



Digital Spatial Analysis of Non-Protected Historic Guild Halls in Beijing under the Historic Urban Landscape Framework

Yifan Yang, Jingyi Zhang*

School of Architecture and Urban Planning, Beijing University of Civil Engineering and Architecture, Beijing 100044, China

*210813j123005@stu.bucea.edu.cn

Abstract. Rapid urbanization has accelerated the transformation of historic urban environments, creating new challenges for cultural heritage research and urban design. In Beijing, many historic guild halls from the Ming and Qing dynasties remain outside official cultural relic protection despite their important role in the city's historical social and spatial structure. Their collective spatial characteristics and socio-spatial relationships have received limited attention in existing studies. This study investigates the spatial distribution of non-protected guild halls in Beijing's outer city under the Historic Urban Landscape (HUL) framework. Rather than treating guild halls as isolated architectural objects, the study interprets them as spatial nodes embedded within historical migration networks, urban functions, and layered urban development. To support this analysis, the research applies GIS-based spatial analysis and visualization methods to examine historical urban layering at the building scale. The results reveal significant clustering patterns associated with guild hall scale, functional type, and provincial origin. These patterns reflect how migrant social networks, urban functions, political regulations, and historical development jointly shaped the spatial organization of Beijing's outer city. The findings further demonstrate that combining the HUL framework with GIS-based spatial analysis can reveal hidden socio-spatial relationships among dispersed everyday heritage sites. The study also suggests several implications for heritage-informed urban renewal and spatial design. Preservation strategies may consider maintaining the spatial clustering of small-scale guild halls around larger ones and using spatial mapping to connect same-origin guild halls into cultural routes. This research expands the understanding of non-protected guild halls within urban heritage studies and demonstrates the potential of integrating HUL theory with GIS-based spatial analysis for the interpretation of historical urban space.

Keywords: Historic Urban Landscape; GIS; guild halls; cultural heritage; urban spatial design.

1 Introduction

Rapid urbanization has accelerated the transformation of historic urban environments and created increasing challenges for cultural heritage research and urban design. In response to these issues, UNESCO introduced the Historic Urban Landscape (HUL) approach in 2011 [1]. The HUL framework emphasizes the broader urban context, historical layering, and the relationships between heritage, communities, and urban life. At the same time, digital technologies have significantly transformed historical urban studies. Geographic Information Systems (GIS), spatial visualization, and digital heritage methods are now widely used to analyze historical urban morphology and spatial evolution.

A core concept of the HUL framework is historical layering, which refers to overlapping spatial characteristics formed through long-term social, cultural, political, and economic transformations. The distribution and interaction of specific building types are important components of these historical layers. Beijing provides a representative case because of its complex urban history and rich architectural heritage. Among these heritage resources, guild halls established by migrants from the same provinces during the Ming and Qing dynasties played an important role in shaping the city's social and spatial structure. Their spatial distribution reflects the interaction between migration networks, urban functions, political regulations, and regional economic activities [2]. These guild halls therefore became important material carriers of Beijing's historical urban layering.

However, current heritage research and digital spatial analysis mainly focus on officially protected monuments and historic districts. Many non-protected guild halls in Beijing remain understudied despite their historical importance within urban commercial and social networks. These non-protected guild halls belong to a category of small cultural heritage sites (SCHSs) characterized by scattered distribution and limited preservation visibility. Traditional heritage analysis usually focuses on the architectural value and physical characteristics of individual buildings. Such approaches often treat heritage sites as isolated objects and cannot adequately explain how dispersed small-scale buildings collectively shaped the structure and evolution of a historic city [3].

In contrast, the HUL framework interprets urban environments as dynamic and layered systems rather than as collections of static architectural objects. Its core concern is the interpretation of layered socio-spatial relationships embedded within urban environments rather than within a fixed spatial scale. Recent studies have increasingly extended HUL-based approaches to building-related heritage analysis through GIS and digital spatial methods [4–6]. These approaches have shown advantages in revealing hidden spatial relationships among dispersed heritage sites and in connecting buildings with their broader urban context. Guild halls are particularly suitable for HUL-based analysis because they functioned not only as individual buildings, but also as spatial nodes connecting migrant communities, urban functions, and historical social networks. However, such approaches have rarely been applied to guild halls [7], particularly non-protected guild halls embedded within the everyday urban fabric.

