



# Decoding urban heritage: a multi-dimensional analysis framework applied to Assiut's historic core

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Received: 28 December 2024 / Accepted: 31 January 2025  
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## Abstract

One of the challenges confronting urban conservation is the inclusion of heritage areas in the development process. While often seen as constraints, heritage areas represent promising opportunities to enhance city character and quality. Nevertheless, the inclusion of heritage areas in the development process is intricate, requiring an extensive analysis of the urban form of heritage areas to facilitate the inclusion process. From this stance, this paper proposes a comprehensive analytical framework for identifying the features and characteristics of heritage areas, using Assiut City in Egypt as a case study. The proposed framework addresses four interrelated dimensions of urban design: the morphological, the functional, the perceptual, and the social. Space syntax methodology, mainly axial mapping, is employed to analyze the urban pattern of Assiut's Historic Core to disclose its spatial configuration and morphological features. The author will use Survey and field observation to address the heritage area's functional, perceptual, and social features (33 respondents and five interviewees). Thus, this paper utilizes a mixed-methods approach, combining quantitative and qualitative techniques to provide a holistic understanding of the urban heritage area. Implications of the study are discussed in terms of the importance of including heritage areas in the development process and how the proposed analytical framework can contribute to revealing the features of urban areas in general and heritage areas in particular. Thus, policymakers and urban planners can map out the areas of improvement and development fostering inclusive, well-integrated urban regeneration and urban development of our cities.

**Keywords** Historic areas · Assiut's Historic Core · Urban dimensions · Space Syntax

## 1 Introduction

One of the challenges confronting urban conservation is the inclusion of heritage areas in the development process. Because of its unique features, the heritage areas have been primarily seen as constraint elements in the development process. The author, however, argues that these areas represent a promising opportunity to enhance the character and quality of our cities. The heritage areas, as well as monuments, contribute to the visual experience of a city and sustain its character and uniqueness. Furthermore, these areas catalyze urban regeneration and promote cultural identity and social cohesion [1–3]. In spite of the increasing research

on urban preservation and morphology. There is a clear gap in understanding the integration of heritage areas with contemporary urban planning in historic and Middle Eastern regions. Focusing on Western cities, much of the existing literature overlooks the distinctive socio-spatial dynamics of Middle Eastern heritage areas, such as their dense urban fabrics, narrow streets, and strong ties to cultural identity. Furthermore, while methodologies like space syntax have been widely utilized in heritage studies, their application in Middle Eastern cities to analyze the interrelation of morphological, social, and perceptual dimensions remains limited. In this sense, the present study aims to address these gaps by introducing a holistic analytical framework tailored to the Middle Eastern context, with Assiut's Historic Core serving as a case study. Because it holds the most complete record of the physical transformations of a heritage area [4, 5], the analysis of urban patterns will be the focus of this paper. This focus aligns with the recent studies that emphasized the importance of urban morphology in understanding and preserving heritage areas [6, 7]. In this sense, the analysis

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**Table 1** The adopted analytical framework (the author)

Urban dimensions	Variables	Analytical techniques
Morphological dimension	Local and global measures Pattern of integration Intelligibility and synergy measures	Axial mapping
Functional dimension	Difficulties of movement Local and global accessibility Patterns of movement	Survey and interview
Perceptual dimension	Sketch map analysis	Sketch map
Social dimension	Social cohesion Safety level Types of social activities	Survey and interview

will focus on the urban pattern of the Assiut's Historic Core to disclose its unique features and how these features can contribute to enhancing the city structure. In the following section, different approaches addressing the analysis of urban patterns will be discussed to map out the analytical framework used in this paper.

## 2 Building the analytical framework

The features of the urban pattern were the subject of many approaches that addressed the urban design arena. Morphological studies, for example, focused on the historical transformation of the urban pattern and how the socio-economic aspects influenced these transformations [4]. In this sense, these studies aimed to understand urban form by mapping the different phases of the transformations that, together, produced it and to disclose the factors and processes that shaped and influenced these transformations [5]. Recent studies have expanded on this approach, incorporating digital technologies to enhance the analysis of urban morphology [6, 8–13].

Focusing on the spatial configuration<sup>1</sup> of the urban pattern, Hillier and Hanson introduced their theory of space syntax [14]. According to the theory, analyzing a given settlement's spatial structure will reveal its urban form's morphological features and the social relations can be mapped [14–16]. Also, the configuration of a given settlement's spatial structure will influence how its inhabitants and visitors use and perceive it [17, 18]. In this sense, Hillier contends that only this configuration influences other aspects of urban

patterns, such as movement patterns, land use distribution, and intelligibility [19].

On the other hand, several studies focused on the perceptual features of the urban pattern [20, 21]. Sketch mapping technique was used to reveal the visual features of the urban pattern. Later, several strategies and classifications were used to analyze the sketch maps and determine their types [22–24]. For example, Appleyard classified the sketch maps into two main types: sequential and spatial [24]. Streets represent the main instrument in the sequential type that organizes users' sketch maps, while buildings take this role in the individuals' sketch maps in the spatial type. The use of sketch maps to reveal the perceptual aspects of urban settings is widely acknowledged in many recent studies [25–27]. Simultaneously, several studies addressed the social dimension of the urban pattern, such as the degree of safety and the connection between urban context and social life in public spaces, highlighting how street-level features can promote social interaction and enhance safety perceptions [28–31]. Also, the social cohesion among inhabitants and the availability of necessary vs. optional activities represent two important social values [32–34]. From the above review, four interrelated urban design dimensions can be mapped out, namely, the morphological dimension, the functional dimension, the perceptual dimension, and the social dimension Table 1. Each dimension's analysis will be conducted individually for this paper's analytical purpose. However, the conclusion and discussion section will address their interrelated nature because of the importance of integrating these dimensions in a holistic approach to urban design and planning [1, 34].

## 3 Methodology

The methodology in this paper depends on a case-study approach, focusing on analysing the Assiut's Historic Core. This analysis will tackle the abovementioned four dimensions. Space syntax techniques (axial mapping) will be used

<sup>1</sup> The spatial configuration expresses the inclusive network of spatial relationships within a settlement, addressing how all spaces interconnect and interact. Conversely, to simple spatial relations that focus on the connection between two spaces only, spatial configuration offers a holistic view of the spatial interactions across the entire settlement or context.

to reveal the morphological features of the historic area as space syntax analysis has been acknowledged to investigate the latent features of historical pattern and their relation to functional patterns [35]. For axial analysis purposes, the map of Assiut's Historic Core was reviewed on the ground to check its accuracy, and later, it was digitized. The axial mapping of the case study was implemented using the cut-off model (analyzing Assiut's Historic Core without its surrounding areas) to disclose its inherited features. However, the analysis of Assiut's Historic Core within its surroundings (the embedded model) was used when necessary.

The axial mapping technique was conducted using "Depthmap" and "Mindwalk" software. The control, connectivity, and local integration measures will be used to highlight the most important streets and destinations at the local level. The global integration and integration core measures will be used to highlight the most important streets at the global level and the ability of the area to link itself with the surrounding context. Finally, intelligibility and synergy measures will be used to identify the legibility level of the Assiut's Historic Core and its importance with the city's spatial structure [17, 36]. Detailed definitions of these measures can be found in Appendix A.

