Research on the usability of space beneath urban overpasses: a case study of Shanghai

Feifei Song, https://orcid.org/0009-0007-0165-5139 ffsong@design.ecnu.edu.cn
Zhi Ma, https://orcid.org/0009-0006-1481-1754 2493558862@qq.com
Lijing Zhu, https://orcid.org/0009-0002-2026-4575 1458356409@qq.com
School of Design, East China Normal University, Shanghai, China

Abstract. This study examines the usability of spaces beneath overpasses in Shanghai, focusing on three sites along the Suzhou River. Using a mixed-method approach combining comparative case analysis and survey data, the research highlights the transformative potential of these underutilised urban spaces. Findings reveal that central sites with professional design interventions exhibit higher adaptability and public engagement, while peripheral sites face challenges from fragmented development. The study underscores the need for context-sensitive, community-focused strategies to integrate underpass spaces into the urban fabric, enhancing connectivity, social inclusion, and liveability.

Keywords: Beneath the overpass; Usability; Leftover space; Shanghai.

Introduction

The dynamic transformation of urban landscapes has brought renewed attention to the potential of underutilised spaces, particularly the areas beneath overpass, which often embody the tension between neglect and opportunity. In cities like Shanghai, where density and spatial constraints are pronounced, these leftover spaces present unique challenges and opportunities for adaptive reuse and urban renewal. Recent studies have highlighted the potential of these spaces to contribute to urban resilience, community engagement, and sustainable development by reimagining them as vibrant public spaces rather than overlooked voids (Covatta and Ikalović, 2022). By examining global and local strategies for repurposing these spaces, such as incorporating play areas, green corridors, and social hubs, researchers have underscored their value in addressing the evolving needs of urban environments, while enhancing the quality of life for residents (Aytac *et al*., 2016; Xia *et al*., 2024). This paper explores the usability of space beneath urban overpasses in Shanghai, shedding light on how innovative design and planning can unlock their potential as integral components of the city's fabric.

A crucial challenge in urban planning and architecture is the leftover space in contemporary cities. These places are discontinued in use, were disregarded during development, or have become outdated because of several urban processes (Tian, 2024). The space beneath overpasses, often seen as "leftover" or "negative", has been a focus of urban planning and architecture. These areas hold great potential for transformation into valuable public or semi-public spaces. As cities like Shanghai face rapid growth and aim for sustainable development, interest in utilising these spaces has grown. Shanghai`s rapid riverfront transformation aims to boost liveability and connectivity, yet the spaces beneath its overpasses remain underused.

As part of the Shanghai urban river planning scheme, the Suzhou River traverses the city's central district, extending to approximately 53 kilometres. To enhance road system connectivity between the river's north and south banks, numerous bridges and secondary roads have been added to the existing elevated highways and major traffic corridors, creating multi-scalar spaces beneath overpasses. While these infrastructural interventions have improved transportation efficiency along the Suzhou River, they have simultaneously generated numerous underutilised spaces beneath waterfront viaducts. These interstitial spaces, extending from the city centre to suburban areas, potentially serve as critical connectors between diverse urban environments, including public waterfront green spaces, residential zones, commercial districts, and recreational areas. However, the predominantly low-clearance nature of these overpass-adjacent spaces has largely resulted in their suboptimal utilisation, presenting a significant urban design challenge that deserves comprehensive investigation.

This paper aims to contribute to the discourse with the main research question: Can the areas located along Suzhou Creek and beneath the overpasses support urban regeneration and social inclusion? What strategies can transform these neglected spaces into valuable assets? Some urban planners advocate reclaiming the space beneath overpasses for parks, markets, or cultural use, promoting social equity and sustainability. Critics argue that noise, pollution, and poor lighting make repurposing these areas costly and potentially impractical. Shanghai's riverfront offers a valuable case study in navigating these challenges. The case study employs a mixed-method approach, integrating comparative case analysis and questionnaire surveys to comprehensively evaluate the repurposing of leftover spaces beneath urban overpasses. By triangulating perspectives from design professionals, municipal planners, and end-users, this methodological framework enables a nuanced examination of spatial reutilisation strategies. It captures the complex interplay between professional urban design intentions and actual spatial appropriation, exploring how these spaces might be reimagined as productive urban interfaces that mediate between transportation infrastructure and urban life.