To address these limitations, this study applies a GIS-based digital spatial interpretation framework under the HUL approach to analyze the spatial distribution of non-protected guild halls in Beijing's outer city. By integrating historical urban landscape theory with GIS-based spatial analysis and visualization, the study aims to reveal hidden socio-spatial structures related to migration networks, functional zoning, and historical urban development. The research further reconstructs historical urban layering at the building scale and explores its implications for heritage-informed urban renewal and spatial design.

2 Materials and Methods

2.1 Study Area and Data Collection

This study focuses on traditional, non-protected guild halls in Beijing. The historical timeline spans from the Ming Dynasty to the Qing Dynasty. Geographically, the research is strictly limited to the outer city, defined as the area enclosed by Qianmen and the South, East, and West Second Ring Roads.

Spatial coordinates and attribute data—including construction periods, primary functions, room counts, and provincial origins—were extracted from authoritative resources such as the historical atlas of Beijing. After systematically excluding incomplete records, 519 valid historical sites were identified for quantitative analysis.

2.2 Digital Spatial Analysis Framework

To systematically examine these sites, this study established a digital spatial analysis framework. This framework integrates Geographic Information Systems (GIS) as a core digital tool within the Historic Urban Landscapes (HUL) theoretical framework. Abstract historical layering is transformed into observable spatial patterns by building a comprehensive digital feature database in ArcGIS. This digital interpretation clarifies how migrant networks and urban functions shaped the environment.

2.3 Spatial Analysis Methods

The framework utilized three specific GIS-based methods (see Fig. 1).

Spatial Autocorrelation: Using Global and Local Moran's I , this method assessed whether the architectural scale of guild halls exhibits spatial dependence. Room count served as the primary independent variable to represent scale.

Kernel Density Estimation (KDE): This tool intuitively visualized spatial hotspots and traced historical shifts in the geographic center of guild hall activity.

Multi-Distance Spatial Cluster Analysis: Using Ripley's K function, this method explored clustering patterns across various distance thresholds.

Together, these digital techniques enabled a systematic, building-scale analysis of temporal evolution, functional types, and provincial origins.

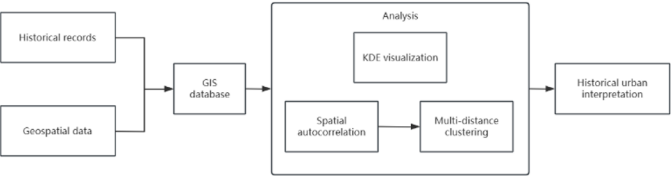


Fig. 1. Digital Spatial Analysis Workflow

3 Results and Discussion

3.1 Factors Influencing Guild Hall Distribution Characteristics

The Global Moran's I analysis for guild hall scale yielded an index of 0.006785 (z-score = 1.72, $p < 0.1$). This result reveals a statistically significant clustering pattern based on architectural scale (see Fig. 2). Local spatial autocorrelation mapping visually decodes the local heterogeneity of these architectural networks (see Fig. 3).