Methods of questionnaires, interviews (semi-structured interviews), and observations (recording pedestrian and vehicular movement through 37 checking points (gates) were used to disclose the functional, perceptual, and social features of Assiut's Historic Core. The selection of questionnaire and interviews samples adopted a simple random sampling method in which Assiut's Historic Core was divided into several clusters where equal respondents/interviewees were chosen randomly. The number of the collected questionnaires is 33, while the interviews are conducted with five persons. The sample is relatively small due to the constraints of time and accessibility to the respondents and interviewees. The structure of the questionnaire and interviews focuses on the functional dimension (difficulties of movement, degree of accessibility, and pedestrian and vehicular movement patterns), the perceptual dimension (sketch map analysis (frequency of streets and buildings, and sketch map types), and the social dimension (social cohesion, safety level, and social activities). This multi-dimensional approach aligns with recent studies emphasizing the importance of integrating various aspects of urban experience in heritage area analysis [1, 2]. The SPSS program was used for the questionnaire's statistical analysis, while the thematic analysis of the interviews was conducted using ATLAS software. The triangulation between the results of different methods—mixed method approach—(axial mapping, questionnaires, observations, and interviews) is expected to address threats of validity and reliability [37, 38]. Table 1 summarizes the adopted analytical framework of this paper in terms of the

addressed urban dimensions, the associated variable, the analytical techniques, and the investigated features.

## 4 The analysis of the heritage area

### 4.1 Defining the case study

Assiut, one of Egypt's oldest cities, traces its origins back to 4000 B.C. when a modest settlement was founded on the Nile's west bank in an area elevated enough to avoid flooding [39]. The city's significance stems from several factors: its central position among the governorates of Upper Egypt, its control over key transportation routes connecting northern and southern Egypt, and its prominence in education, being home to the two largest and oldest universities in the region—Assiut University and Al-Azhar University. Also, several studies have highlighted the significance of Assiut's heritage in sustainable urban development. For instance, Elnokaly and Elseragy examined the potential of sustainable urban regeneration in Egyptian historic centers, using Assiut as a case study [40]. Located 375 km south of Cairo, Assiut sits at 27° 10' N latitude and 31° 10' E longitude. The city is bordered by the Nile River to the east and north, while the Dorunka Mountain and agricultural lands define its western and southern edges, respectively Fig. 1.

The current case study (Assiut's Historic Core) is a part of the Gharb Al-Balad district and represents the oldest part of Assiut City Fig. 2. The case study has a triangular shape surrounded by three streets: 26<sup>th</sup> July St. at the north, Al-Methaq St. at the east, and Al-Seka Al-Gadeda St. at the south. The area has two main squares: Al-Mogahden Square and Al-Magzob Square. Three streets, 26<sup>th</sup> July St., Al-Qesarya St., and Al-Seka Al-Gadeda, represent the commercial streets, and Al-Souq (the market) represents the leading commercial square. The average width of the main peripheral streets is 16m, while the average width of the inner streets is 6m. The average height of the buildings is three floors. The layout has several historical, religious, and commercial buildings, mainly concentrated alongside Al-Qesarya St. Figure 2.

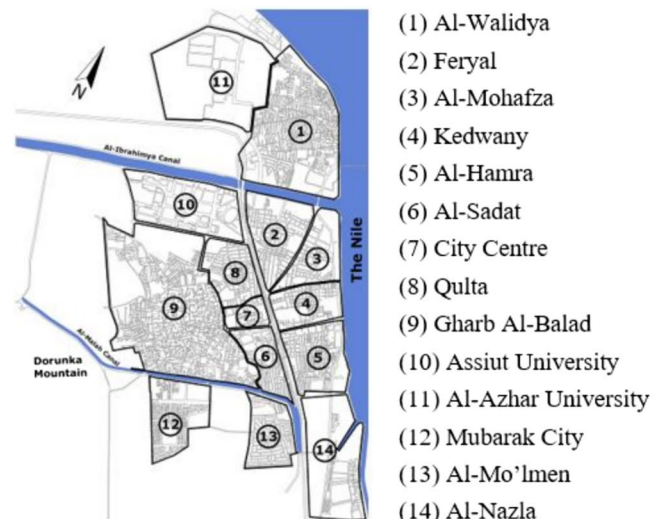
### 4.2 Morphological (spatial) analysis

#### 4.2.1 Local and global measures (syntactic values)

Maps of local measures show that boundary streets and thoroughfares have the highest connectivity, local integration, and control values Fig. 3. This indicates that these streets, in addition to Al-Qesarya St., exert a high control over the inner spaces in the spatial structure of the heritage area. Also, these streets represent the main distribution of movement and the attraction paths for public buildings



(a) Assiut location in Egypt



(b) Different districts in Assiut

Fig. 1 Map of Assiut City [41]

and activities. On the other hand, the majority of the inner streets have the lowest values in local maps (highlighted in blue in Fig. 3).

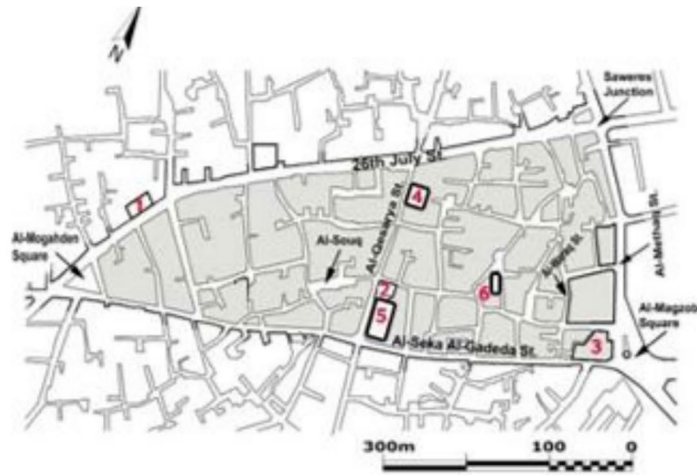
Global integration maps show that boundary streets and Al-Qesarya St. captured the highest integration values in Fig. 4a, c. In this sense, boundary streets, in addition to Al-Qesarya St., have a twofold role: linking internal spaces with each other and linking the whole pattern with its global context. Conversely, the inner streets represent the segregated spaces in the spatial structure. This occurs because inner streets do not directly connect with the main streets due to their features: shortness and dead ends. These features assist in reducing the connectivity of the inner spaces and increase their depth, segregation, and privacy.

#### 4.2.2 Pattern of integration

The top 10% integration core is shown in Fig. 4b, d. The shape of the integration core, which in this case takes the form of a penetrated core, reveals two essential characteristics. First, the heritage area depends on its peripheral streets and Al-Qesarya St. to link itself to its context. Second, Al-Qesarya St. penetrates its spatial structure and links its inner spaces with the peripheral streets. However, Al-Qesarya St. does not link many spaces directly with the peripheral streets because few spaces are found alongside its path. In addition, these few spaces are connected to a small number of spaces, while most inner spaces are located farther away from—more steps away—Al-Qesarya or the peripheral streets. In this sense, the highly integrated streets themselves experience difficulty in linking with the inner spaces, which sustain their privacy. Considering that these highly integrated

streets are responsible for connecting the whole pattern to its context, the heritage area has a low ability to integrate with its surroundings.

