

Assessing the impact of urban investment on place identity through morphological transformation using GIS and space syntax: The historic center of Karbala

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Abstract

There is a clear impact of urban investment in religious cities resulting from modern expansion projects, which may affect the spatial characteristics contributing to the formation of place identity. However, these relationships have not received sufficient quantitative investigation in the historic center of Karbala, Iraq. This research aims to examine the morphological, functional, and spatial transformations associated with urban investment and their potential implications for the spatial components of place identity by integrating Geographic Information Systems (GIS) and Space Syntax analyses. A comparative spatial analysis was conducted based on planning data, land uses, street network data, Geographic Information Systems were used to measure changes in land use and urban morphology. The street network was also analyzed using DepthmapX 0.8.0, based on the segment map, angular analysis, and a metric radius of 500 meters. The adopted indicators included Connectivity, T1024 Integration, and T1024 Total Angular Depth. The results showed significant morphological and functional transformations; residential land use declined from 35.02% to 28.58%, religious land use increased from 7.83% to 26.73%, and the tourism-related commercial land-use category, after harmonizing the classification, increased from 24.13% to 27.65%. The main streets around the two holy shrines had relatively high Connectivity and Integration values and lower Total Angular Depth values. The findings reveal measurable changes in land use, urban fabric and street-network configuration that could influence the spatial aspects of place identity through demolition and removal of old historic buildings. Integrating GIS and Space Syntax provides a framework for balanced urban development and historic-environment conservation.

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1. Introduction

Urban investment is one of the most important factors in the morphological configuration of historic cities. Investment projects stimulate economic growth, infrastructure development and urban regeneration, but at the same time change the physical shape and functional characteristics of historic urban areas. They may lead to changes in land-use patterns, street networks, and building morphology, thereby affecting the spatial characteristics contributing to the formation of place identity [1]. Historic religious cities are particularly exposed to these transformations because investment activities are often concentrated around major religious and tourist destinations to accommodate the number of visitors, which reached approximately 20 million visitors in 2026, according to what was published by the Al-Abbas Holy Shrine. Although these developments may meet the needs of the historic city to accommodate these numbers, they may

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also reduce residential functions and alter traditional urban fabrics. Therefore, achieving a balance between urban investment and the conservation of historic urban environments has become a major challenge for urban planning. The historic center of Karbala has experienced rapid urban transformation during the past two decades, associated with the increase in religious tourism and expansion projects surrounding the two holy shrines. Commercial, religious, and service activities have expanded, replacing parts of the traditional residential fabric and altering the organization of the historic street network. Despite these transformations, their morphological, functional, and spatial implications have not been comprehensively evaluated using integrated spatial methods. Geographic Information Systems have been widely used to examine land-use change and functional change, while Space Syntax has been used to analyze spatial accessibility and street-network configuration. However, studies integrating temporally harmonized land-use analysis with segment-map-based Space Syntax analysis to examine historic religious centers remain limited. Therefore, this research examines the morphological transformations associated with urban investment in the historic center of Karbala between 2010 and 2026.

2. Urban Investment Concept and Dynamics

Urban investment has been used as a strategic tool for encouraging sustainable urban development through the effective allocation of financial and human resources to improve the physical, economic and social environment of cities. Its helps improve of the quality of urban life through development of urban infrastructure, public utilities, housing and urban facilities, and at the same time to the economic growth and the competitiveness of urban regions [1]. Urban investment is not just an economic function but rather a spatial planning process that directs public and private resources to the urban and historic centers to revitalize local economies and enhance the efficiency of urban systems. In this context, investment not only influences the physical form of the city, but also its functional organization, spatial structure and socio-cultural values, making it a fundamental driver of urban transformation [2]. Recent studies emphasize that urban investment is not merely about financing development projects, but also a strategic tool for altering cities. Besides economic revitalization and infrastructure improvements, investment projects can also bring about substantial spatial and social changes especially in historic urban areas. The transformation of land use, building patterns and urban functions in these areas can result in a gradual change of the identity and character of the place [3].