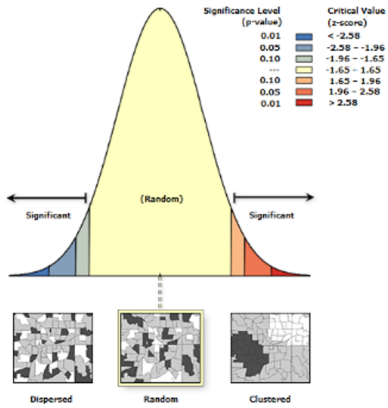


Fig. 2. Global spatial autocorrelation of guild halls at multiple spatial scales

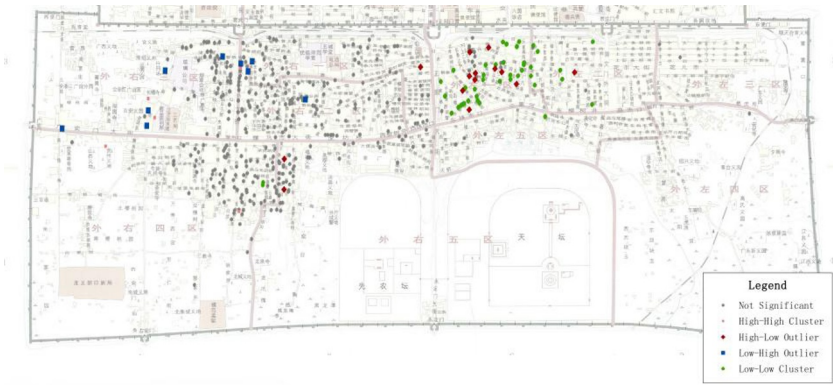


Fig. 3. Local spatial autocorrelation of guild halls at multiple spatial scales

In Dongcheng District, the GIS workflow captures clusters of uniformly small guild halls tightly bound to larger hubs. This spatial arrangement demonstrates a hierarchical social network materialized in space. Conversely, in Xicheng District, the spatial analysis captures a clustered pattern of large guild halls concentrated around Xuanwumen Street. Rather than treating these buildings as random historical remnants, the local spatial autocorrelation approach maps the spatial manifestation of historical social capital. It demonstrates how macro-level social networks directly organized the physical urban fabric.

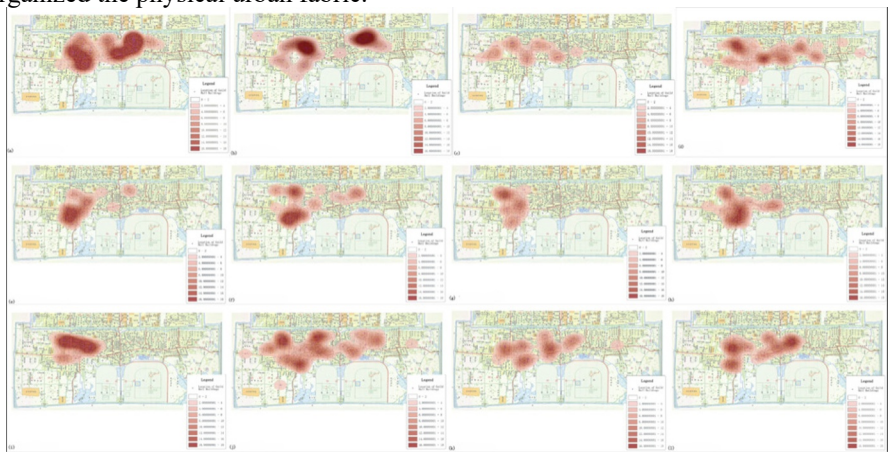


Fig. 4. Kernel Density Analysis Map of Guild Halls of Different Native Provinces in the Outer City of Beijing During the Ming and Qing Dynasties: (a) Jiangxi Province; (b) Hubei Province; (c) Hebei Province; (d) Shanxi Province; (e) Jiangsu Province; (f) Guangdong Province; (g) Sichuan Province; (h) Henan Province; (i) Shaanxi Province; (j) Zhejiang Province; (k) Fujian Province; (l) Anhui Province.