**4.2.2.1 Intelligibility and synergy measures** Figure 5 shows the intelligibility and synergy values of the current pattern in its cut-off and embedded models. Intelligibility and synergy values in the cut-off model, 0.597 and 0.871, respectively, are higher than their corresponding values in the embedded model, 0.381 and 0.785. However, the intelligibility value, particularly in the embedded model, is low compared to other urban patterns in Assiut [42]. As a result, it is expected that users of the current pattern may find it challenging to construct a good mental image. The steep and tightly interwoven character of the spaces of the current pattern in the scattergram proposes the heritage area as a distinctive area in the city structure Fig. 5d. In the actual context, the current pattern represents the old trading center of Assiut City. This indicates that the heritage area sustains its importance in the city structure. Thus, the site attracts high movement rates and land uses (see Figure). To sum up, the morphological analysis produces two main results. First, most axial lines (spaces) are distinguished by their short length and dead ends. These features reduce the integration between the inner spaces and main streets, which link the heritage area to its context. As a result, this area has a low ability to integrate with its surroundings. Second, the boundary streets and thoroughfares represent the most important streets in the spatial structure of the heritage area. This aligns with the real situation. The boundary streets and Al-Qesarya St. represent the context of commercial and social activities and are the busiest streets in the heritage area.



The Historical area within Gharb Al-Balad district

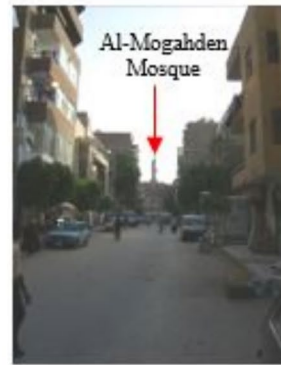
- |                             |                        |
|-----------------------------|------------------------|
| 1- Al-Mogahden Mosque       | 2- Sedy Galal Mosque   |
| 3- Al-Magzob Mosque         | 4- Public bath (HAMAM) |
| 5- Trading centre (WEKALA). | 6- AL-Kashef Mosque    |



Al-Seka Al-Gadeda St.



26<sup>th</sup> July St.



26<sup>th</sup> July St.



Al-Qestarya St.

**Views from main streets**



Al-Souq place



Al-Maqrabi alley



Sedy Galal alley



Al-Kashef mosque and square

**Views from inner streets**

Fig. 2 The layout of the Assiut's Historic Core and views from its streets (The Author)

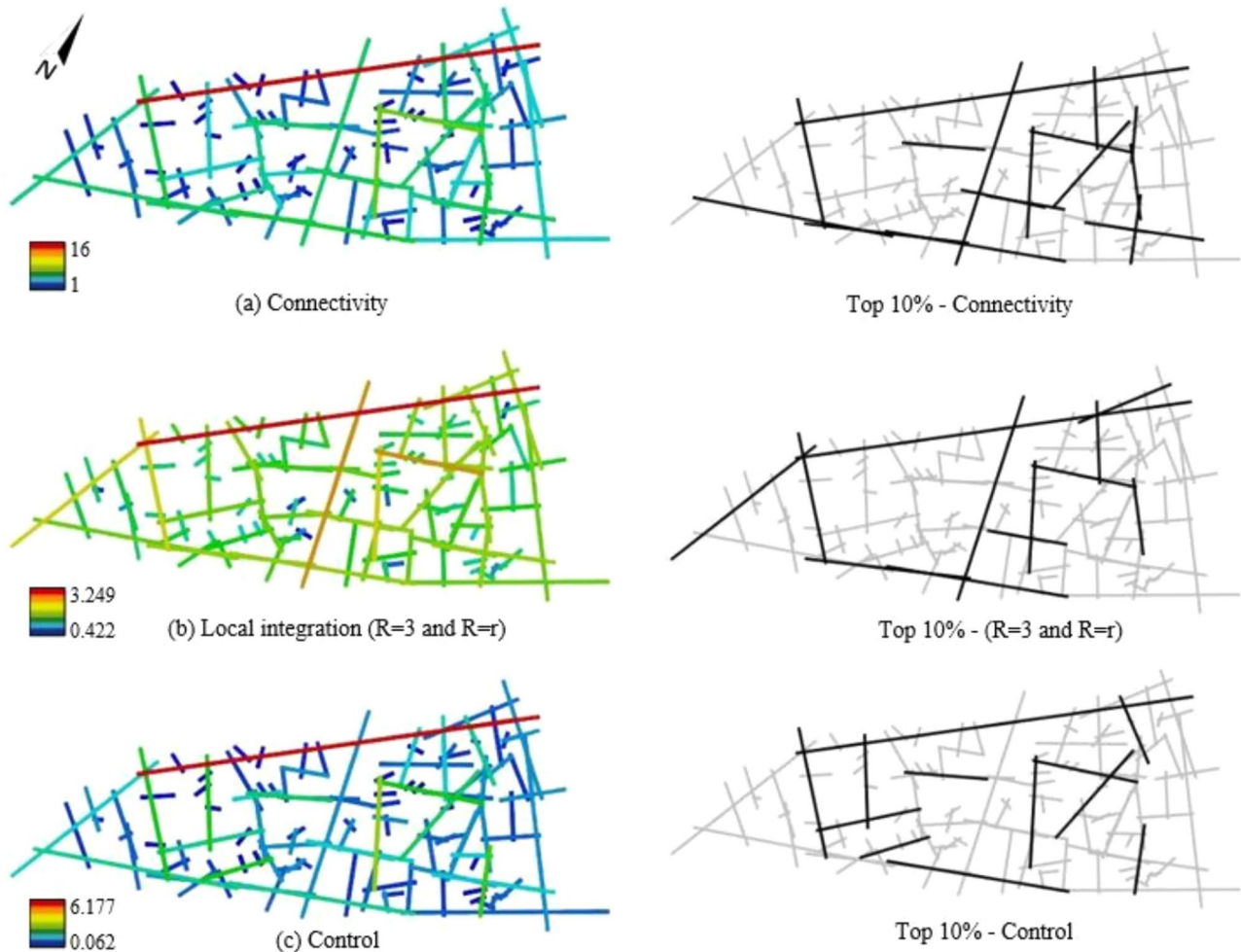


Fig. 3 Maps of local measures of the case study and their top 10% (The author)

### 4.3 Functional analysis

#### 4.3.1 Difficulties of movement

The respondents of the questionnaire determined three main difficulties: the narrow and winding nature of streets (73%), the large number of street intersections (67%), and the unlevelled nature of streets (52%) Fig. 6. However, the respondents reported that the difficulty of unlevelled streets is found in the inner spaces, not the main ones. They noted that it is challenging to use cars in inner streets, which forces them to use the boundary streets of the heritage area, which are typically crowded. This shows that the spatial structure of the heritage area seems unadoptable to the new requirements of the inhabitants (using cars). In actuality, vehicles have considerable difficulty going through the inner spaces of the heritage area. This may seem acceptable to raise the sense of safety and privacy for the inhabitants, but, on the other hand, it could obstruct the emergency services.

#### 4.3.2 Local and global accessibility

Addressing local accessibility, the majority of respondents reported that the current pattern has either 'very good' or 'good' local accessibility. In contrast, 19.4% reported that the current pattern has 'poor' local accessibility Fig. 7. Considering the global accessibility, most respondents indicated that the current pattern has either 'very good' (52%) or 'good' (33%) accessibility. Alternatively, 12% of the respondents indicated that the current pattern has 'poor' accessibility, while 3% reported having a 'very poor' global accessibility. Alternatively, all respondents reported that the current pattern has either 'very good' or 'good' accessibility to the main streets and public transport Fig. 7.