Materials and Methods

Study Area

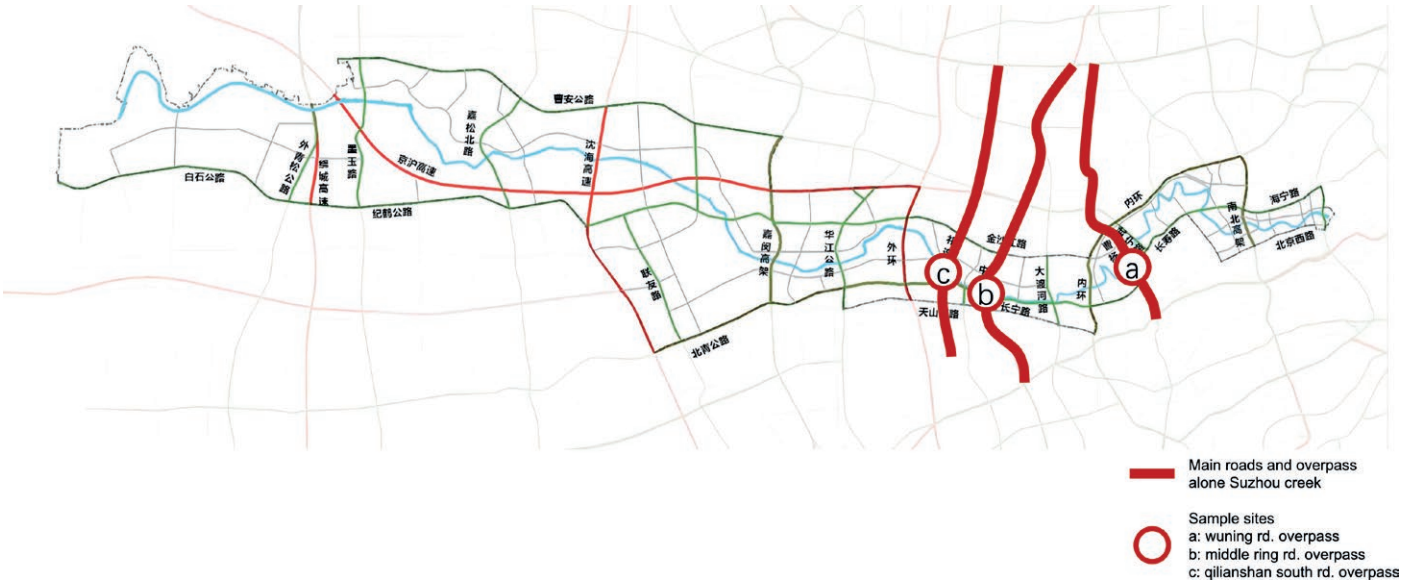
Shanghai (31°14′ N, 121°29′ E), strategically positioned in the Yangtze River Delta region of eastern China. Characterised by its unique geographical configuration, the city encompasses a complex urban landscape where natural water systems and infrastructural networks intersect critically. The Suzhou River, a pivotal hydrological feature, traverses the urban fabric, serving as a key morphological and ecological corridor that has profoundly shaped the city's spatial development. The Suzhou River's urban section demonstrates a paradigmatic case of infrastructure-induced spatial complex-

ISSN online: 2239-0243 | © 2025 Firenze University Press | http://www.fupress.com/techne
DOI: 10.36253/techne-16945

