYuan Expy-Keyun Rd			●	●			○
	Guangyuan Expy-Huanan Exp			●	●			○
	Keyun Rd-Huangpu Blvd Mid			●	●			○
	Zhongshan overpass	●					●	●
	Guangyuan Expy-Guangzhou blvd N	●				●		●
	Huanan Expy-Zhongshan blvdWs	●						○
	Guangyuan Expy-Yudong W Rd			●		●		●

Figure 10. External environmental factors affecting the utilization of space under the viaduct in Tianhe District

3.3.2. Relationship with roadways under the viaduct

By the spatial relationship between urban viaducts and under-viaduct roads, the primary spatial configuration forms in the Tianhe District can be classified into three categories: road central, single-sided road, and road-edge configurations (**Figure 11**). Most of the on-ramps in the Tianhe District are positioned in the central roadway, with bridge pillars erected within the green spaces beneath the viaducts. This configuration segregates the spaces under the viaduct due to the presence of roadways on either side, limiting pedestrian access and diminishing the usability of these spaces. Consequently, such areas are often designated for simple landscaping. Another configuration places the on-ramps on a single side of the road (e.g., Guangzhou Expressway- Huanxi West Road, Liede Avenue-Huangpu Avenue, and so forth), with bridge pillars situated between the motorized and non-motorized lanes. In non-motorized lanes, where vehicle speeds are lower and traffic pressure is reduced, these viaduct underpasses are more conducive to pedestrian access and utilization. Moreover, when roadways are near commercial and residential areas, a viaduct underpass can effectively compensate for the deficiency in nearby public activity spaces. These locations facilitate the permeation of pedestrian traffic into such areas, thereby providing indispensable real-world conditions for the utilization and development of viaduct underpasses. In conclusion, the roadway-edge layout is utilized for all five prominent river-crossing bridges located in the Tianhe District. Pedestrian walkways or recreational promenades are frequently integrated along the borders of urban roads, thereby significantly improving pedestrian accessibility to the regions of the viaduct underpass. In addition, it is worth noting that the spaces located beneath river-crossing bridges often possess larger physical dimensions in terms of length and width, which consequently present enhanced prospects for re-purposing and advancement.

The form of the viaduct and its relationship to the roadway underneath the bridge

Type	Position	Piers type			Urban spatial relations			Evaluation
								●reasonable
		Single-column	Double-column	Y-column	Road center	One side	Road edge	○unreasonable
River-cros	Liede Brg		●				●	●
sing	Guangzhou Brg		●				●	○
bridge	Hua'nan Brg		●				●	○
	Pazhou Brg		●				●	○
	Dongpu Brg		●				●	○
Viaduct	Guangzhou Expy-ZhongShan Blvd M		●				●	●
	GuangZhou Expy-Huangpu Blvd E		●		●			●
	Guangzhou Expy-Huanxi W Rd		●			●		○
	Keyun Rd -Linjiang Blvd		●		●			●
	Huanan Expy(JU)		●			●		○
	Huanan Expy(SCNU)		●			●		○
	Liede Blvd-Huangpu Blvd W		●			●		○
Off-ramp	Huanan Expy-Huacheng Blvd		●			●		○
	Keyun Rd-Tangxia Xisha 1 Ln		●			●		●
	Zhongshan Blvd Mid-Tianfu Rd		●		●			○
	Guangyuan Expy-Tianshou Rd		●		●			○
	Huangpu Blvd-Chebei S Rd		●		●			○
	Guangyuan Expy(train station)		●		●			○
	Liede Blvd-Linjiang Blvd		●		●			○
Overpass	Guangyuan Expy-Guangzhou Expy	●		●				●
	Huanan Expy-Huangpu Blvd W	●		●				●
	GuangYuan Expy-Chebei Rd	●		●				○
	GuangYuan Expy-Keyun Rd	●		●				○
	Guangyuan Expy-Huanan Exp	●		●				○
	Keyun Rd-Huangpu Blvd Mid	●		●				○
	Zhongshan overpass	●		●				●
	Guangyuan Expy-Guangzhou blvd N	●		●				●
	Huanan Expy-Zhongshan blvdWs	●		●				○
	Guangyuan Expy-Yudong W Rd	●		●				●