Going to the interview analysis, all five participants said that the current pattern has good local accessibility, while most of them reflected on its poor global accessibility. They reported four reasons for this poor global accessibility: narrow streets, unlevelled streets, unpaved

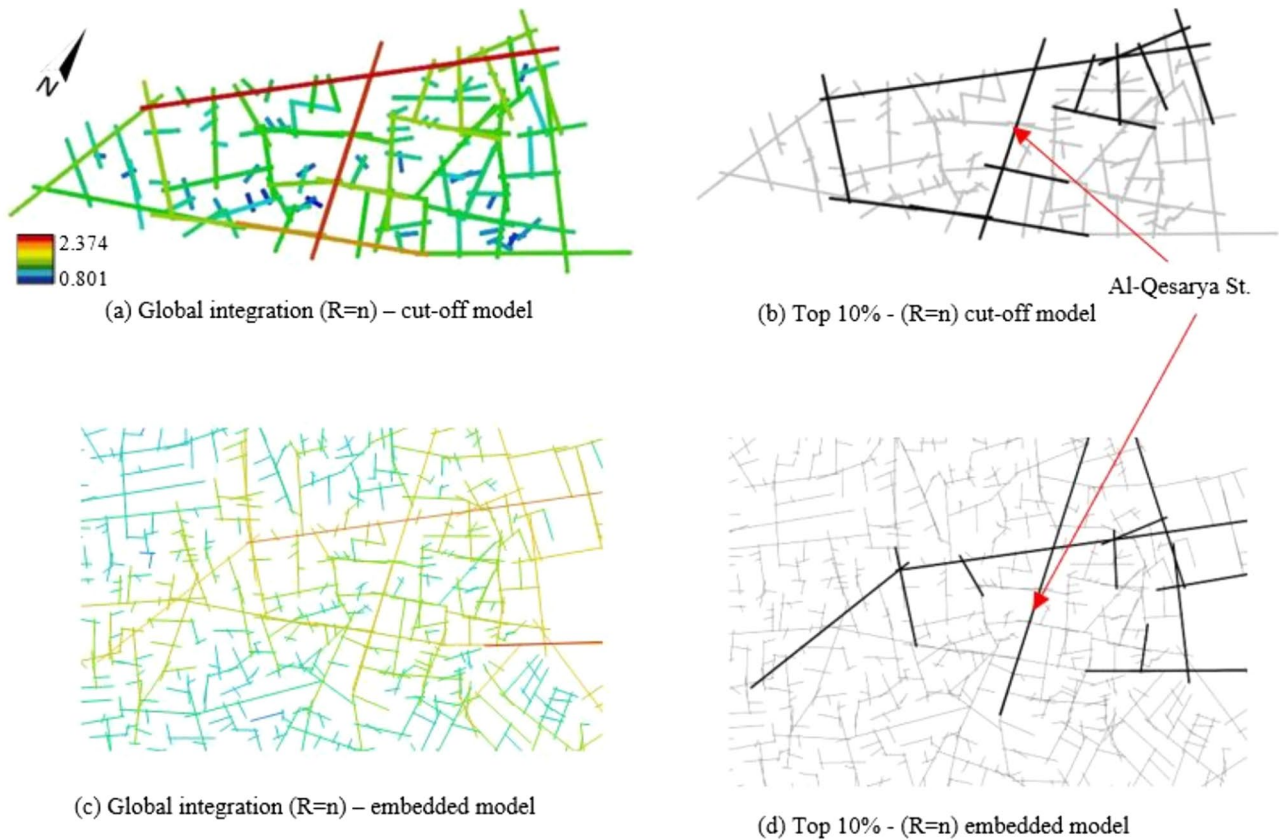


Fig. 4 Maps of global integration of the case study and their top 10% (The author)

streets, and overcrowding. Also, they noted that narrow and unlevelled streets represent the main obstructions that reduce vehicular accessibility. Regarding accessibility to main streets and transport, all participants said that the current pattern has good accessibility.

Comparing the questionnaire and interview results, there are some contradictions concerning global accessibility. The majority of questionnaire respondents reported that the current pattern has good global accessibility, while the majority of interviewees reflected on its poor global accessibility. It seems that the respondents to the questionnaire did not consider their area to be poorly connected to its surroundings because of its good accessibility to main streets and public transport, as confirmed by all respondents.

### 4.3.3 Patterns of movement

The pedestrian movement shows that the peripheral streets, in addition to Al-Qesarya St., have the highest movement

rates, while the inner streets captured low movement rates Fig. 8a. Only Al-Souq1 St., which leads to the market, captured a high movement rate because of its commercial status. Regarding car movement, the peripheral streets are associated with high levels of movement, while the inner streets are primarily related to low levels of movement Fig. 8b.

The interfaces of males, females, and children usually occur in highly commercial streets such as Al-Seka Al-Gadedda and Al-Souq1 streets Fig. 8c. However, some segments were dominated by the occupation of specific groups. For example, the eastern boundary of the current pattern is occupied by females; males occupy the northern segment of Al-Qesarya, while children mainly occupy some inner spaces. This distribution of different categories is related to the morphological and social characteristics of the current pattern. Regarding the pedestrian-vehicular interface, peripheral streets represent the only context in which this interface takes place Fig. 8d.

Briefly, the functional analysis produces several results. First, narrow and unlevelled streets represent two critical