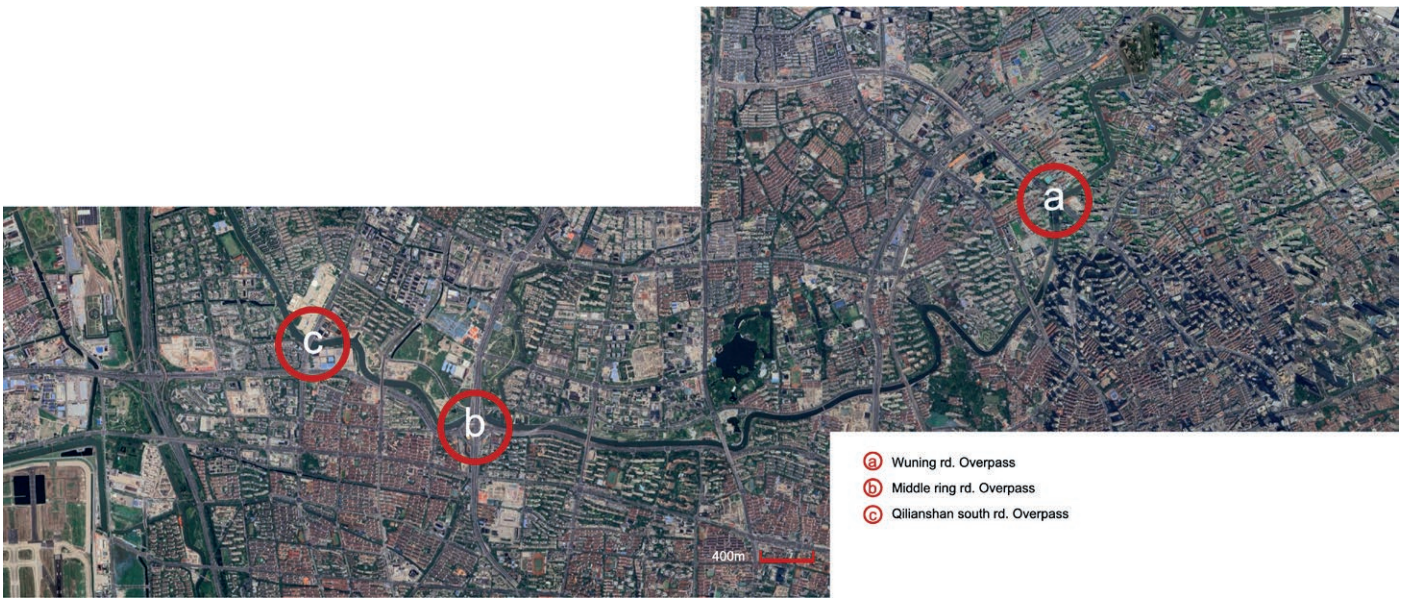
01 | Three study sample sites along the Suzhou Creek, Suzhou River waterfront area construction plan, edited by the author

02 | Detailed site map of study areas, drawing by the author

01 |



02 |



ity, where multiple transportation modes – elevated highways, secondary roads, and riverbank pathways – generate a multi-layered urban landscape of interstitial spaces beneath transportation infrastructure (Fig. 1). These spatially ambiguous zones beneath overpasses represent a critical research domain, highlighting the tension between infrastructural efficiency and spatial potential in contemporary urban design practices.

This research deliberately selected three specific urban sites located beneath overpasses along the municipal section of the Suzhou River as research samples (Fig. 2). These sites were strategically chosen to represent diverse urban contexts and infrastructural relationships:

– Site A, located within Shanghai's central urban area and inside the Inner Ring Elevated Highway, presents a complex, multi-functional context. Characterised by high accessibility and proximity to diverse urban programmes including residential, commercial, and office spaces, this site exemplifies the most intensively networked urban fabric.

– Site B, positioned underneath the Middle Ring Elevated Highway, represents a transitional urban zone. Currently under development, its surrounding environment is predominantly composed of office complexes, public facilities, and urban riverfront parks. The site demonstrates a comprehensive and evolving urban landscape with mixed functional attributes.
– Site C, situated in the city's peripheral urban area near the Outer Ring Elevated Highway, distinctly differs from the other two. Primarily surrounded by residential districts, this site exhibits strong community-oriented characteristics and a more localised spatial identity.

These sites were selected not merely for their geographical diversity but for their distinctly different developmental trajectories:

– Site A, located beneath the Wuning Road Interchange, was designed by a relatively prominent architectural design team. It has garnered significant online visibility and experienced multiple cycles of business closures and reconstructions, particularly around the pandemic period.
– Site C, conceived as a public space and community station extending from a residential neighbourhood, emerged through a design competition. Despite undergoing a transformation process, it has struggled with both utilisation and broader public engagement.
– Site B is an emergent urban space, partially developed by individual property owners without a comprehensive design or planning strategy, highlighting the incremental and fragmented nature of urban infrastructure development.

