

# The Effect of Morphological Changes on the Urban DNA Structure in the Historical City Centers: Al-Kadhimiya Historical Centre in Iraq

Sally Fakhri Khalaf Abdullah<sup>1</sup>, Mohammed Mahdi Hussein<sup>2</sup> & Noor Hadi Alsaffar<sup>3</sup>

Department of Architecture Engineering, College of Engineering, University of Baghdad, Iraq.

Department of Architecture Engineering, College of Technical Engineering, Al-Farahidi University, Iraq.

s.fakhri@coeng.uobaghdad.edu.iq

dr.mohammad.mahdi@alfarahidiuc.edu.iq

n.saffar1104@coeng.uobaghdad.edu.iq

## Abstract

Many historical centers have undergone changes that have affected their urban structure as a result of the pressures they experience. Some of them have been caused deliberately by the urban interventions while others have accumulated over time. Often, those accumulated over time are not taken into consideration, in either conservation or development practice.

This paper employs the idea called the Urban DNA Structure (uDNAs) in historical centers and examines how the uDNAs and their elements can be affected by the morphological transformations in them. It is based on the premise that Local Urban Spaces and Organic Streets (LUSOS) are some of the basic elements that contribute to the formation of uDNAs in historical centers and the improvement of the quality of urban life.

Undoubtedly however, there is a lack of knowledge about the changes in the uDNAs of the structures of the historical centers due to the morphological changes. This has affected that structure, particularly the elements of LUSOS. The study aims to identify the changes in the uDNAs due to the changes of the structures of their basic elements represented by the LUSOS which in turn would have affected the morphological changes.

The study uses the space syntax method to analyze the two morphological phases to identify the changes of the Al-Kadhimiya Historic Center in Iraq. The results emphasize the importance of the Local Urban Spaces (LUS) to be effective, attractive, and human-friendly urban spaces and the process of changing their structure and functions affecting the Organic Streets (OS) and therefore the uDNAs in the structures of the historical centers.

**Keywords:** Historical City Centers, Urban DNA Structure, Local Urban Spaces, Organic Streets, Morphological Changes. Al-Khadhimiya

## Introduction

A city is a gathering of physical structures consisting of masses (buildings) and spaces (open spaces) that are directly and dynamically affected by the political, economic, environmental, social, and cultural changes of its inhabitants. Undeniably, they have an impact on the vitality of those components (Carmona, 2010; Najah et al., 2023). All livable cities have their own unique characteristics expressed through their own structures and spaces (streets and public spaces). Thus, it can be argued that livable cities have their own genetic codes or DNA structures, which can be identified as the urban DNA structures or the uDNAs. These constitute the physical characteristics of a city structure and make them different from the other cities.

Understanding the role of the uDNAs in the urban fabric could ensure their proper physical growth and continuity, as buildings are linked through characteristics and relationships. Streets and public urban spaces are linked to each other to ensure the continuity and flow of the movements through them. This suggests that cities that are affected can recover if any issues of their uDNAs are resolved (Al-Dulaimy and Al-Alwan, 2011; Crowhurt and Lennard, 1995).

uDNA is one of the innovative concepts used to describe the basic urban structure and the unique and common characteristics of those elements. It can be employed to understand the different elements that restrict the performance of the urban system. It is also the functions that must be available in shaping the future scenarios thus proposing the optimal urban form. It has been pointed out that each city has its own DNA, which is how a city becomes distinct from the others (Shallal & AL-Alwan, 2012; Wu & Silva, 2011).

Urban DNA is frequently studied to describe how the space composition of a region develops and predicts the space forms it takes during the evolution. Thus, a behavioral classification of cities can be developed according to their DNA (Votsis & Haavisto, 2019; Lee, 2017; Al-Khafaji & AlKledar, 2015).

It is noted that LUSOS in the historic centres of Baghdad have been subjected to change in their forms due to the construction of roads and the changes in the land use resulting from the urban interventions or basic designs. This has led to the destruction of large parts of the compact urban organic fabrics and thus significant changes in the urban structures of the historical centres. The research analyses the morphological changes in one of the historical centres in Baghdad (the historical centre of Al-Kadhimiya): a city that originated around the Kadhim shrine that was subjected to various removals of its urban fabric or the construction of the roads there. These have led to the change of the uDNAs of the region and thus have affected the structure LUSOS in which vital, attractive and human-friendly spaces exist.

This research focuses on the transformations of the uDNAs of the urban structures of historical centres due to the morphological changes. The study aims to identify the changes in the uDNAs due to the changes of the structures of their basic elements represented by the LUSOS which in turn would have affected the morphological changes.