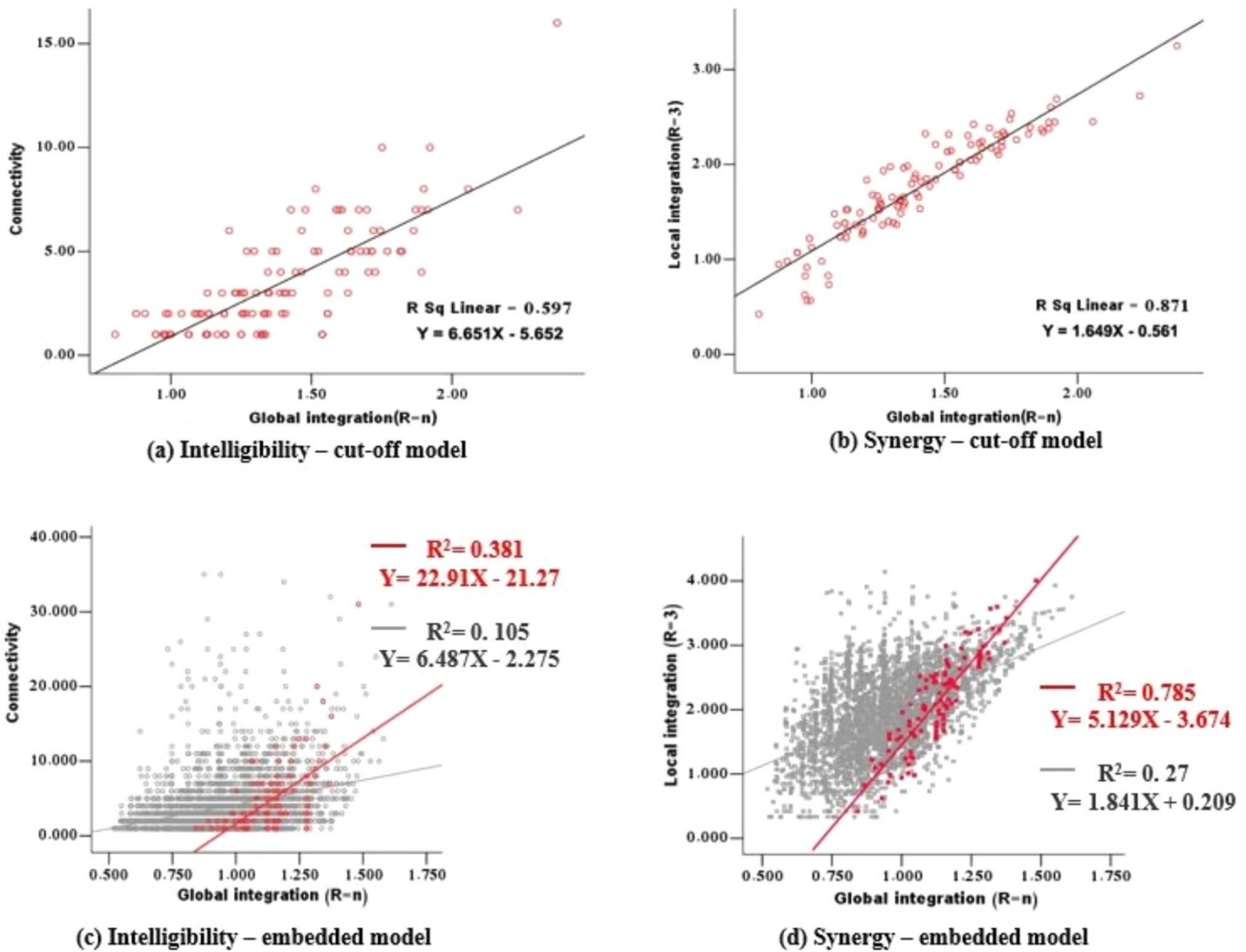
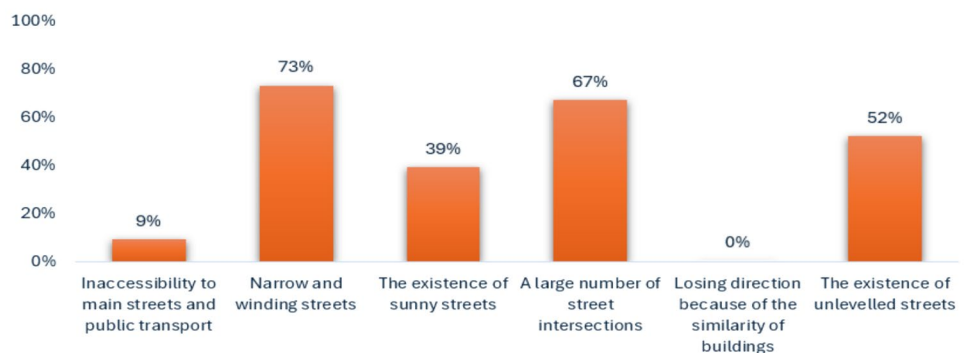


Fig. 5 Scattergrams of intelligibility and synergy of the heritage area in its cut-off and embedded models (The author)

Fig. 6 Difficulties of movement—questionnaire analysis



factors reducing smooth movement and accessibility. Second, the heritage area has good local accessibility and low global accessibility. Finally, maps of movement patterns show the importance of peripheral streets and Al-Qesarya St. as the main attractors of both pedestrian and vehicular movements.

#### 4.4 Perceptual analysis.

##### 4.4.1 Frequency of streets and buildings

Figure 9 shows the street frequency as it appears in the sketch maps of different respondents. Notably,