3. Urban Investment in Historic Cities

Urban investment should find a balance between economic development and urban heritage protection. Compared with today's urban areas, ancient cities have specific spatial structures, cultural values and historical identities that are quite vulnerable to urban transition. Investment projects can improve infrastructure, revitalize local economies and increase public services, but they can also change land-use patterns, disrupt traditional urban fabrics and erode place identity if executed without thorough spatial planning [4]. Holy Karbala is a good example of a historic religious city that gets persistent investment from religious tourism and pilgrimage activities [5]. These expenditures have allowed urban growth and economic development but have also created increased pressure on the historic urban core, transit infrastructure and heritage assets. Thus, the evaluation of the impacts of investments on historic cities requires an integrated view, taking into account both the alteration of space and the conservation of heritage for sustainable urban development [6].

4. Place Identity

Place identity is one of the basic dimensions that differentiate historic cities. It mirrors the interaction between their physical form, cultural values, historical continuity and human experience. Place identity is not a static characteristic, but rather a dynamic construct that evolves through the ongoing relationship between people and their spatial environment, while retaining the essential attributes that define the uniqueness of a place. In historic urban centers, the identity of the city is embodied in the urban fabric, street network, architectural vocabulary, landmarks and socio-cultural activities that give the city its distinctive character [7,8]. Economic development

usually implies rapid urban change and investment. However, if not sensitive enough to the historic context these processes are able to change defining spatial and cultural characteristics [9,10]. Therefore, protecting place identity is a delicate balance between urban development and the protection of tangible and intangible heritage. The investment is to enhance, not diminish, the specificity, continuity and cultural significance of historic urban environments. "In historic contexts, place identity is not merely an aesthetic or memorial quality; it is intrinsically tied to the structural logic of space. Spatial configuration dictates the patterns of co-presence and movement, which in turn sustain the socio-cultural rituals that define place identity. When aggressive urban investments alter street connectivity and land-use hierarchy, they disrupt the traditional spatial core, leading to a phenomenon of 'spatial identity displacement' where local memory is replaced by transient tourism dynamics."

5. Spatial Configuration and Urban Morphological Transformation

The spatial configuration and urban morphology are a basic foundation for understanding the physical structure of historic cities and the processes that regulate their spatial evolution. Urban morphology concerns the arrangement of streets, plots, blocks, buildings and land-use patterns. Spatial configuration concerns the interactions between these elements and the way in which they affect accessibility, movement and spatial integration within the urban fabric [11]. Morphological transition in ancient city centers is a dynamic process, which results from the combination of social, economic, functional and planning elements, which often leads to changes in street networks, land-use distribution, building density, and public spaces [12]. Such modifications can change the continuity, coherence and functional performance of the traditional urban fabric and affect the general spatial organization of the city. Therefore, the analysis of spatial configuration and urban morphology provides a holistic framework for analyzing the physical impact of urban investment and allows the use of GIS and Space Syntax methodologies to quantify spatial transition in historic urban contexts.

6. Derivation of the Research Indicators

In light of what was presented in the theoretical framework, and after reviewing a group of studies that addressed urban investment and place identity, it became clear that the impact of investment is not limited to physical change in the urban fabric, but extends to the functional structure and the overall configuration of the urban fabric. Accordingly, a set of measurable indicators was identified, distributed across the morphological, functional, and spatial dimensions, allowing the analysis of the transformations that occurred and the interpretation of their implications for the spatial components of identity. These indicators were selected because they represent measurable physical, functional, and configurational characteristics, through which the impact of urban investment on the spatial components of the identity of the old historic center can be interpreted.