By examining these three sites, the research aims to unpack the complex spatial, functional, and developmental nuances of urban spaces beneath elevated infrastructure, offering insights into their potential for adaptive reuse and urban regeneration.

Methodology

The methodology for this research encompasses two primary analytical approaches, namely comparative case analysis and quantitative survey research, designed to comprehensively investigate the usability of spaces beneath urban overpasses in Shanghai. As mentioned in the previous section, the comparative case analysis focused on examining the daily spatial utilisation of three research sites under the guidance of design professionals, planning departments, and client-driven transformation strategies. This approach employed a multifaceted analytical framework involving:

– Spatial Typology Comparison: A systematic examination of spatial configurations across the selected sites.
– In-depth Interviews: Qualitative insights gathered from key stakeholders involved in the design and transformation processes.
– Social Media Effect Analysis: Evaluating online visibility and public perception through digital media and communication platforms.
– The questionnaire design was meticulously crafted, drawing directly from the specific contextual characteristics of the three research sites. The survey instrument was specifically structured to:
– Assess Users' Spatial Perception: Capture respondents' subjective experiences and interpretations of spaces beneath urban overpasses.
– Measure Satisfaction Levels: Quantify user satisfaction through carefully constructed evaluation metrics.

Questionnaire survey data were processed and analysed using SPSS software (Version 27.0), employing rigorous statistical techniques to evaluate date reliability, conduct validity assessments, and generate statistically robust insights into spatial usability.

Results and Discussions

Comparative case analysis

Through comprehensive field investigations and research, we systematically collected primary site spatial information for the three research sites, including green space area, overpass coverage, structural height, and surrounding functional distributions (Tab. 1). Our analysis revealed nuanced spatial characteristics and transformation dynamics across different urban contexts.

Spatial distribution and infrastructure characteristics:

Our findings demonstrate a significant correlation between urban peripherality and infrastructural density. As one moves from the city centre towards suburban areas, overpass coverage and green space areas progressively increase. Notably, the Wuning Road Bridge underspace (Site A) is the most compact urban setting, with approximately 240 square metres of area and limited adjacent green spaces. Conversely, this site exhibits the most diverse and concentrated commercial ecosystem.

Transformation Trajectories and Functional Adaptations:

The comparative analysis of site transformations (Fig. 3) unveils distinctive evolutionary patterns:

Site A (Wuning Road Interchange)

– Experienced the most frequent design iterations and reconstruction cycles
– During the Covid-19 pandemic, remarkably repurposed as a temporary rest area for delivery workers and essential service personnel
– Demonstrated significant social equity value through adaptive reuse
– Characterised by high design flexibility and commercial potential