## The Theoretical Basis

This paper is based on the premise that the spatial structure of a historical center consists of Local Urban Spaces and Organic Streets or LUSOS, which are vital components of the uDNAs of a historical center, subjected to changes due to morphological changes. According to Crowhurt and Lennard (1995), the uses, effectiveness, or attractiveness of these spaces are transformed and thus their structures change to meet the contemporary and future needs and lifestyles, affecting the uDNAs of the historical centers. The LUSOS are vital physical spaces and attractive social areas that have been cumulatively formed in the urban structures of historical centers providing breathing spaces in the traditional urban fabric. As Whyte (2003) shows, they are surrounded by buildings and other facilities, thus playing an important role in the overall composition and organization of the public urban spaces of historical centers. The relationships and associations between the LUSOS within a historical center form a system linked to the dynamic relationships between a space, shape and function of these spaces and their relationships with the surroundings. LUSOS are part of the uDNAs; i.e. within a relational system with each other, with the surroundings and with the city as a whole. These relationships,

in turn, affect the pattern of people using the LUSOS and in the formation of places of assembly and positive social interactions (Memluk, 2013).

The main properties of the LUSOS in a historical center are social proximity. LUSOS represent the social spaces that are constructed in a deliberate or structured manner and are linked to the physical context of the historical center and achieve a hierarchy at a global level. Local open spaces are small spaces that give a sense of viability of these spaces so that the users interact positively with them. This achieves social convergence as well as the association of space occupants with each other as space-social groups. According to Hussein (2014), LUSOS are the urban spaces that support and maintain the social life in a historical center.

The second property is Urban Integration which is based on the inter-connectedness of the coherent patterns of the urban fabric and the space organization of LUSOS, as they are topically distinct continuous spaces that reflect social spaces; namely the system of space movement and daily journeys between parts of the historical centers (Hussein, 2014).

The third property is connectivity that represents communication or interdependence. It is a fundamental generator of the compact urban form of a historical center, as the space evidence of the LUSOS between the components of the urban system, represented by paths, nodes, and relationships between them. They in turn lead to the integration and communication of the system and thus achieve the highest positive impact on the urban evidence of the historical centers (Abdullah & Al-Alwan, 2019).

The last property is safety which means that the LUSOS provide a sense of privacy of space to its inhabitants by achieving the hierarchy of the structure of the historical center. The adoption of containment and enclosure at the local level gives the inhabitants a tendency to defend space. The gradation of spaces in-between (public-private) at the global level (Hussein, 2014), thus achieves a mixed, diverse, vibrant, and automatically occupied spaces and a spatial structure which in turn creates a sense of security for the users of that environment (U.N. Habitat, 2020).

## Literature Review

Numerous studies have dealt with the uDNAs and their importance in understanding the urban structures of cities, and the possibility of their development according to the capabilities offered by their own compositions. The principles on which the cities designed have succeeded in achieving a cultural, vital, and environmental balance are those principles forming the uDNAs of those cities (Major, 2013; Dan and Rampuria, 2017). Dan and Rampuria (2017) point out that by decoding the uDNAs code, it is possible to understand the spatial network local analysis and the commonalities between the spatial structures, thus achieving and designing flexible and efficient networks (Dan & Rampuria, 2017). Moreover, Major (2013) says that uDNAs generate a true understanding of the urban form, whether it is organic (distorted networks) or geometric (regular networks), and this generates a clear difference between the forms and the processes. In other words, this difference exists between the form of an urban structure and its method of work, and also between the static, stable and dynamic formations of urban spaces because it is directly related to social life (Major, 2013).

Other studies have focused on the effects of uDNAs on the urban intervention processes. Urban intervention or design is more logical if the uDNAs model of the city to be developed is identified and diagnosed. The uDNAs are a set of absolute concepts that control the relationships and basic functions in design (Li et al., 2022; Kaya & Bolen, 2017). In fact, Li et al. (2022) and Kaya & Bolen (2017) point out that the best way to understand the analytical approach of the uDNAs is to consider urban design as a combination of several diverse elements due to their diversity in space, time, and spatial scale, as uDNAs represent the distribution of the changing urban patterns (Li et al., 2022; Kaya and Bolen, 2017). Research shows that uDNAs help in understanding the urban processes. If the urban interventions are designed and studied, and they are on a large scale of the urban structures, they won't be complex. If the urban interventions are cumulative and unplanned, and they are on a smaller scale and affect a small part of the urban structure, they will create more complex urban patterns. Kaya and Bolen

(2017) show that by understanding the uDNAs, it is possible to control the growth and expansion of settlements and their density (Kaya and Bolen, 2017).