Figure 11. The form of the viaduct and its relationship to the roadway underneath the bridge

4. Recommendations

Based on the conducted field research about the current state and spatial arrangement of the utilization of viaduct underpasses in Tianhe District, it has been observed that the utilization of the studied spaces exhibits a significant correlation with its urban spatial relationship, the neighboring area's functional attributes, and the structural characteristics of the viaduct itself. Secondly, the questionnaire survey was used to understand the actual needs of the residents, and the purpose of this survey was to explore as much as possible the potential for the development of edible landscapes in the viaduct underpass. The authors' methods in addition to the traditional field surveys, questionnaires, and interviews, also attempt to obtain real insights of residents from experiential participation.

In general, the usage of underutilized areas beneath viaducts is a significant approach to enhancing the urban landscape, preserving the urban ecological environment, and effectively utilizing land resources. This study centers on the activation and optimization of the viaduct underpasses in Tianhe District, employing the concept of joint participation. It presents a design strategy encompassing ordering, sharing, and quality, and investigates the sustainable approach of repairing, activating, and utilizing the underutilized viaduct underpass through the implementation of an edible landscape.

In conclusion, the viaduct underpasses in Tianhe District exhibit a pronounced public character, while concurrently displaying notable attributes such as low utilization rate, inadequate administration, and absence of planning. Based on the field research, in conjunction with the regulations established by the pertinent planning departments in Guangzhou and the actual circumstances of the viaduct underpasses in Tianhe District, the subsequent ideas for revitalization are suggested:

4.1. Management system for strong interventions

Within the Tianhe District, there exist viaduct roads that are enclosed by fences, partitioning the viaduct underpass into numerous plots. Notably, the Huangpu Avenue - Zhongshan Road intersection serves as an example of this configuration. Regrettably, these divided plots, due to the presence of both the fences and the viaduct, remain consistently vacant. Based on the survey findings, the urban areas flanking the Huanan Expressway encompass a university district, a commercial area known as Pearl River New Town, a financial hub, and some residential areas. These areas exhibit a strong demand for public activities and need a well-established infrastructure viaduct underpass. Urban planners must implement effective intervention measures that target the removal of enclosed spaces and occupied areas, enhance the accessibility of the road beneath the viaduct, and integrate dedicated bicycle lanes and recreational walkways. The main goal is to create a useful area of the viaduct underpass that is prim, primarily facilitates leisurely pedestrian mobility, and fosters public interaction. Furthermore, the objective is to conceptualize the area of the viaduct underpass in a way that optimizes its potential for recreational purposes. The broad expanse of unutilized open space and public area situated beneath the bridge compensates for the deficiency of public service amenities in the adjacent communities and commercial zones, thereby catering to the recreational requirements of both retirees and local inhabitants residing in the proximate regions. It is recommended that city administrators adopt a cohesive approach to developing the viaduct underpasses through assertive intervention. For example, by leveraging the structural integration of three-dimensional agricultural landscapes, the aim is to transform the underutilized viaduct underpasses into an urban oasis that is visually accessible to the public. It is imperative to establish a comprehensive zoning and design framework for the viaduct underpass, accompanied by a robust regulatory mechanism to govern its utilization. The implementation of a top-down management approach would facilitate the integration of the operations of the three-dimensional farm

located viaduct underpass. This approach will also enhance the promotion and coordination of the involvement and utilization of the viaduct underpass by all stakeholders.

4.2. Creating an ecological green corridor

The available space beneath the large node viaduct region is substantial, and it is proposed to establish the community agricultural park in the viaduct underpass to cater to the activity requirements of the neighboring residents. Such as Liede Avenue - Huangpu Avenue West, Liede Bridge, and Guangzhou Bridge, along with other areas near urban business offices and residential functions, the surrounding residents of the activities the demand is strong. Currently, the space under these viaducts is covered with hard paving and remains unused. When considering planning strategies, it is beneficial to prioritize landscape and functional improvements. This can be achieved through the implementation of sound insulation and the utilization of sound-absorbing panels to construct a three-dimensional planting wall.