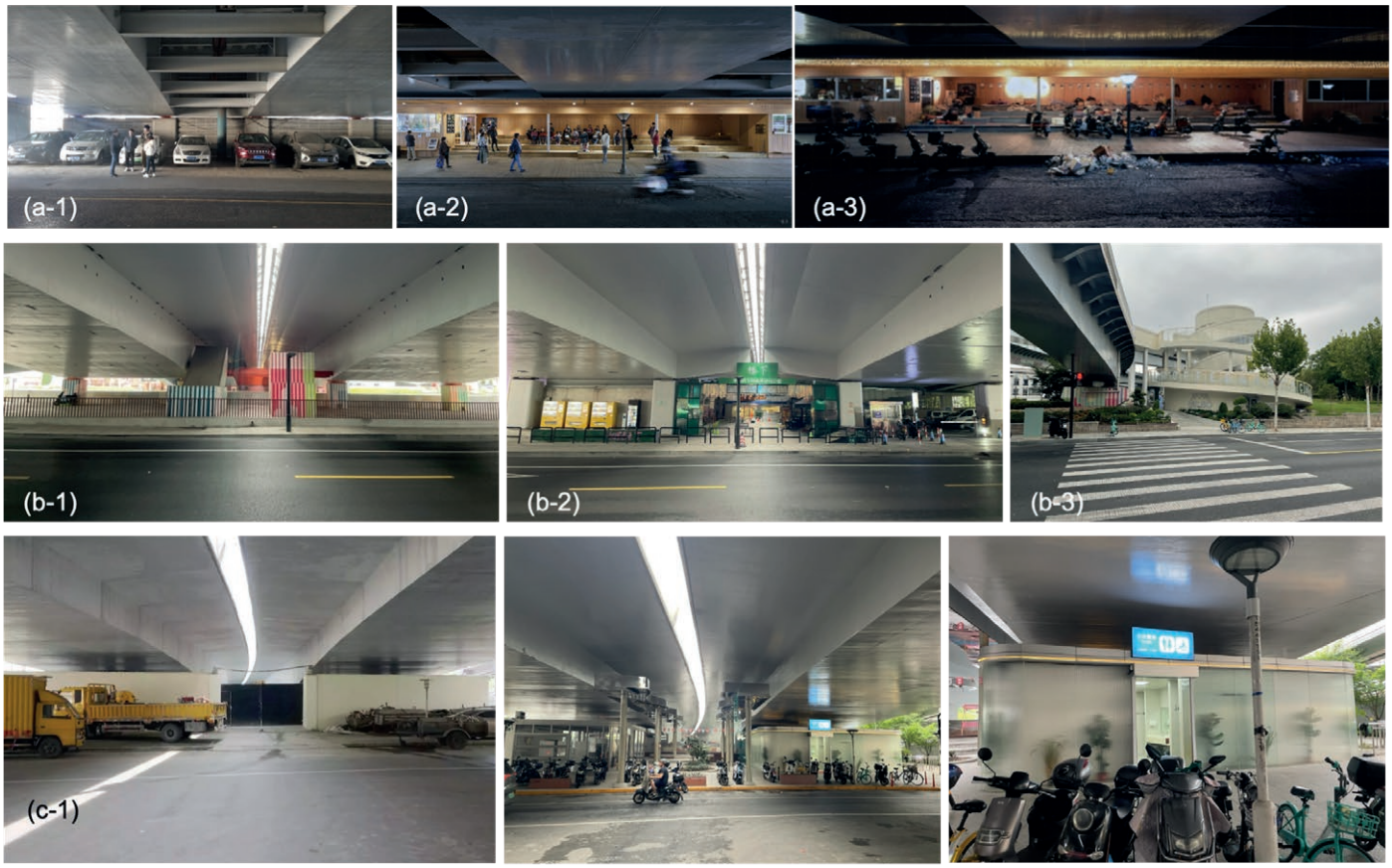
Tab. 01 | Detailed site map of study areas, drawing by the author

03 | Three research sites, a-1: Wuning rd. before renovation, a-2: after renovation, a-3: during the pandemic (2022 April); b-1: Middle ring rd. current situation, b-2/3: partially developed by individual property owners; c-1: Qilianshan south rd. before renovation, c-2/3: after renovation, a2/3 by Atelier Z+, edited by the author

Tab. 01 |

Object of study	Green space Renewal state	Main function	Green area(m')	Covered area of flyover (m')	Flyover height(m)	Surrounding environment
(a) Wuning Road Bridge riverside space	update completed	Entertainment and access	485	238.7	5	Although the traffic volume of Guangfu West Road passing through the bridge is not large, the noise in the bridge is not small, and the busy traffic flow of Wuning Road on the bridge brings a sense of vibration from time to time
(b) Middle ring road riverside space	updating	Entertainment and access	35000	2100	8-10	The vicinity of the node is dominated by residential functions,and the area is densely populated,which is a typical high-density community
(c) Qilianshan south Road Bridge riverside space	update completed	Entertainment and access	11600	6000	4	The neighbourhood is dominated by factories, Creative parks and residential areas

03 |



Site C (Peripheral Urban Area)

- Underwent a single design competition guided by Shanghai Urban Public Space Design Promotion Centre
- Developed as a community-service oriented station
- Incorporated limited functional elements such as calligraphy classrooms and public restrooms
- Currently experiencing substantial underutilisation, predominantly used for non-motorised vehicle parking
- Minimal interaction with surrounding community infrastructure.

Site B (Transitional Urban Zone)

- Lacks formal design intervention from professional planners
- Characterised by spontaneous private-sector development
- Emergent spaces including night cafés, clubs, and light extreme sports facilities
- Limited engagement with immediate neighbourhood users.

The comparative analysis reveals that Site A's central location, combined with its diverse commercial context, significantly reduces transformation complexity. Its adaptive capacity suggests potential for intensive, commercially-oriented functional attributes.