There are also some studies which have reviewed the importance of uDNAs for the purpose of distinguishing and showing the local morphological characteristics and features and their differences at many levels of the urban structure, with a focus on the size and geometry of the urban structure plans (Hanna, 2012; Bafina, 2012). Bafina (2012) shows that distinguishing between the (DNA) genotype and the phenotype as found in living organisms leads to the emergence of sociotypes and stlyotypes in urban design, which contributes to the interpretation of the spatial characteristics of the urban structures (Bafina, 2012).

Studies have also focused on the relationship of uDNAs to the movement in urban settlements, through urban networks and their impact on the pedestrian movements (Spring, 2017; Al-Saaidy & Alobaydi, 2021). According to Spring (2017) and Al-Saaidy and Alobaydi (2021), urban networks are the main generators of pedestrian movements. They are the starting points for developing the urban structures by identifying the generated and transformed parts and the fixed and preserved parts (Spring, 2017; Al-Saaidy & Alobaydi, 2021).

These studies examining uDNAs have concluded several aspects that can be summarized as follows:

- \* Most of the studies have focused on the importance of uDNAs in understanding the urban structures, which generates more effective interventions and smarter solutions for the forms and processes, and thus for the urban formation and configuration.
- \* Some studies have focused on the importance of the uDNAs in organizing the movements and activities in the urban structures.
- \* There is a limited knowledge about the occupation of urban spaces, especially the LUSOS with buildings, which has affected the uDNAs of the cities and exceptionally the historical city centers.

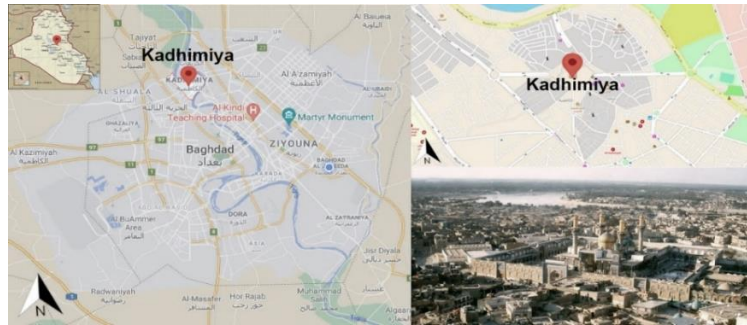
From the above research, one can define the research problem as the lack of knowledge about the changes in the uDNAs of the structures of the historical centers due to the morphological changes. These have affected the structures, particularly the elements of the LUSOS, which are among the basic elements of the structures of the historical centers. LUSOS are assumed to be some of the basic elements that have influenced the changes in their structures on uDNAs and thus on the morphological changes of the historical centers.

## Research Methods

This paper deals with the study of one of the historical centers in Baghdad (Al-Kadhimiya Historical Center), as LUSOS in the study area were filled with the modern buildings, which have affected the structures of the region. The paper relied on the space syntax technology in order to detect the changes in the uDNAs, by analyzing two morphological stages.

## The Case Study Area

The study area is located in the northern part of Baghdad, bordered to the East by the Tigris River. It is called Al-Kadhimiya relative to the shrine of Imam Musa bin Jaafar (Al-Kadhim). It has taken a circular shape, with a diameter (0.5) km and estimated with an area of 60 hectares because of its growth around the shrine. The area is characterized by a compact organic urban form consisting of buildings and urban spaces (the main axes leading to the shrine, organic streets, and local urban spaces, (Fig. 1), (The Town Planning Office For The Master Plan of Baghdad, 1967).

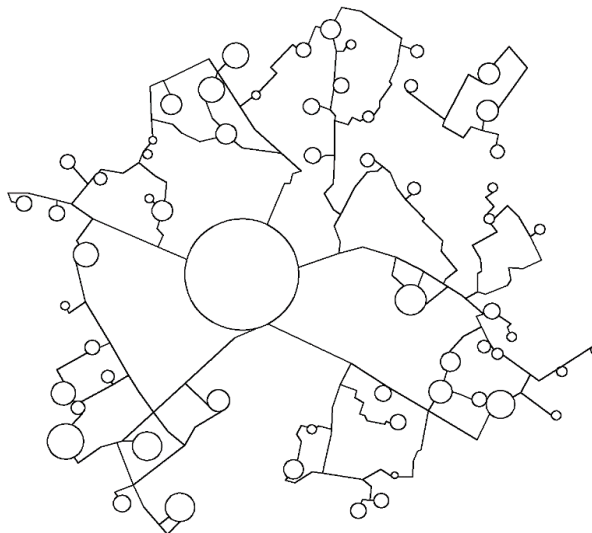


**Fig. 1:** (a) Baghdad map and Al- Kadhimiya location (b) Al-Kadhimiya location map and Aerial view of Kadhimiya. Source: Wikimapia & <https://www.google.com/maps/@33.3121598,44.431404,11z>

The research deals with two morphological phases to detect the change in the uDNAs of the study area: the first phase was in 1920, before the urban interventions, and the second phase is at present.