Additionally, the integration of a semi-automated three-dimensional agricultural landscape within the viaduct underpass can be explored. This approach not only enhances the visual appeal but also optimizes plant lighting conditions while effectively utilizing rainwater resources. The stereoscopic agricultural landscape wall is designed to showcase the harmonious coexistence between humans and nature. It takes into consideration various factors such as sound insulation, dust control, ecology, greening, and safety protection in the viaduct underpasses. The aim is to minimize intervention and promote low-impact development in this area. Additionally, a semi-automated three-dimensional agricultural landscape is implemented on both sides of the viaduct underpass. This serves as a natural green barrier to ensure the safety of pedestrian and public activity areas. Simultaneously, it enhances the overall greening of the viaduct underpass, thereby improving its aesthetic quality and coherence (**Figure 12**). The linear viaduct underpass serves as a three-dimensional edible landscape, contributing to the establishment of an efficient greening and cooling system. Additionally, it acts as a barrier against traffic pollution, integrating traffic roads and green spaces to create a network of urban ecological spaces.

Figure 12. Map of space revitalization strategy under the viaduct in Tianhe District

4.3. Well-equipped service facilities

At the same time, within the realm of urban planning, the area of the viaduct underpass should be incorporated as part of urban space planning. The accessibility and demand of the viaduct underpass must be fully considered in the design of the viaduct. To cater to the demands of public leisure activities, entertainment, sports and fitness facilities, and rest areas, it is possible to incorporate suitable activity sites in the viaduct underpass. These sites serve not only as spaces for short-term relaxation and enjoyment but also as venues for fostering communication and interaction among users. In addition, it is imperative to consider the lighting infrastructure and signage system within the viaduct underpass to adequately address the safety requirements associated with nocturnal crossing

4.4. Encouraging stakeholder engagement

The relevant stakeholders of the community agricultural park in the viaduct underpass involve the city management and planning departments, urban residents, and tourists. The management department concerned may consider implementing a top-down management approach to incentivize stakeholders to proactively adopt the park and actively engage in the creation of a highly efficient, well-managed, and sustainable environment for the viaduct underpass. The implementation of community agriculture in the viaduct underpass involves the utilization of semi-automated 3D devices to facilitate the production, processing, transportation, assignment, edible, and disposal of food. This integrated approach creates a self-contained local food system that optimizes the utilization of the available viaduct underpasses. Moreover, it addresses the food supply requirements of the nearby residents while also promoting social interaction and recreational activities. It is important to note that the successful realization of this endeavor relies heavily on the active involvement of both the residents and city administrators.

5. Conclusions

The findings of this study contribute to a better understanding of the potential utilization of viaduct underpasses in the case study. The literature analyzed supports the argument that rapid urbanization contributes largely to the lost space of viaduct underpasses. Although the study area the presence of viaducts has increased connectivity and mobility for urban dwellers, the presence of leftover space has also contributed to the discontinuity of urban space. The leftover space of the viaduct underpass is small, irregular, and closed, presenting a fragmented, dysfunctional, and underutilized lost space. In addition to this, the emergence of lost spaces in the viaduct underpass confirms the problems related to urban management, resulting in closed and inaccessible. The urban fabric and its spaces should be seen as a well and efficiently functioning system.

Therefore, landscape architects, urban planners, and corresponding management authorities should consider proactive measures to address the challenges of the existence of lost spaces in cities from different perspectives. The existence of lost spaces in the study area should be seen as an opportunity to re-imagine and revitalize the city by transforming them into public spaces that support human outdoor activities through landscape design means. The approach of intervening through edible landscapes seems feasible as an effective measure to activate unused spaces, transforming lost spaces of viaduct underpasses into places with a sense of belonging and vitality. Suggestions for future research could include long-term observations of specific sites, along with feedback and suggestions from residents and the surrounding area, to extend the value of the research and provide more comprehensive strategic recommendations.

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