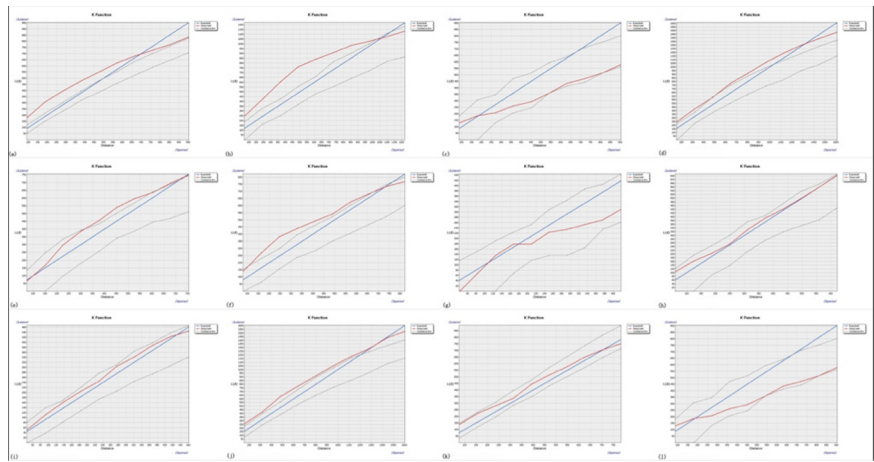


Fig. 5. Ripley's K-function analysis of guild halls by province of origin in the outer city of Beijing during the Ming and Qing dynasties: (a) Jiangxi; (b) Hubei; (c) Hebei; (d) Shanxi; (e) Jiangsu; (f) Guangdong; (g) Sichuan; (h) Henan; (i) Shaanxi; (j) Zhejiang; (k) Fujian; (l) Anhui.

Furthermore, introducing provincial origin as an attribute variable into the geospatial database uncovers deep spatial heterogeneity across different migrant groups. The digital classification of guild halls from 12 provinces maps three distinct spatial typologies: Overall Dispersed, Overall Agglomerated, and Small-Group Agglomerated (see Fig. 4 and Fig. 5).

The GIS database translates qualitative records into multi-distance cluster metrics. This visually demonstrates how regional economic imbalances and localized wealth patterns shaped uneven structural densities within the historic urban landscape. Digital technology thus objectifies historical regional inequalities. It visualizes them as quantifiable spatial characteristics within the city's architectural environment.

3.2 Digital Interpretation of Historical Urban Space

The integration of Kernel Density Estimation (KDE) and multi-distance spatial cluster analysis allows for the computational interpretation of historical functional structures. While Ripley's K-function analysis indicates that both commercial and examination guild halls exhibit highly consistent clustering intensities within an 800-to-900-meter radius (see Fig. 6). However, KDE mapping exposes their profound geographical segregation (see Fig. 7). Commercial guild halls are strictly concentrated around trade nodes like Qianmen and Dashilar. In contrast, examination guild halls populated literati centers near Xuanwumen and Liulichang. Digital visualization uncovers a "similar scale, distinct location" pattern. This pattern identifies a spatial attribute-matching mechanism. It shows how historical building functions dynamically adjusted to specialized urban infrastructure.

Temporally, tracking these spatial layers through chronological subsets reveals a profound spatiotemporal reconfiguration of Beijing's historic core. The KDE series documents a massive structural migration: Ming Dynasty guild halls were concentrated in the East City, whereas Qing Dynasty structures shifted decisively toward the southwest (Fig. 8, Fig. 9).

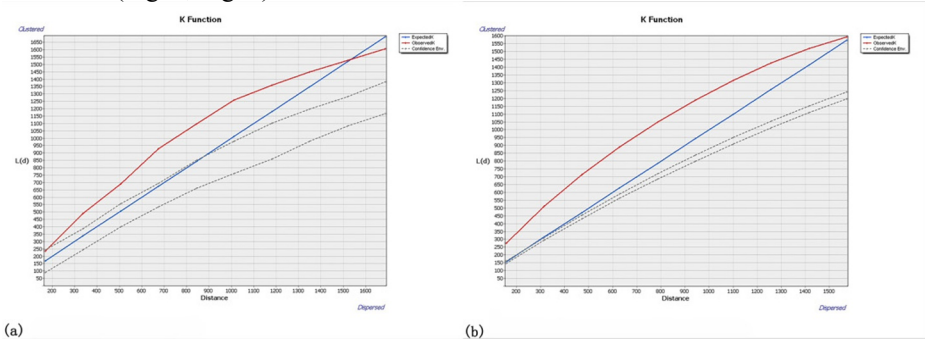


Fig. 6. Ripley's K-function analysis of commercial and imperial examination guild halls in the outer city of Beijing during the Ming and Qing dynasties: (a) Commercial Guild Halls; (b) Imperial Examination Guild Halls.