### The First Morphological Phase (1920)

The urban fabric around the shrine has adopted a cohesive and compacted pattern that has not undergone significant radical changes. This pattern has come in line with the natural conditions of the area, social and religious aspects of its inhabitants and the construction techniques available at the time. The uDNAs of Al- Kadhimiya is represented by the traditional organic fabric and the space structure, characterized by the gradual open spaces of the private spaces of the traditional houses and by the semi-private narrow winding organic streets and then semi-public LUS to the public space. The main open square on the holy shrine and the main axis (Fig. 2, Fig. 3a & Fig. 4) is where many commercial units are located, and these axes meet in the town center (Kareem, 2011).



**Fig. 2:** uDNAs of old Kadhimiya in 1920.  
Source: Author.

### The Second Morphological Phase (Present Time)

The urban shape of the study area has been radically changed by the removal of the buildings around the shrine, which began in the 1980s, with 9 hectares of historical urban fabric removed and replaced by the modern multi-story buildings. The removals have created a large urban space around the shrine where the place could not be distinguished and recognized. They have also created destruction of the human scale of the ancient urban fabric. The construction of the modern roads have led to a change in the movement system and space system in the study area, as the main movement at the site has been the movement of cars leading to the shrine



intersecting with the pedestrian traffic. These methods have also caused the link between the semi-private and private spaces directly with the public space, which has affected the privacy of the inhabitants (Fig. 3b & Fig. 4 b) (Warren, 1982).

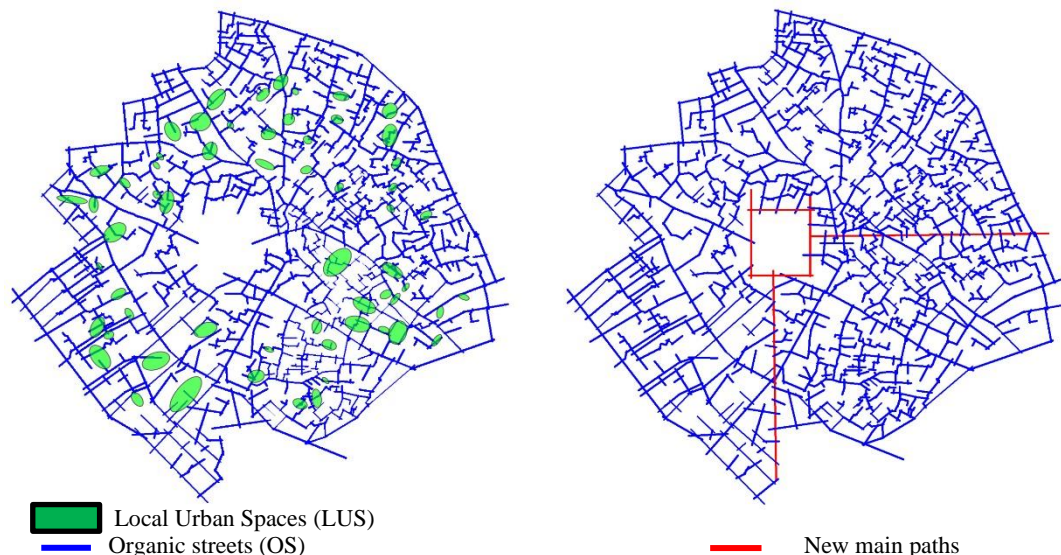
In fact, the dominance of the region's commercial uses around the shrine has led to the internal migration of the inhabitants from the traditional area to the edge of the city, and as a result, there has been a significant expansion in the area during this phase. This expansion has been not only horizontal but also vertical, as the number of floors of buildings has increased, especially in the central area, which has been characterized by the high cost of land (Abbas, 2018).

The network spaces in the old fabric are composed of three classes of spaces; first, the main commercial axes linking the center and its external borders, which are the most public spaces. Second, the narrow alleys that connect the main axes with the residential buildings, which are of two types: either connected axes (open ended) or cul-de-sacs which are semi-public spaces. Finally, there are the local open spaces that are used as temporary spaces for commercial exchange during the daytime and as social spaces (meeting and children's play) during the evening periods.



**Fig. 3:** (a) Aerial view of old Al-Kadhimiya in 1920 showing Traditional urban fabric (b) Al-Kadhimiya Currently after the establishment of the main wide streets.

Source: The Baghdad Municipality



**Fig. 4:** (a) Al- Kadhimiya in 1920 showing LUSOS. (b) Al- Kadhimiya Currently showing that all LUS replaced by new Commercial buildings and the establishment of new main streets.