Table 1. Indicators for measuring the impact of urban investment on morphological, functional, and spatial transformations and their implications for the place identity of the historic center of Karbala

Dimension	Main Indicator	Operational Measurement
Morphological	Land-use change	Measures the transformations between residential, commercial, and religious uses
Morphological	Demolition and removal	Demolition and removal processes in the historic center and major expansion projects
Functional Dimension	Change in functional balance	The decline in residential use versus the expansion of religious, commercial, hotel, and service uses by comparing land-use proportions between 2010 and 2026
Spatial Dimension	Pedestrian movement	Identifying the main axes most likely to attract the movement of individuals and passage through them towards the two shrines
Spatial Dimension	Accessibility	Identifying the streets that provide ease of access and indicating the streets affected by urban transformations

6.1 Research Methodology

The research adopted a comparative descriptive-analytical approach, combining morphological analysis using Geographic Information Systems (GIS) with spatial analysis using Space Syntax, with the aim of assessing the impact of urban investment on the transformations of place identity in the historic center of the city of Karbala during the period 2010–2026. Spatial data were collected from land-use plans, official plans, the street network, high-resolution satellite imagery, as well as field observation. The maps were then georeferenced, and the coordinate system, spatial boundaries, and land-use classifications were unified, while the data were digitized and organized within a unified geodatabase to ensure the accuracy of the temporal comparison [13]. The GIS analysis was based on three main indicators. The first involved measuring land-use change by calculating the area and proportion of each use and the magnitude of its change between the two periods. The second involved monitoring the physical transformations of the urban fabric, including demolition and removal processes. The third indicator involved measuring changes in functional balance by analyzing the decline of the residential function in contrast to the expansion of religious, commercial, hotel, and service uses associated with visitation.

7. Study Area

The study was carried out in the ancient center of Karbala, Iraq, which includes the shrines of Imam Hussein and Al-Abbas, and embodies the historical, religious and urban core of the city. The study area was delimited using the officially accepted limits of the historic city, according to the goals of analyzing the influence of urban investment on morphological change [15]. It comprises the traditional neighborhoods of Bab Al-Salalmah, Bab Al-Taq, part of Al-Mukhayyam, Bab Al-Najaf, Bab Al-Khan and Bab Baghdad that together preserve the traditional urban fabric but with the most intensive investment and redevelopment projects carried out in recent decades. Therefore, the historic center is a suitable case study for analyzing the interaction between urban investment, spatial transformation and changes in the urban morphology [16].

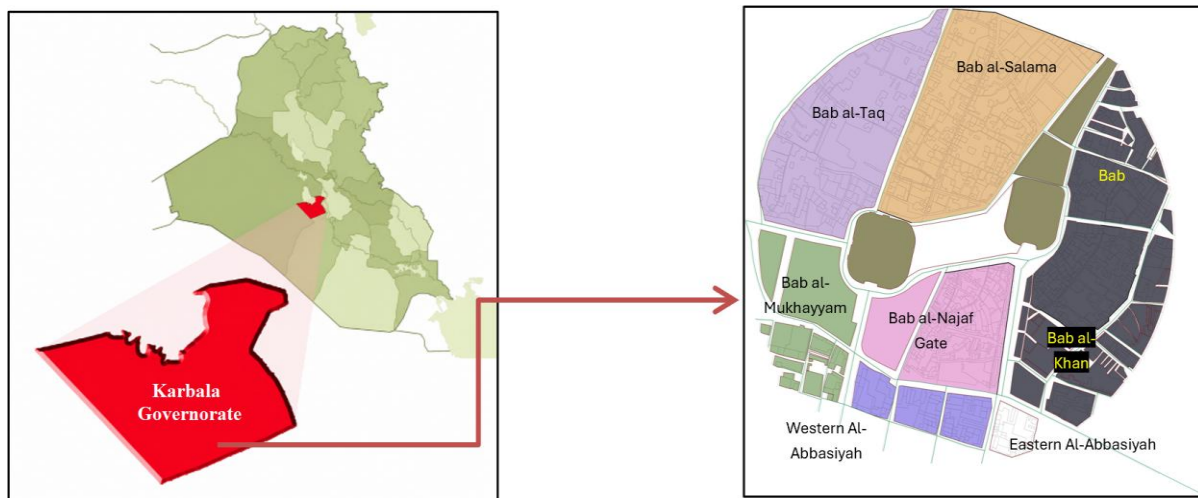


Fig. 1. Location and boundaries of the study area within the historic center of Karbala