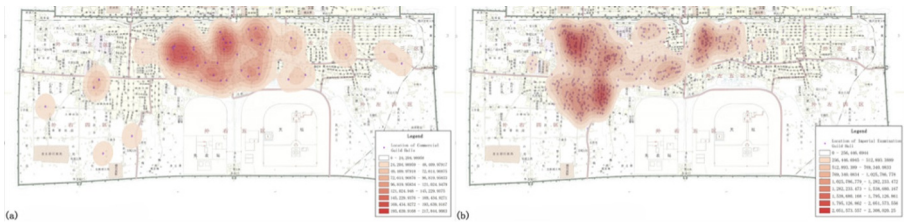


Fig. 7. Kernel density estimation of commercial and imperial examination guild halls in the outer city of Beijing during the Ming and Qing dynasties: (a) Commercial Guild Halls; (b) Imperial Examination Guild Halls.

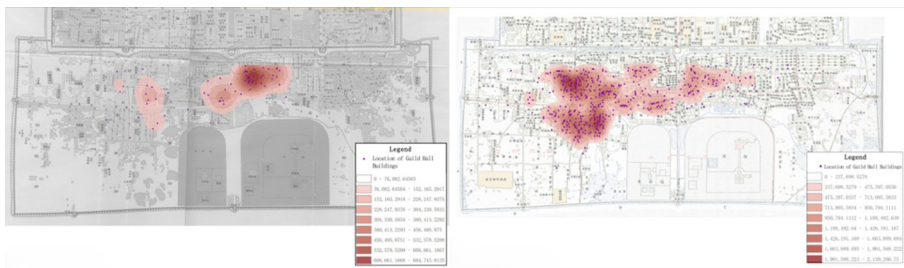


Fig. 8. Kernel density estimation of guild halls in the outer city of Beijing: (a) Ming Dynasty; (b) Qing Dynasty.

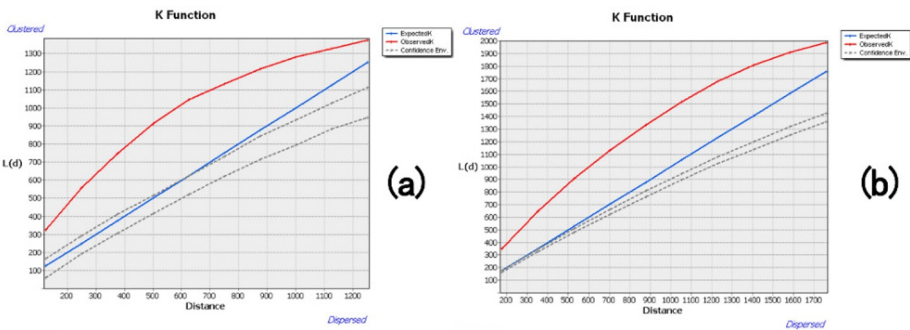


Fig. 9. Ripley's K-function analysis of guild halls in the outer city of Beijing: (a) Ming Dynasty; (b) Qing Dynasty.

Digital spatial analysis reconstructs this transition not merely as a timeline of past events, but as a top-down spatial restructuring. Top-down policies, such as historical residential segregation mandates, interacted with the functional requirements of migrant communities. By mapping these shifting centroids across historical periods, digital visualization demonstrates how political forces and functional zoning rules intersected over time. This intersection created overlapping, layered historical strata at the building scale.

3.3 Implications for Digital Heritage and Urban Spatial Design

These digital spatial insights directly inform modern urban renewal and adaptive re-use design strategies under the HUL framework.

First, the identification of scale-based hierarchical clusters suggests that preservation must transition from single-monument protection to holistic pattern conservation. Designers can leverage spatial cluster boundaries to integrate small-scale guild halls as subordinate community nodes. These nodes are anchored by larger historic halls, thereby preserving the original spatial logic.