Tab. 02 | Basic information statistics of the samples, drawing by the author

Item	Category	Percent%		
		Middle Ring Overpass	Wuning Road and Bridge	Qilianshan south Road Bridge
Gender	Male	57.00	57.53	62.50
	Female	43.00	42.47	37.50
Age	<age 18	3.70	6.84	3.40
	Age 18-30	43.20	34.24	38.63
	Age 31-60	48.14	57.53	54.54
	>age 60	4.96	1.39	3.43
Identity	Adjoining resident	35.18	31.50	28.40
	Nearby employee	28.39	26.02	42.04
	Tourist	25.92	31.50	17.04
	Nearby business	10.51	10.98	12.88
Degree of familiarity	know well	29.01	24.65	25.00
	Know better	41.97	32.87	38.63
	ordinary	16.66	26.02	27.27
	Less familiar	8.02	6.84	4.54
	Very unfamiliar	4.34	9.62	4.56

Sites B and C, in contrast, demonstrate more challenging spatial transformation processes, characterised by either fragmented private initiatives or limited public engagement.
These findings underscore the complex interplay between urban infrastructure, spatial design, and socio-economic dynamics in reimagining underutilised urban spaces beneath overpasses.

Survey with Questionnaire
The data collection for this research was conducted over the period of November-December 2024, covering both weekdays and weekends. Electronic questionnaires were randomly distributed within the three overpass spaces and their surrounding communities, resulting in a total of 323 valid responses (Tab. 2): 162 from the Middle Ring Overpass along the Suzhou River, 88 from the Qilianshan South Road Bridge, and 73 from the Wuning Road Bridge. The questionnaires were filled out and collected under the guidance of the research team, ensuring a 100% effective response rate.
The age distribution of participants revealed a balanced representation of young and middle-aged groups, with the majority falling within the 26 to 40 years old range. However, the participation of those under 18 and over 60 was relatively low, at 4.33% and 3.72% respectively, indicating a need to better engage these age segments.
Adjoining residents and nearby employees accounted for the highest proportions of respondents, suggesting a strong interest in the research topic from these groups. While the percentage of visitors and tourists was lower than the previous two categories, they still represented a significant portion of the sample. Conversely, the proportion of on-site business owners was the lowest, potentially indicating a relatively lower level of engagement or concern about the research issue among this stakeholder group.
The analysis of respondents' familiarity with the research case revealed a notable distribution pattern. Approximately 66% of participants reported being "very familiar" or "fairly familiar" with the case, suggesting a general understanding and awareness among the sample. However, 28.38% of respondents indicated being "moderately familiar" or "slightly unfamiliar", and 5.57% even expressed being "very unfamiliar". This highlights the existence of knowledge gaps within the respondent pool, which should be considered in the interpretation of the research findings.
The data collected through the questionnaires was analysed using SPSS software (version 27.0) to assess its reliability and validity. The overall Cronbach's alpha for the scale was 0.983, which is considered a high level of reliability (coefficients of 0.70 or higher are generally regarded as indicating high reliability). All the latent variables in the scale also had coefficients above 0.7, indicating good internal consistency. Furthermore, the Kaiser-Meyer-Olkin (KMO) value was 0.990, which is greater than the recommended threshold of 0.7, and the Bartlett's test of sphericity showed statistical significance. These results indicate that the structure of the perception measurement scale is consistent with the theoretical assumptions underlying the questionnaire, validating the feasibility of the analysis.
Referring to relevant literature on recreational environments and drawing from the experiences of comprehensive parks and community parks, a preliminary investigation was conducted on three research sites located beneath overpasses. Using an Internet platform, 100 visitors and residents were randomly selected to share their recreational experiences and evaluations. The purposes of recreation, key environmental factors of concern, complaints about green space conditions, and expectations for improvement were identified from their feedback. Combining the characteristics of recreational environments and visitors' activity patterns, a preliminary evaluation system for visitors' perceptions of underpass green spaces was developed.
Factors mentioned fewer than 20 times by participants – such as the aesthetic appeal of pavement and water features, the distance to nearby sales points, air quality, and ergonomics – were excluded. While ensuring the evaluation system reflected the core environmental characteristics of green spaces under overpasses, revisions and integrations were carried out. Ultimately, the visitor perception evaluation form was structured around five perception dimensions, comprising 30 environmental perception factors.
The questionnaire consisted of two parts, precisely the characteristics of the sample group and the visitor perception evaluation form. The latter asked visitors to assess whether the actual performance of a specific environmental perception factor met their expectations during their recreational experience. A 7-point Likert scale, ranging from 1 ("very poor") to 7 ("very good"), was used as the scoring standard to capture visitors' evaluations of the actual performance of these perception factors (Tab. 3).