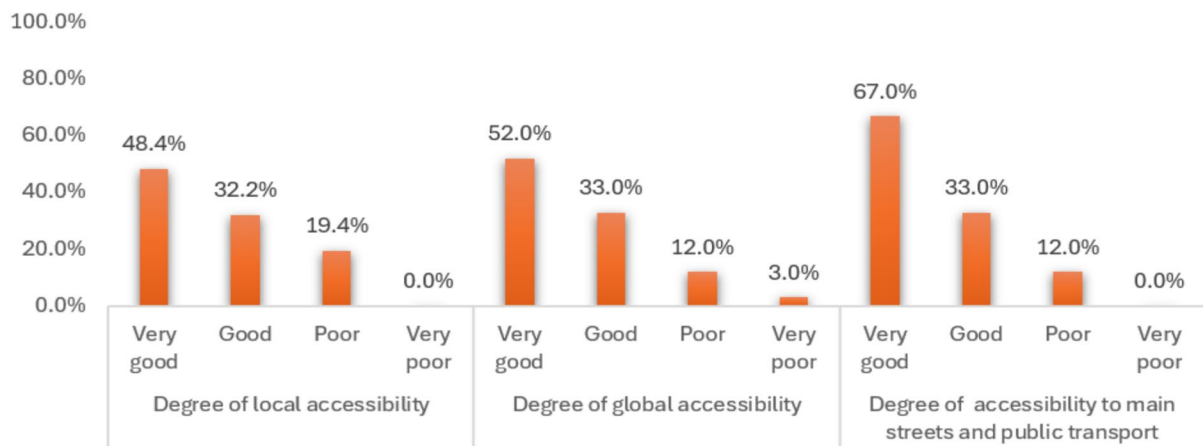


Fig. 7 Degree of accessibility—questionnaire analysis

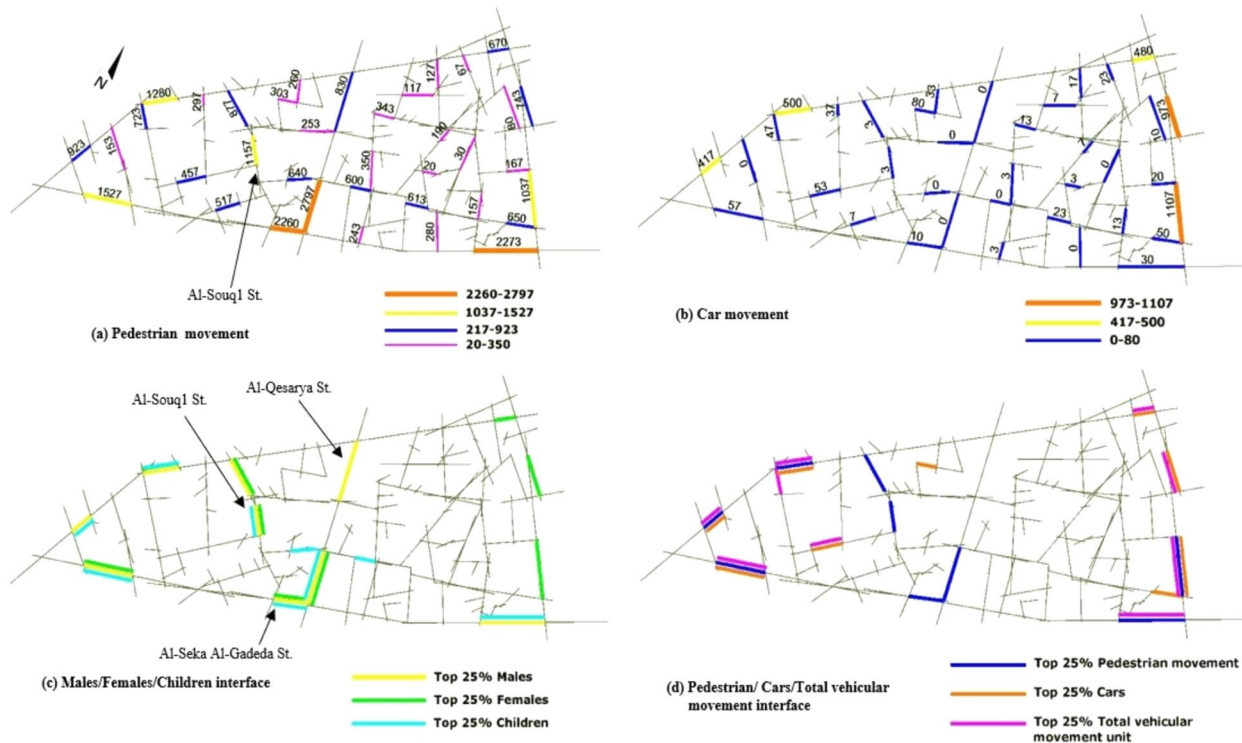


Fig. 8 Movement patterns across the layout of the heritage area (observation analysis—37 gates)

thoroughfares and straight streets captured high-frequency values in the sketch maps. These high-frequency streets are also distinguished by their mixed land uses and divergence from peripheral streets. Alternatively, dead-end, winding, and mainly residential streets captured low-frequency values Fig. 9a.

The building frequency map is shown in Fig. 9b, in which only two buildings, Al-Khairya School and Al-Magzob

Mosque, captured an equal high-frequency value (65%). Other buildings, however, show low-frequency values (40% or lower). The building frequency map reflects several features. First, most buildings appearing in the sketch maps are located on the main streets or at the intersections between main and secondary streets. Second, buildings capturing high-frequency values are sited alongside the streets, which captured high frequencies in the accumulative map Fig. 10.

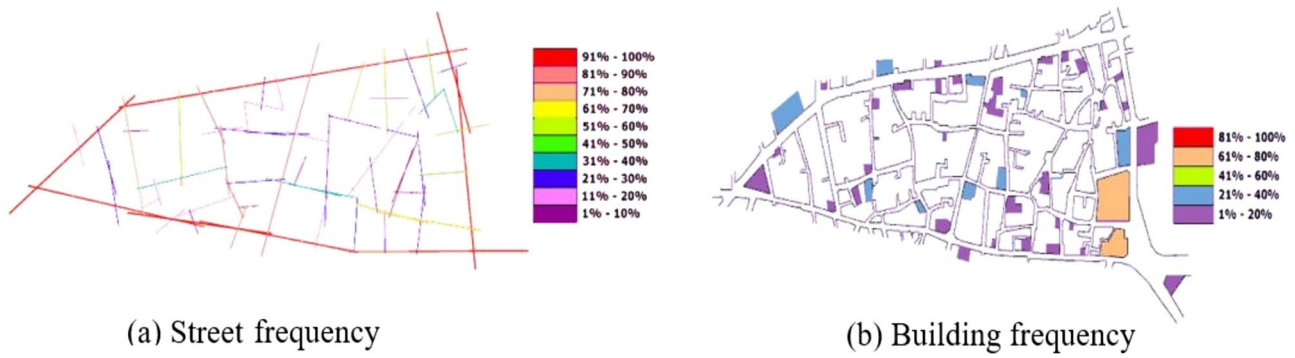


Fig. 9 Streets and buildings frequency maps – (Questionnaire analysis)

Fig. 10 Building frequency map vs. street frequency map (top 25%) (The author)



Table 2 Types of sketch maps (questionnaire analysis)

	Map types			Total
	Sequential	Spatial	Mix	
No. of respondents	11	0	12	23
Frequency (%)	47.8	0	52.2	100

4.4.2 Types of sketch maps

As shown in Table 2, 52.2% of the respondents adopted sequential and spatial types in their sketch maps, while 47.8% only adopted the sequential type. None of the respondents, however, adopted the spatial type only in their sketch maps. This reflects the dominance of the sequential type, highlighting the significant role of streets as a structural instrument of the current pattern. The supremacy of sequential type occurs due to the nature of the urban blocks of the heritage area, which are distinguished by their large size and the continuity of their boundaries, which decreases the opportunity of having individual buildings in the current spatial structure. Consequently, not many buildings can be perceived as autonomous entities in the current pattern,

which stimulates the respondents to use them as reference points.

In summary, the perceptual analysis of the current pattern produces two main results. First, main and straight streets represent the structural instrument used by individuals to navigate their environment. Second, the respondents found some difficulty recognizing most dead-end streets in their sketch maps.

4.5 Social analysis

4.5.1 Social cohesion

Regarding the social cohesion among inhabitants, the majority of respondents reported that the social ties are either “strong” (67%) or “medium” (24%). However, 9% of the respondents reported that the social relations among inhabitants are “weak.” Respondents who indicated that the social relations among inhabitants are strong indicated several reasons for these strong relations: closeness of buildings (90%), existence of dead-end streets (77%), similarity of living standards (77%), low density (13%) and availability of social gathering places (3%). Alternatively, respondents who

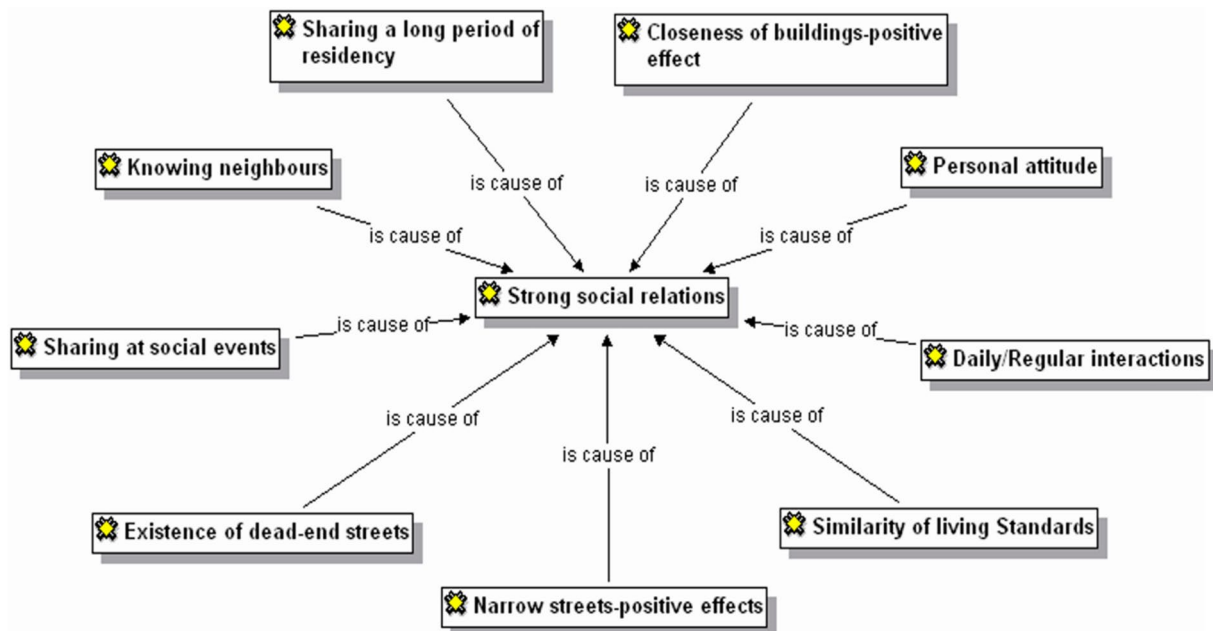


Fig. 11 Reasons for good social relations among the inhabitants—interview analysis

reported that social relations are weak identified several reasons: shortage of gathering places (67%), existence of many street intersections (67%), remoteness of buildings (33%), diversity of living standards (33%) and high density (33%).