8. Data Collection and Pre-Processing

The study was based on several spatial datasets from official planning authorities and complemented by field observations. The main datasets were the authorized master plan for the historic city of Karbala, land use maps, cadastral maps, street network data and high-resolution satellite images. Historical and modern spatial datasets were collected to do a comparative assessment of urban growth from 2010 to 2026. All datasets were georeferenced, projected to a single coordinate system and organized into a GIS geodatabase to ensure consistency and dependability for further morphological and spatial studies [16].

9. Results and Discussion

9.1 GIS-Based Morphological Analysis

Geographic Information Systems (GIS) were employed to analyze the morphological transformation of the historic center of Karbala through a comparative spatial analysis of historical and recent datasets. The prepared spatial database was used to identify and quantify changes in land use, street networks, urban blocks, building density, and the spatial distribution of investment-related developments.

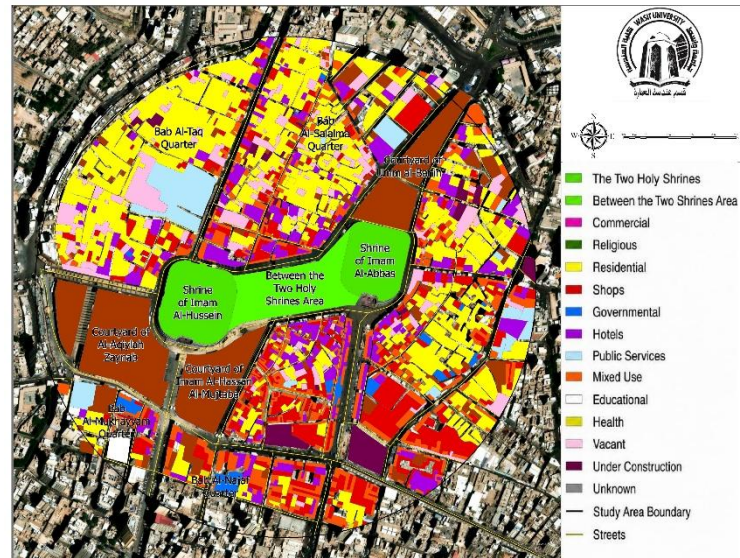


Fig. 2. Land use (2026)



Fig. 3. Land use (2010)

9.2 Morphological Analysis of Land Use (2010–2026)

The morphological analysis of land use in the historical heart of Karbala shows major changes to the functional structure of the urban fabric between 2010 and 2026, as a result of urban development and investment related to religious tourism. The residential land use occupied the largest share of the study area with 35.02% in 2010 followed by the commercial land use with 24.13%. This reflects the dominance of the residential function while the commercial activities were still concentrated at the two holy shrines and along the main streets. Land use for religious purposes was 7.83 percent, public services 6.19 percent and vacant land 8.37 percent of total area.

Smaller proportions of land uses were educational (5.28%), under construction (4.05%), mixed-use (3.75%), agricultural (2.93%), governmental (2.19%) and healthcare (0.24%) purposes.