Source: Authors.

### Data Collection

Data was collected by field surveys, maps and satellite images of the study area as shown in the Fig. 3, and tested in two morphological phases to identify the changes in the

uDNAs that have affected the LUSOS in the study area, according to the urban measurements of LUSOS Principles (Table 1):

- First Morphological Phase (1920), before the urban intervention
- Second Morphological Phase (present)

**Table 1:** Urban Measurements of LUSOS.

Source: Authors based on. (Hussein,2014; Abdullah and Alwan, 2019; U.N. Habitat, 2020).

| Principles of LUSOS | Urban Measurement | Indicators                            |
|---------------------|-------------------|---------------------------------------|
| Social Proximity    | Meeting Surfaces  | Interactions between users            |
| Urban cohesion      | Urban Integration | Integration of meeting surfaces       |
| Continuity          | Connectivity      | Relationships between paths and nodes |
| Safety              | Hierarchy         | The hierarchy from public to private  |
|                     | Territory         | Control of space                      |

### Measuring Tools

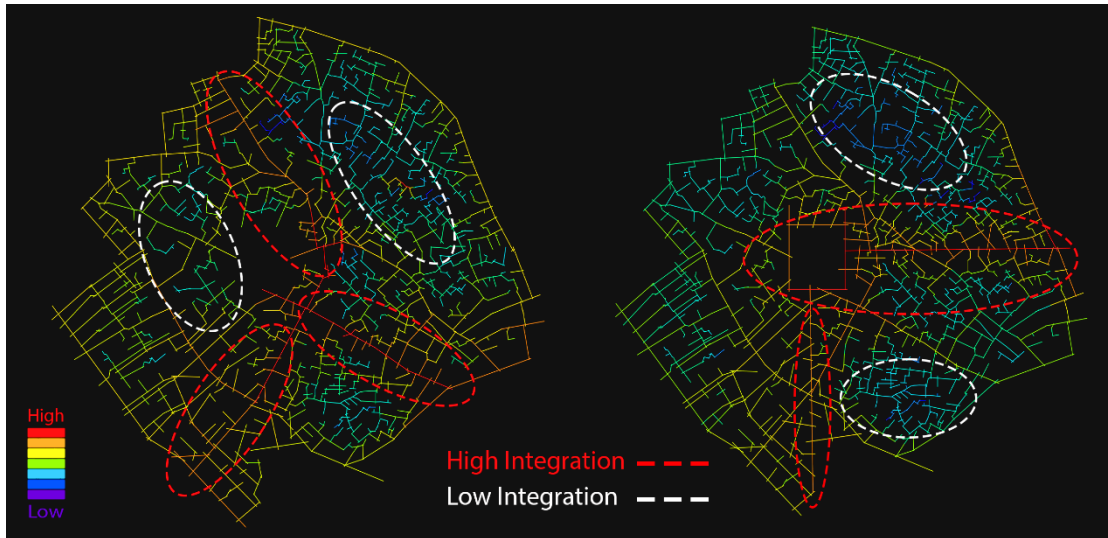
The configurational analysis of the study area was conducted using depthmapX net 0.35 to determine the change in the uDNAs of the area through graph analysis of the axial map. The program calculates the values of the compositional properties according to the following phases:

- Draw the axial map using AutoCAD-2020 for each phase (the 1920s and the current time). Use the longest and lowest number of possible pivot lines, the lines don't cross any physical element.
- Calculate the values of the structural properties (global integration, local integration, connectivity, control and choice), and then calculate the Pearson Coefficient values to measure the correlation ( $r$ ) between relationships. Prepare graphs.