Second, the three identified provincial clustering typologies provide a structured framework for developing networked heritage trails. Using digital mapping to link historically similar origin guild halls allows for the design of cohesive cultural routes, such as a "hometown trail". This mitigates isolated and fragmented preservation.

Finally, acknowledging historical functional segregation suggests that adaptive re-use should align with legacy spatial attributes. Former commercial nodes can be reactivated for modern retail and markets. Meanwhile, examination centers can morph into contemporary libraries or educational hubs. This approach integrates traditional historical urban landscape theory with digital visualization. Consequently, it ensures that historic spaces sustain their contextual identity within contemporary urban design.

4 Conclusion

This study developed a GIS-based digital spatial analysis framework under the Historic Urban Landscape (HUL) approach to investigate the spatial distribution of non-protected guild halls in Beijing's outer city.

The results revealed spatial clustering associated with guild hall scale, functional type, and provincial origin. These patterns reflect the influence of migration, commerce, political functions, and urban development on the spatial organization of Beijing during the Ming and Qing dynasties. The study also demonstrated the value of digital visualization in revealing hidden cultural structures in everyday heritage.

These findings suggested urban renewal should preserve small guild halls alongside large ones for community and cultural uses, respect the traditional strengths of different functional zones, use markings or axes to maintain historical connections when infrastructure cannot be restored, and link same-province guild halls via signs or walking routes.

By integrating traditional historical urban landscape theory with digital spatial visualization and analysis methods, the research established a building-scale framework for interpreting historical urban cultural space.

Acknowledgments

The authors wish to express their sincere gratitude to Yufei Li for the valuable assistance during the manuscript preparation and writing process.

Ministry of Education Humanities and Social Sciences Planning Fund Project: Spatiotemporal Evolution Mechanisms and Revitalization Inheritance Strategies of Beijing's Ming and Qing Guildhalls in the Context of Urban Regeneration (23YJAZH177)

Disclosure of Interests

The authors declare no conflicts of interest.

References

1. UNESCO (Institution): Recommendation on the Historic Urban Landscape. UNESCO, Paris (2011). <https://whc.unesco.org/en/hul>
2. Wang, Y., Yu, L., Zhu, H., Kan, T.: Possibilities and Recommendations for Digitally Empowering the Development of Tourism Resources in Beijing's Local Guild Halls. In: Majoul, B., Guan, G., and Groom, N. (eds.) Proceedings of the 4th International Conference on Language, Art and Cultural Exchange (ICLACE 2023). pp. 332–342. Atlantis Press SARL, Paris (2023). https://doi.org/10.2991/978-2-38476-094-7_42
3. Zhang, S., Sun, H., Jiang, M., Zhao, J.: An HUL Assessment for Small Cultural Heritage Sites in Urban Areas: Framework, Methodology, and Empirical Research. *Land*. 14, 1513 (2025). <https://doi.org/10.3390/land14081513>
4. Ornelas, C., Sousa, F., Guedes, J.M., Breda-Vázquez, I.: Monitoring and Assessment Heritage Tool: Quantify and classify urban heritage buildings. *Cities*. 137, 104274 (2023). <https://doi.org/10.1016/j.cities.2023.104274>
5. Feng, B., Li, W.: Study on Historic Urban Landscape Corridor Identification and an Evaluation of Their Centrality: The Case of the Dunhuang Oasis Area in China. *Land*. 14, 585 (2025). <https://doi.org/10.3390/land14030585>
6. Su, C., Wang, X., Wang, Y., Chen, Y., Dai, F., Chen, X.: Mediating Roles of Cultural Perception and Place Attachment in the Landscape–Wellbeing Relationship: Insights from Historical Urban Parks in Wuhan, China. *Land*. 14, 1176 (2025). <https://doi.org/10.3390/land14061176>
7. He, D., Yuan, L., Chen, W.: The connections between Historic Urban Landscape layers in Jingdezhen, the porcelain capital of China. *Landscape Research*. 49, 393–409 (2024). <https://doi.org/10.1080/01426397.2023.2296508>

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