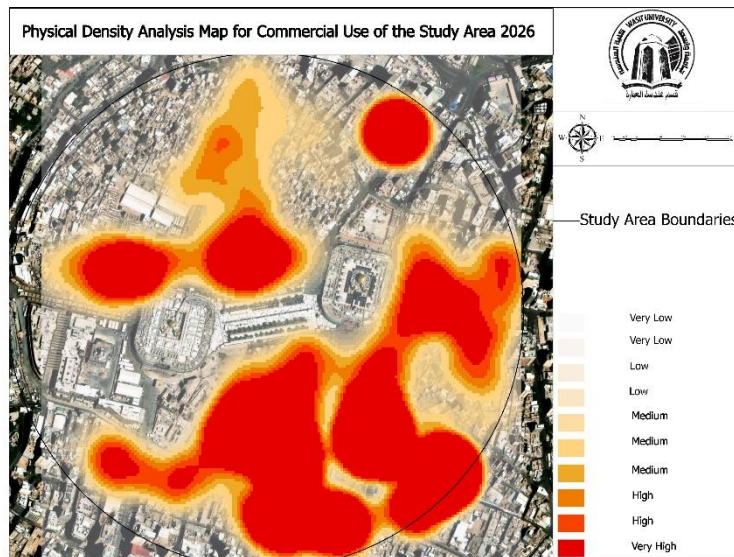


Fig. 4. Spatial distribution of commercial land use (2026)

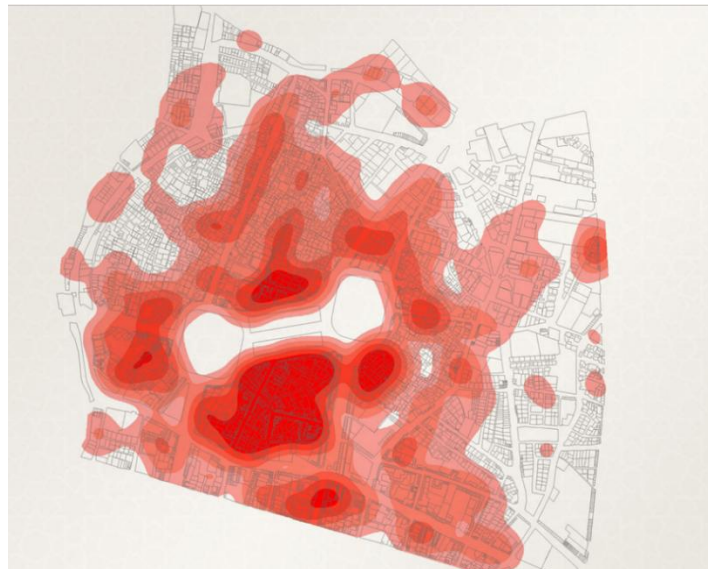


Fig. 5. Spatial distribution of commercial land use (2010)

By 2026 the functional mix of the historic core had changed considerably. Residential land use decreased to 28.58% while religious land use expanded significantly to 26.73% and became the second largest land use category due to the expansion and redevelopment projects around the two holy shrines. Commercial operations also diversified further with commercial land use (11.89%), hotels (8.25%) and retail outlets (7.51%). These two groups together make up 27.65% of the whole study area, showing the growing dominance of tourism-related economic activity in the historic urban core [18].

A comparison between the two periods shows that the morphological alteration was not confined to changes in the land-use proportions, but also included a reorganization of the functional structure of the historic core. The growth of religious, commercial and tourism land uses eroded the ancient residential fabric, particularly along the major transportation corridors encircling the two holy shrines. The proportion of unoccupied land also reduced from 8.37% in 2010 to 6.80% in 2026, implying that previously undeveloped parcels were converted into urban development and service-related developments. Educational and governmental land uses reduced from 5.28% to 0.42% and from 2.19% to 1.08% respectively, suggesting the property was reallocated to serve religious, commercial and tourism-oriented uses [19,20].

Overall, the data suggest that urban investment has been the main driver of the morphological reconfiguration of the ancient heart of Karbala. The increasing use of land for religious, commercial and tourism-related purposes has reorganized the spatial organization of the area, changed its functional hierarchy and altered the conventional urban fabric to meet the increasing needs of religious tourism.