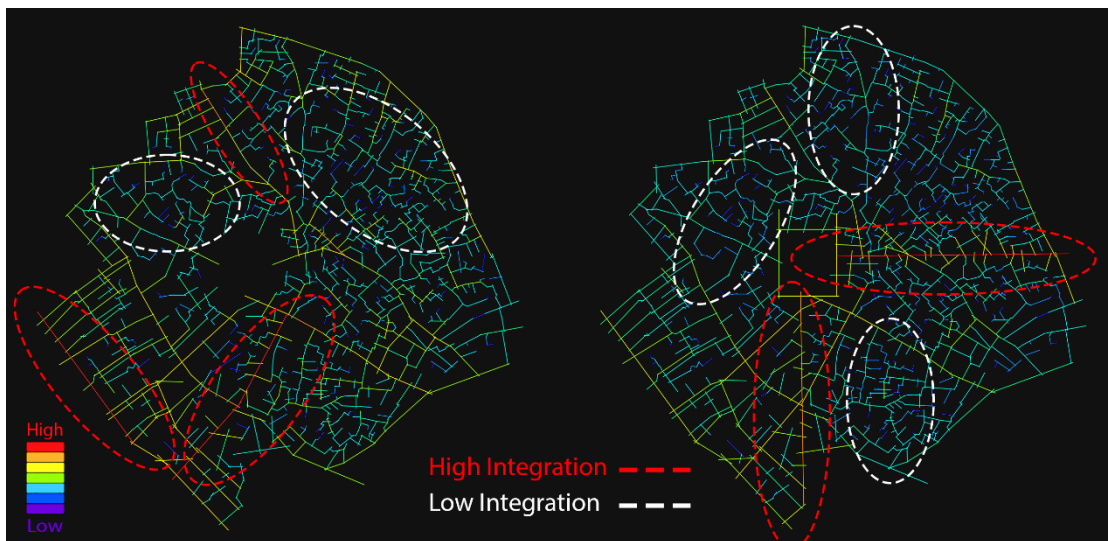
### Results and the Discussion

The research in the axial analysis deals with the morphological changes by conducting the phased structural analysis of the two morphological phases of the study area (Al-Kadhimiya Historical Center) and aims to identify changes in the uDNAs that have affected the LUSOS. The analysis of the two morphological phases shows the following results (Table 2):

- The first morphological phase shows that the LUS is located within the nucleus of global and local integration, as these spaces are used by the residents and strangers (visitors) and are spaces for positive interactions, movements, and public events. That will meet the surfaces between the local movement of residents extending within the residential districts and the global movement inside and outside the historical center. Local integration has been achieved because of its association with the events and activities related to the daily needs. While the OS are located within the residential districts and linked to spaces, LUS have high local integration. Therefore, they were used by the inhabitants. The deep spaces are isolated and used only by the residents. The integration index ranges from the highly integrated public main streets and decreases gradually to record its lowest value within the isolated residential areas, while OS in the second morphological phase has emerged more isolated due to the LUS exploitation in commercial uses (Fig. 5 & Fig. 6).



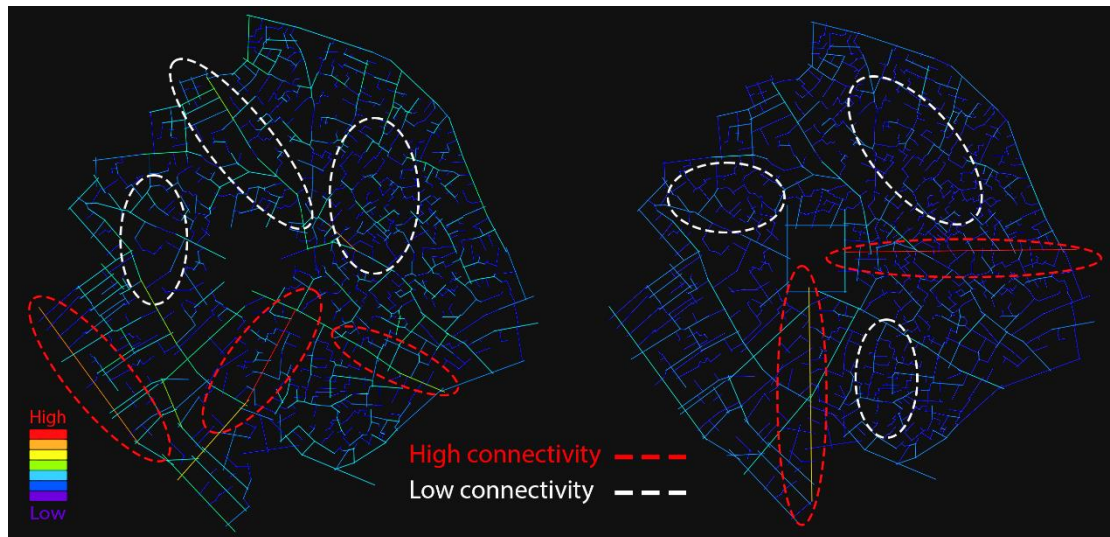
**Fig. 5:** Comparative analysis of global integration on the (a) first morphological phases and (b) second morphological phases of Al- Khadimiya historical center  
Source: Authors



**Fig. 6:** Comparative analysis of local integration on the (a) first morphological phases and (b) second morphological phases of Al- Khadimiya historical center  
Source: Authors

- The results of the connectivity analysis in the study area for the first morphological phase indicated that a strong connectivity nucleus was achieved in the main axes and OS axes associated with the LUS. These spaces indicate the cohesion and accessibility of the spatial organization of the region. The weak connectivity spaces have spread among those with high connectivity. The main axis of the study area achieved high connectivity, while the current phase indicated high connectivity only in the main axes of the study area (Fig. 7).