Discussions
The findings of this study highlight the complex interplay between infrastructural design, urban context, and the evolving

Tab. 03 | Visitors' perception measurement table of spaces beneath the overpasses along Suzhou creek in Shanghai, drawing by the author

Tab. 03 |

	Dimension classification environmental perception dimension serial number		Environmental perception factors
Accessibility	Path organization perception	3	Complete continuous walking space
		4	Guide motor vehicle deceleration
		6	Visibility and convenience of entrances and exits
	Safety and security perception	7	pilot system
			Risk buildings or structures and facilities
		8	disaster prevention facilities
			monitoring system
		17	Night lighting condition
	Aesthetic perception	22	Coordination with the surrounding environment
		15	Space openness
		18	Artistry of public facilities
		19	Vegetation viewing
Usability	Physical environment perception	1	Green space noise under bridge
		2	Overpasses cover shaded areas
			Suitable for aging and transformation
		11	wheelchair accessible passage
		12	Such as garbage cans,toilets and other public facilities are complete
			Whether the green space is smooth and undamaged
		14	Shelter from the wind and rain
		16	Whether the floor material is suitable
		20	Distribution and quantity of leisure facilities
	Activity and cultural perception	21	Whether the activity facilities are adequate

needs of urban residents. By examining three underpass sites along the Suzhou River in Shanghai, the research provides valuable insights into the usability and transformation potential of these underutilised urban spaces.

The comparative analysis of the three sites underscores the significance of urban location and development strategies in shaping the spatial utilisation of underpass areas. Site A, situated in the central urban zone, demonstrated high accessibility and commercial adaptability, driven by its proximity to a dense urban fabric and robust design interventions. Its multifunctional transformation during the Covid-19 pandemic illustrates the potential of underpass spaces to address urgent social needs while promoting equitable urban development. In contrast, Site B and Site C, located in transitional and peripheral urban zones, respectively, reflect fragmented and incremental development patterns, resulting in limited functional diversity and public engagement. These disparities indicate that centralised, coordinated planning plays a crucial role in unlocking the potential of underpass spaces. Urban residual spaces, when viewed through a solutions-oriented lens, can resolve site-specific challenges by creatively addressing functional deficits. Such spaces, if strategically planned, have the potential to mitigate urban problems and enhance spatial connectivity (Ayudya and Anggiani, 2021). The questionnaire survey revealed significant variations in user satisfaction across the three sites, influenced by factors such as location, accessibility, and the alignment of design features with user expectations. Site A, with its well integrated design and commercial amenities, garnered relatively higher satisfaction levels, reflecting the importance of aligning spatial transformations with the needs of diverse user groups. Conversely, Site C, despite being conceived as a community-oriented space, struggled with underutilisation and a lack of broader public appeal. This disparity highlights the need for participatory design processes that incorporate the perspectives of local residents and potential users to ensure the success of underpass revitalisation projects.

This study demonstrates that underpass spaces can serve as critical connectors in the urban landscape, linking residential, commercial, and recreational areas. However, their transformation requires a nuanced approach that balances infrastructural efficiency with community-oriented design. While Site A illustrates the benefits of professional design and iterative development, Sites B and C highlight the risks of fragmented, ad hoc planning approaches. These findings suggest that adaptive reuse of underpass spaces must be guided by a comprehensive urban design strategy that considers the unique characteristics of each site and engages multiple stakeholders in the planning process.