Fig. 8. Imam Hussein Qibla Street in the historic center of Karbala



Fig. 9. Imam Al-Abbas Qibla Street in the historic center of Karbala



Fig. 10. Imam Hussein Qibla Street in the historic center of Karbala

10. Preprocessing of Data

The street network of the historic center of Karbala was digitized in AutoCAD as street center lines and transformed into a segment map. After checking its geometric accuracy, connectivity, and network continuity, the map was imported into DepthmapX version 0.8.0. Angular segment analysis was conducted using the Tulip method with 1024 angular bins and a metric radius of 500m. The analyzed network included the interconnected streets and dead-end alleys within the defined study area surrounding the two holy shrines, whereas unrelated streets outside the study boundary were excluded. The extracted measures comprised Connectivity, T1024 Integration at R500 metric, Node Count, and T1024 Total Depth at R500 metric. The measures were used to analyze the direct spatial connections, angular accessibility and spatial depth of the 500-m movement network.

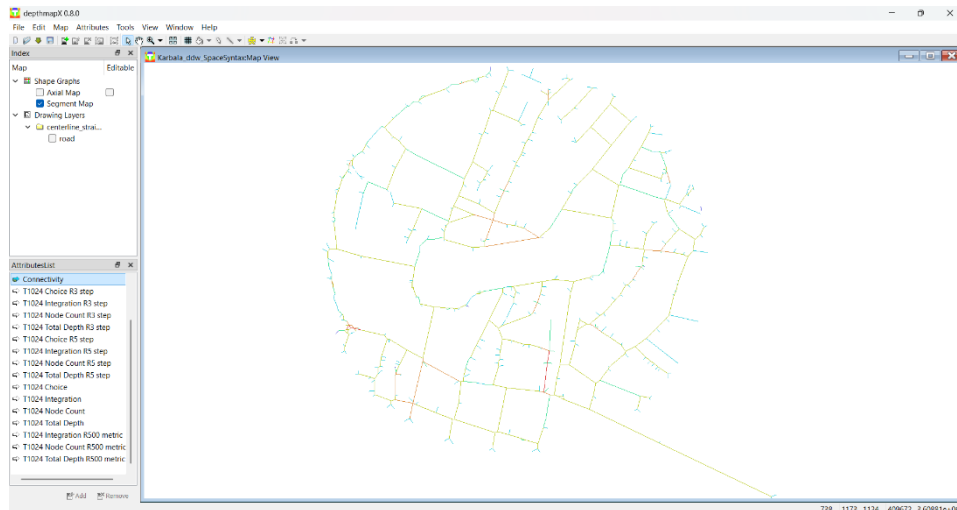


Fig. 11. Segment map of the historic centre of Karbala used for space syntax analysis

10.1 Connectivity Analysis

The connectivity analysis reveals a hierarchical street network in the historic center of Karbala. The main streets surrounding the compound of the shrine are the corridors with the highest values of connectivity, which means that these corridors are the main movement routes due to the greater number of direct links between streets. In contrast, the conventional backstreets have lower connectivity ratings, indicating their position as local access roadways with less direct links. This spatial arrangement highlights the significance of the main roadways in structuring urban circulation, while the old alley network persists in its localized and less interconnected form.



Fig. 12. Connectivity map of the historic center of Karbala

10.2 Angular Integration Analysis at R500 Metric

The analysis shows a clear spatial hierarchy in the historic core of Karbala. The highest levels of integration are for the main roads surrounding the two holy sites. These corridors are the most accessible and spatially integrated parts of the street network. They are the main routes of pedestrian mobility and urban activities, as they are strategically located and directly connected with the urban core. The peripheral roads and old lanes have low integration scores indicating a more divided spatial organization with limited accessibility. The clustering of highly integrated streets around the shrine precinct corresponds to the spatial distribution of commercial, religious and service activities, suggesting that urban investment has been focused on the most accessible corridors, which in turn has reinforced changes in land use and the spatial structure of the historic center.