In the interview analysis, all the participants confirmed strong social relations among inhabitants. They reported several reasons for these strong relations in Fig. 11. Among these reasons, three are related to the pattern features: the closeness of buildings, dead-end streets, and narrow streets. The participants explained that those three reasons enhance their daily interaction with their neighbors and help them to be updated with their neighbors’ news.

4.5.2 Safety level

Respondents were asked if they felt safe when walking in their area. Most of them (79%) reported that they felt safe ‘all the time.’ However, 18% of the respondents reported feeling safe ‘during the day only,’ while 3% did not feel safe at all. Among those who reported that they did not feel safe either during the night or at all, 57% of them identified vacant streets as one of the reasons for their feeling unsafe. Other reasons included remoteness from the main streets

(29%) and the existence of lengthy and winding streets (14%). Furthermore, respondents identified three places as unsafe areas: the northern part of Al-Qysaria St., Al-Souq, and Al-Waraq St.

Turning to the interview analysis, three participants confirmed that they felt safe all the time, and two reported that they always felt unsafe at night or all the time. The participants identified the same unsafe places reported above and provided several reasons that reduce the safety of these places. In the case of the northern part of Al-Qesarya St., the participants stated that youths who sit in coffeeshouses upset passersby, females in particular. In the case of Al-Souq and Al-Waraq St., they reported that their vacant nature at night makes them unsafe places. These places are vacant at night because of the nature of their land use and spatial features.

4.5.3 Social activities

Regarding the heritage area’s social activities, shopping and passing captured the highest percentage (73%) Table 3. Other activities identified by respondents were meeting (70%), sitting (64%), children’s play (33%), and walking (3%). The interview analysis produced similar results

Table 3 Social activities that occur in the layout of the heritage area (questionnaire analysis)

	Meeting	Shopping	Walking	Children’s play	Sitting	Passing
No. of respondents	23	24	1	11	21	24
Frequency (%)	70	73	3	33	64	73

and determined three places where these social activities occur: streets, coffeehouses, and mosques. They reported that streets are the main places where most social activities occur. Also, mosques are reported as being the main places where people can meet and sit with each other daily. Coffeehouses are reported to be the main gathering places for specific categories: unemployed youths and elderly people. In this sense, coffeehouses represent particular places in which social interaction occurs. However, the coffeehouse has two roles. On the one hand, it represents a meeting place for some people, encouraging social interaction and putting eyes on the streets. On the other hand, coffeehouses can be considered a threat to certain social groups, such as females. This explains why some responses to the questionnaire and from interviews identified Al-Qesarya St., which has many coffeehouses, as an unsafe street:

"Most people who sit there [at coffeehouses] are either unemployed youths who cannot find work or elderly people ... I think these coffeehouses become a place to gather outlaws" (Participant #1)

In summary, the social analysis gives several results. First, the current pattern maintains the privacy of its inner spaces, which helps increase the strength of social relations among inhabitants. Second, some streets have been identified as unsafe. Finally, the pattern lacks open and gathering spaces where social activities can be implemented.

## 5 Discussion and recommendations

The spatial configuration of the current pattern has a significant influence on its function. The morphological importance of peripheral streets and Al-Qesarya St. coincides with their functional importance as the main commercial streets. Alternatively, the frequency of dead-end features of inner spaces reduced their accessibility, particularly for vehicular movements. Thus, movement by car in the current pattern from one space to another can only be accomplished using peripheral streets and a few thoroughfares, increasing the traffic load on these peripheral streets. Also, the heritage area's spatial configuration compared to the whole city's configuration shows its distinctive location in the city structure Fig. 6d. This distinctiveness maintains the functional importance of the heritage area as a commercial center, particularly on its peripheral streets and Al-Qesarya St. This explains the usual crowding along the main streets of the current pattern.

At the same time, the heritage area's spatial characteristics once influenced their perception. The high-integrated streets capture high values in the sketch map, while dead-end streets with low integration values did not appear

amongst high-frequency streets. Also, the spatial configuration of the current pattern has a vital role in enhancing social relations among inhabitants through its segregated, dead-end, and narrow streets. Furthermore, it enables the inhabitants to control their interface with strangers. In this sense, the main and peripheral streets represent the inhabitants-strangers interface, while inner spaces represent the inhabitants-inhabitants interface in which they can sustain their privacy. However, the segregation of some inner streets, such as Al-Waraq St., led to their identification as unsafe streets. Also, highly integrated streets represent the primary context of different social activities; for instance, the most popular meeting places, coffeehouses, are primarily found on the main streets. However, there is an apparent contradiction in terms of global accessibility between questionnaire respondents and interviewees due to differences in perception. While the questionnaire's respondents assert the ease of access to main streets and transport, the interviewees reported that narrow and unpaved streets hinder vehicular movements. These insights highlight the importance of integrating quantitative and qualitative methods to offer more nuanced interpretations of the spatial and social dynamics of heritage areas. The key characteristics of the urban pattern of the Assiut's Historic Core are summarised in Table 4.

From Table 4, the heritage area, with its unique features and historical buildings, can work as a focal point within the city structure, enhancing its characteristics. However, several recommendations should be considered to alleviate the inclusion of the heritage area in the development process of Assiut City:

To reduce the block size of non-historical buildings to increase inter-accessibility on the one hand and decrease the depth of the spatial structure on the other. The deep structure of the heritage area and its surroundings led to the identification of their district (Gharb Al-Balad) as one of the worst two districts in Assiut City [42].

Increase the integration of the heritage area with its surroundings by focusing on the development along the main spins of the pattern. This can increase the accessibility between the area and its environs. Also, the primary spin, which has historical buildings, can be the main spin in the whole district and can work as a visual reference in the spatial structure of the district and the city. This can maximize tourism activity and finance the conservation process of the heritage area [43]. However, the surrounding areas (non-sensitive areas) should be as shallow as, or shallower than, the heritage area in terms of spatial structure to absorb the bulk of movement and to reduce the land use transformations in the heritage area. Otherwise, the concentration of movement and land uses in the heritage area can threaten its sustainability.