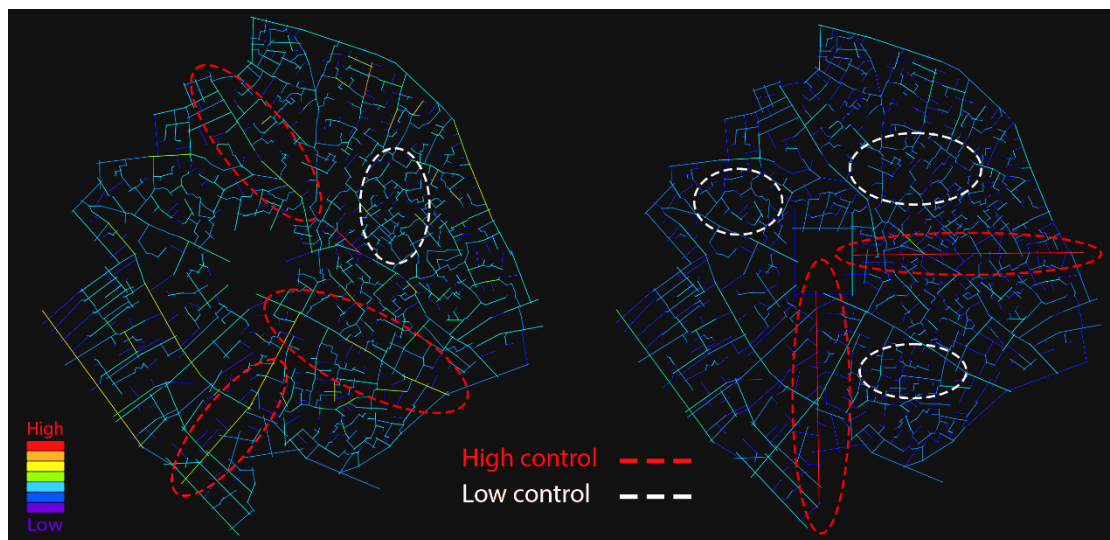




**Fig. 7:** Comparative analysis of connectivity on the (a) first morphological phases and (b)- second morphological phases of Al- Khadimiya historical center

Source: Authors

- The nucleus of global control consists of matching the nucleus of high control in the LUSOS of the study area with the nucleus of local integration and thus have a high Local Spaces Correlation with all parts of the space system in the first morphological phase. There is also a possibility of movement and mobility through its spaces to all parts of the space system as a result of its correlation with the public activities in the study area. While weak control nuclei were distributed among the strong control nucleus spaces within the residential districts, it is difficult to access these spaces from the other parts of the space system of the study area. Besides, many of these spaces do not provide a degree of choice to move to other spaces through it, while the analysis results of the current phase have shown a weak nucleus of control as a result of the weak local connectivity of OS (Fig. 8).

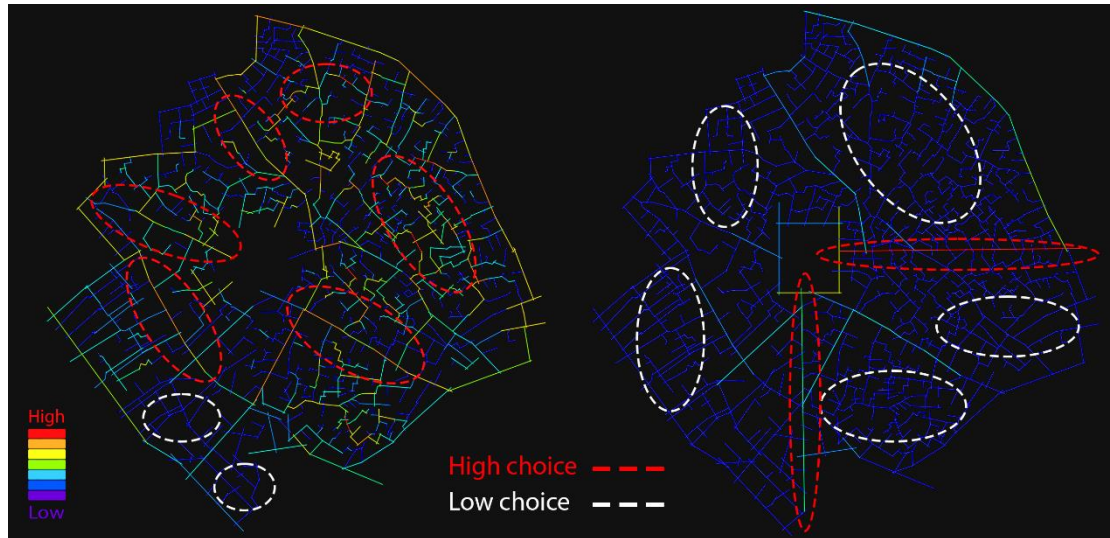


**Fig. 8:** Comparative analysis of control on the (a) first morphological phases and (b) second morphological phases of Al- Khadimiya historical center