Fig. 13. Integration map R500 of the historic center of Karbala

10.3 Global Depth Analysis

Analysis of the Global Depth indicates a distinct spatial hierarchy within the historic center of Karbala. The streets around the two holy shrines have the lowest global depth values. This indicates that their topological distance to the whole street network is the least and they are the most accessible urban corridors. However, the depth values of the peripheral streets and traditional alleys are increasing, indicating that they are increasingly separated spatially from the core of the network and less accessible.

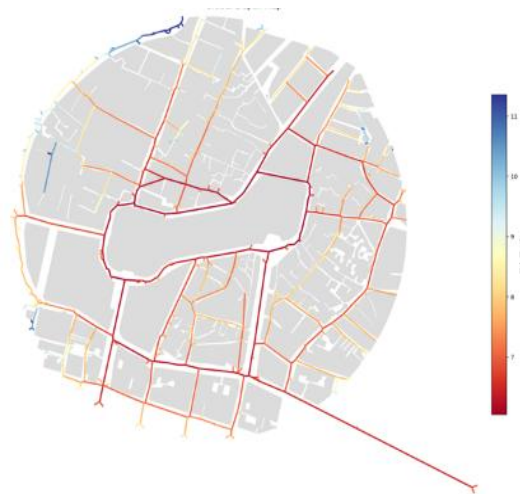


Fig. 14. T1024 total angular depth at R500 metric

This pattern shows that the spatial accessibility is concentrated around the central shrine compound. The traditional alley network still maintains a relatively deep and localized spatial pattern. After conducting the Space Syntax analysis of the street network, numerical values were extracted using the indicators of Integration, Connectivity, and Mean Depth. To interpret the results at two levels, the general descriptive statistics of these indicators were first presented at the spatial-network level by determining the minimum and maximum values and calculating the arithmetic mean and standard deviation, thereby providing a reference basis for interpreting the general configurational characteristics. The values of the main streets were then analyzed and compared with the general network averages to identify the most integrated, connected, and accessible axes.

Table 3. Descriptive statistics of the space syntax measures for the street network within a 500-m metric radius around the two holy shrines

Measure	Minimum	Maximum	Mean	SD
Connectivity	1.00	6.00	3.16	1.06
T1024 Integration, R500 metric	4.50	97.37	47.81	17.93
T1024 Total Depth, R500 metric	0.42	2054.77	801.38	338.38

11. Conclusions

The study examined the morphological, functional and spatial changes related to urban investment in the historic center of Karbala and the possible implications for the spatial components of place identity through the integration of GIS and Space Syntax analyzes. The following conclusions have been reached: The harmonized GIS comparison revealed a strong land-use transformation from 2010 to 2026. The residential land use has reduced from 35.02% to 28.58% whereas the religious land use has increased from 7.83% to 26.73%. Tourism-related commercial use increased from 24.13% to 27.65%.

- The observed demolition, removal, and major shrine-expansion projects contributed to changes in the traditional urban fabric and functional balance of the historic center.
- The Space Syntax analysis showed that the principal streets surrounding the two holy shrines exhibited comparatively high Connectivity and T1024 Integration values and lower Total Angular Depth values within the 500-m metric radius, indicating their important role in structuring movement and accessibility.
- The GIS and Space Syntax results demonstrate measurable morphological, functional, and spatial transformations. However, they do not establish a statistically tested relationship between land-use distribution and spatial integration or directly measure the perceptual and social dimensions of place identity.
- The integration of GIS and Space Syntax provides a useful framework for examining how changes in land use, urban fabric, and street-network configuration may influence the spatial characteristics contributing to place identity.
- Future urban investment should be guided by evidence-based planning policies that balance development requirements with the conservation of the historic urban fabric, residential continuity, and the spatial characteristics of the historic center.
- GIS and Space Syntax can be used to assess the likely spatial impacts of planned developments, prior to their implementation.