**Table 4** The main features of the urban pattern of the Assiut’s Historic Core (The author)

Dimensions	Variables	Main features
Morphological dimension	Local and global measures	<input type="checkbox"/> Boundary Streets and Al-Qesarya St. represent the main links with high local and global values <input type="checkbox"/> Most inner streets have the lowest local and global values
	Pattern of integration	<input type="checkbox"/> Penetrated integration core <input type="checkbox"/> Relatively introverted structure, which exercises high control on the inhabitant-stranger interface <input type="checkbox"/> Low ability to integrate with its surroundings
Functional dimension	Intelligibility and synergy measures	<input type="checkbox"/> High intelligibility and synergy values (cut-off model)
	Difficulties of movement	<input type="checkbox"/> Narrow and winding streets <input type="checkbox"/> A large number of street intersections <input type="checkbox"/> The existence of unlevelled streets
	Local and global accessibility	<input type="checkbox"/> There is considerable difficulty regarding local and global accessibility <input type="checkbox"/> Good access to main streets and public transport <input type="checkbox"/> Unlevelled streets reduce the global accessibility (vehicular movements)
	Patterns of movement	<input type="checkbox"/> Boundary streets and Al-Qesarya St. captured the highest movement rates <input type="checkbox"/> Inner thoroughfares represent the context of the pedestrian interface, while main street intersections represent the context of the pedestrian-vehicular interface
Perceptual dimension	Sketch map analysis	<input type="checkbox"/> The dominance of boundary streets and thoroughfares on the sketch maps <input type="checkbox"/> The dominance of the sequential type
Social dimension	Social cohesion	<input type="checkbox"/> A good social relation among inhabitants results from the features of urban patterns (dead-end and narrow streets and segregation of inner spaces, which sustain their privacy)
	Safety level	<input type="checkbox"/> It has a safe layout but has some unsafe streets
	Social activities	<input type="checkbox"/> Both optional and necessary activities take place

Besides maintaining the privacy and safety features of the inner space, their physical features (width and pavements) should be reviewed to adapt to modern requirements (accessibility of emergency services).

From the above analysis and recommendations, the proposed framework can be adopted in urban planning policies by leveraging its four dimensions to guide the conservation and development process of heritage areas. The morphological dimension highlights the key streets, buildings, and spaces for preservation, while the functional dimension addresses accessibility challenges. The perceptual dimension reflects the visual legibility and highlights the areas of improvement that help smooth navigation and enhance the identity of the areas. The social dimension highlights the importance of preserving social cohesion and safety. Thus, through the integration of these dimensions, urban planning policies and local authorities can ensure heritage areas contribute to sustainable development including tools such as space syntax and participatory approaches to foster inclusive, well-integrated urban regeneration and urban development of our cities. Also, this study’s findings emphasize the ongoing debate supporting the inclusion of heritage into the broader sustainability spectrum [1, 44, 45]. Furthermore, using space syntax in this study revealed the spatial configuration features of walkability, accessibility, and community

interaction that represent key pillars of sustainable urban development. In this sense, the notion of heritage areas as assets rather than constraints, as the author advocates, urban policies can leverage their exclusive features to promote sustainability and tourism aspects.

## 6 Conclusion and contribution

The current paper highlights the importance of the spatial configuration of historic areas in shaping their functional patterns. This was evident in the historic core of Assiut City, where highly integrated streets, which evolved over time, now serve as central commercial and social hubs, which aligns with Fareh & Djamel view that spatial configuration resulting from historical development substantially influences current movement patterns and functional allocation [46]. Alike, Roders, and van Oers highlight how preserving historical elements can boost cultural tourism and strengthen local identity [1], echoing the continued role of historical religious and commercial buildings along Al-Qesarya St. in the city’s identity. Also, the use of space syntax methodology in this paper to offer nuanced insights into the link between historical urban patterns and contemporary functionality aligns with Kropf’s stressing that the

implication of advanced technologies in analyzing urban morphology, providing more accurate tools for identifying how historical changes shape current use patterns [6]. Thus, the current research proves the efficiency of space syntax methodology in disclosing the latent features of historic urban patterns and their relationship to functional patterns. This emphasizes the role of spatial configuration in shaping human behavior and movement patterns and aligns with cities as movement economy theory [47].

The main contribution of the current research is its proposal of a holistic framework that integrates four interrelated urban design dimensions: morphological, functional, perceptual, and social. This multi-dimensional framework provides a more thorough understanding of urban heritage areas, combining quantitative techniques with qualitative methods that offer a more nuanced and robust analysis of urban heritage areas. This mixed-methods approach helps to address potential validity and reliability threats in urban studies. Thus, the current research introduces a novel analytical framework that combines established urban analysis techniques with contemporary digital tools, providing a replicable methodology for studying other urban heritage areas globally. Also, the current research, by focusing on Assiut, Egypt, adds to the limited literature on urban heritage in non-Western contexts, particularly in Middle Eastern cities, contributing to a more diverse and global understanding of urban heritage conservation. This highlights the framework's potential for broader application, offering a universal approach to studying and preserving urban heritage areas across diverse cultural and geographical settings.

## Appendix (A) definitions and terms of axial analysis

**Axial line:** a straight sightline that is possible to follow on foot.

**Axial map:** depicts the least number of the most extended axial lines covering all convex spaces of a layout or a building and their connections.

**Connectivity value:** calculates the number of immediate neighbors directly connected to a space (axial line). Connectivity is a local measure.

**Control value:** measures the degree to which a space controls access to its immediate neighbors, considering the number of alternative connections each of these neighbors has. Control is a local measure.

**Deep structure** refers to the structure in which its spaces have many steps (turns) from each other. The graph of such a system has a tree-like graph, and its mean depth value is high.

**Global integration value ( $R = n$ ):** describes the average depth of a space (axial line) to all other spaces in the spatial structure.

**Integrated vs. segregated spaces:** integrated spaces refer to those spaces that have the lowest number of steps from all spaces in the spatial structure (marked in red and orange in integration maps), while segregated spaces are those spaces that have the highest number of steps from all spaces (marked in blue and dark blue in integration maps).

**Integration core** refers to the most integrated spaces (axial lines) in the spatial structure. Integration core can be mapped as a specific proportion of the most integrated spaces in the system, such as the top 5%, top 10%, or top 25%.

**Intelligibility value:** intelligibility refers to the ability to predict the global spatial structure through the local properties of its individual spaces. Intelligibility value can be measured by examining the correlation between connectivity as a local property and integration as a global property. High correlation values indicate that the system is likely to be Intelligent, while low correlation values indicate that the system is likely unintelligible.

**Local integration value ( $R = 3$ ):** describes the average depth of a space (axial line) to all other spaces located three steps away from this space.

**Mean depth value:** The mean depth of a space (axial line or convex space) is the average depth of this space from all other spaces in the structure.

**Radius-Radius integration ( $R = r$ ):** describes the average depth of a space (axial line) to all spaces located 'r' steps away from this space. The number of 'r' equals the minimum mean depth of the system from the most globally integrated axial line. For example, if the minimum mean depth of a system from its most globally integrated axial line is 5, then radius-radius integration is equal to R5. Radius-radius integration is designed to reduce the edge effect for any system under investigation.

**Shallow structure** refers to the structure in which its spaces have fewer steps (turns) from each other. The graph of such a system has a 'bush-like' graph, and its mean depth value is low.

**Synergy value** refers to the correlation between local integration ( $R = 3$ ) and global integration ( $r = n$ ). Synergy value is used in the part-whole analysis to identify a system's most distinctive areas (focal areas). In this analysis, through a scattergram showing the distribution of global integration vs. local integration, the regression lines of different areas are compared with the regression line for the whole city. Areas with high synergy values and well

clustered in the scattergram represent the focal areas in the city (Hillier, 1996).

**The edge effect** refers to the tendency of the edges of the spatial structure to be different (be segregated) from the interior areas because of their juxtaposition to the edge.

**Funding** The author declare that no funds, grants, or other support were received during the preparation of this manuscript.

**Data availability** Data will be made available at a reasonable request.

## Declarations

**Conflict of interest** The author have no relevant financial or non-financial interests to disclose.

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