In response to the above conclusions, this study selected three cases of urban overpass space revitalisation outside Shanghai (Fig. 4), located in New York (a), Istanbul (b1/2), and Seoul (c1/2). These three projects are highly representative. Project A, located in the heart of Manhattan, New York, is situated directly beneath the famous High Line Park, surrounded by a vibrant creative and artistic industry cluster. This project capitalises on the concentration of resources and demand in the central urban area by designing a gallery within the underpass space, which not only activates the space but also integrates and interacts with the surrounding industries. Project B is located in the busy Mecidiyekoy Square area of Istanbul, and the development of the square is part of the Istanbul Metropolitan Municipality's plan to renovate the area and create a better physical environment enriched with contemporary art. Therefore, the project follows an urban design strategy, featuring a bookshop and ex-

04 | Comparative analysis of cases outside the Shanghai area, a: LISSON GALLERY, New York, USA, 2016, designed by studio MDA and studio christian wassmann, photos by Jason Schmidt.
b-1/2: Mecidiyekoy Art & Istanbul Bookstore, Istanbul, Turkey, 2021, designed by KAAT ARCHITETURE + URBAN & caps.office, photos by Orhun Ulgen Works.
c-1/2: Eungbong terrace, Seoul, South Korea, 2023, designed by YZA, photos by kyungsub shin, edited by the author

hibition space beneath the overpass. The transparent glass façade offers visual permeability to the otherwise dark underpass space during the day, while lighting design activates the area at night, providing a pleasant urban retreat for the busy crowds. Project C shares many similarities with Site C mentioned earlier. Located in a high density residential area in Seoul, it serves as a community-oriented space. The design also incorporates reflective metal materials and better considers the needs of nearby residents for small-scale gathering, activities, and relaxation. The open design elements offer a space that connects well with the surrounding community, functions as a recognisable landmark, and provides a space for rest and leisure.

Conclusion

This research provides a robust framework for understanding the potential of underutilised spaces beneath the overpasses in Shanghai, offering critical insights into their role in urban regeneration and social inclusion. The study's mixed-method approach, combining comparative case analysis and quantitative surveys, underscores the value of integrating professional design perspectives with user feedback to inform spatial transformation strategies. Key findings reveal that centrally located underpass spaces, such as Site A, demonstrate higher adaptability and public value when supported by comprehensive design interventions. In contrast, spaces in transitional and peripheral areas, like Sites B and C, face challenges stemming from fragmented development and limited user engagement. These results emphasise the importance of context-sensitive design approaches that prioritise connectivity, environmental quality, and community needs.

In conclusion, this study offers a valuable contribution to the discourse on adaptive reuse of urban spaces, providing actionable insights for planners, designers, and policymakers. It demonstrates that with innovative design, strategic planning, and community involvement, even the most overlooked urban spaces can become integral components of a city's fabric, enhancing liveability and connectivity for residents across all demographics. Future research should further explore the long-term impacts of such transformations, and expand the scope to include comparative studies across different cultural and urban contexts.

REFERENCES

Aytac, D.O., Arslan, T.V. and Durak, S. (2016), "Adaptive reuse as a strategy toward urban resilience", *European Journal of Sustainable Development*, Vol. 5. Available at: https://doi.org/10.14207/ejsd.2016.v5n4p523 (Accessed on 03/04/2025).

Ayudya, D. and Anggiani, M. (2021), "Study on urban residual space as solutions review for area problems", *Sinergi*, Vol. 25, No. 245. Available at: https://doi.org/10.22441/sinergi.2021.3.002 (Accessed on 03/04/2025).

Covatta, A. and Ikalović, V. (2022), "Urban resilience: A study of leftover spaces and play in dense city fabric", *Sustainability*, Vol. 14. Available at: https://ideas.repec.org/a/gam/jsusta/v14y2022i20p13514-d947191.html (Accessed on 03/04/2025).

Tian, Y. (2024), "Evaluation of the literature on the use of space underneath elevated highways in urban leftover space renewal", *American Journal of Art and Design*, Vol. 9, pp. 24–30. Available at: https://doi.org/10.11648/j.ajad.20240902.11 (Accessed on 03/04/2025).

Xia, J., Zhao, Z., Chen, L. and Sun, Y. (2024), "How urban renewal affects the sustainable development of public spaces: Trends, challenges, and opportunities", *Frontiers in Environmental Science*, Vol. 12. Available at: https://doi.org/10.3389/fenvs.2024.1482169 (Accessed on 03/04/2025).