References

- [1] Al-Naghi M. Urban Investment and Urban Development. 2013.
- [2] Tsimperis EM. Identification of Investment Opportunities in Urban Regeneration Projects [Master's thesis]. Department of Real Estate, Planning and Geoinformatics, Aalto University School of Engineering; 2015.
- [3] United Nations Human Settlements Programme (UN-Habitat). International Guidelines on Urban and Territorial Planning. Nairobi: UN-Habitat; 2015. Available from: <https://unhabitat.org/international-guidelines-on-urban-and-territorial-planning>
- [4] Razouqi SZ. Urban Investment. Baghdad, Iraq; 2009.

- [5] Al-Shadidi HA, Al Kaabi MMF. Impact of Investment Projects in Changing Master Plan of Najef Holy City. Pakistan Journal of Life and Social Sciences. 2024;22(2):491-505. <https://doi.org/10.57239/PJLSS-2024-22.2.0036>
- [6] Farhan SL, Abdelmonem MG, Nasar ZA. The Urban Transformation of Traditional City Centres: Holy Karbala as a Case Study. Archnet-IJAR: International Journal of Architectural Research. 2018. <https://doi.org/10.26687/archnet-ijar.v12i3.1625>
- [7] El-Eqapy AHH. The Ultimate Characters for Identity in Contemporary Architecture. Journal of Planner and Development. 2021.
- [8] Al-Dahwi SH, Alwan YI. Impact of Religious Tourism Landmarks in Authenticity Dimensions of Urban Identity for the City. Iraqi Journal of Architecture. 2015.
- [9] Al-Hilo IA, Al-Baghdadi AA. Promoting the Cultural and Urban Identity of the Holy Cities: The Case Study of Al-Najaf, Iraq. Kerbala Journal for Engineering Science. 2022.
- [10] Strandberg C, Styvén ME. The Multidimensionality of Place Identity: A Systematic Concept Analysis and Framework of Place-Related Identity Elements. Journal of Environmental Psychology. 2024. <https://doi.org/10.1016/j.jenvp.2024.102257>
- [11] Alkinani AS, Almansuri DS. The Role of Competitive Advantage in Investing in Place Identity. Journal of Planner and Development. 2024.
- [12] Farhan SL, Akef V, Antón D, et al. Factors Influencing the Transformation of Iraqi Holy Cities: The Case of Al-Najaf. Scientific Review Engineering and Environmental Sciences. 2021. <https://doi.org/10.22630/PNIKS.2021.30.2.31>
- [13] Shahin BR, Kamounneh HH. Architectural Transformations in Holy Cities Center: The Holy City of Najaf as a Model.
- [14] Hillier B, Hanson J. The Social Logic of Space. Cambridge: Cambridge University Press; 1984. <https://doi.org/10.1017/CBO9780511597237>
- [15] Fadhil A. The Role of Urban Transformations in Highlighting the City's Landmarks: Case Study of Old Karbala. Kerbala Journal for Engineering Science. 2021;1(1):1-20. <https://doi.org/10.63463/kjes1021>
- [16] Al-Jumaili RKS. Karbala City: A Study of Its Origin and Urban Development. Karbala, Iraq; 2012. [In Arabic].
- [17] Diwan Engineering Consultancy. Master Plan of the Historic Centre of Karbala. Baghdad, Iraq; 2011.
- [18] Diwan Engineering Consultancy. Urban Development Plan of the Historic Centre of Karbala. Baghdad, Iraq; 2007.
- [19] Karbala Governorate, Directorate of Urban Planning. GIS Database and Land Use Maps of the Historic Centre of Karbala; 2026.
- [20] Al-Abbas Holy Shrine, Department of Engineering Projects. Urban development data of the historic centre of Karbala; 2026.