Source: Authors

- From the axial maps of the second morphological phase, it is possible to note the transformation of directing the secondary movement axes OS within the old urban fabric to

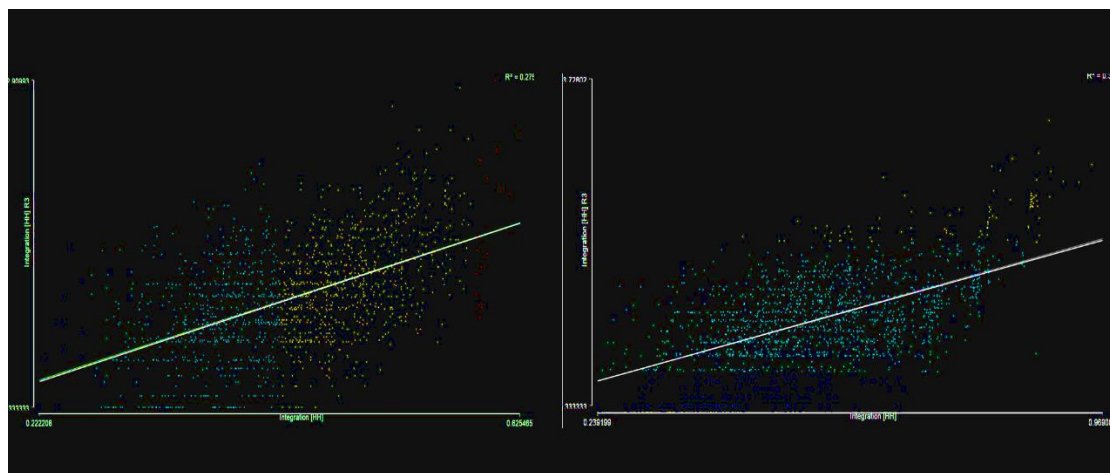
connect with the modern linear streets. There, the shift is based on the change in land use from the residential to the commercial. The LUS has been occupied with the commercial buildings, which has increased access to them. On the other hand, this change has led to many axes of the OS becoming deeper than they used to be, due to the disappearance of the hierarchy of the LUSOS. Many of the OS were linked with each other through the LUS spaces, but that interdependence disappeared because of the modern buildings that have occupied the LUS (Fig. 9).



**Fig. 9:** Comparative analysis of choice on the (a) first morphological phases and (b) second morphological phases of Al- Khadimiya historical center

Source: Authors

- The synergy indicator between global and local integration in both phases showed a weak correlation between the global and the local urban structure. It thus achieves a weak correlation between the local centers (secondary) and global structure (the main movement axes as indicated by the analysis) (Fig. 10).



Synergy = 0.275

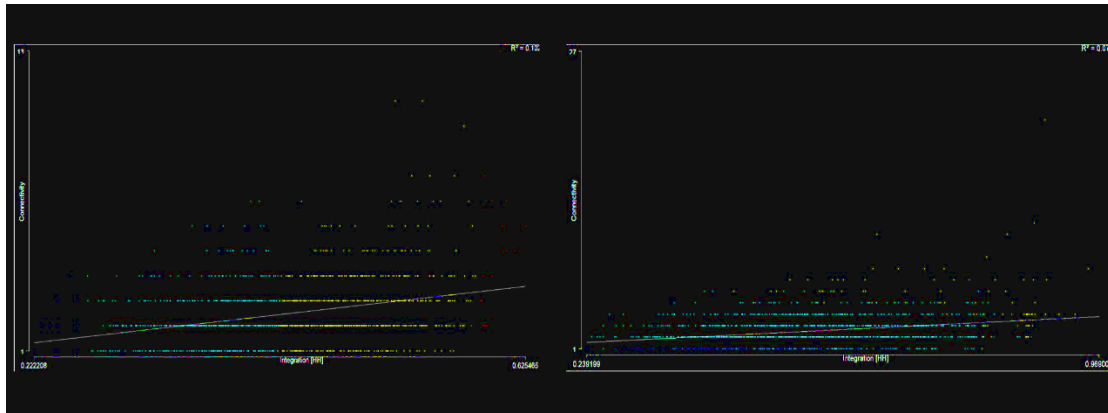
Synergy = 0.322

**Fig. 10:** Comparative analysis of synergy on the (a) first morphological phases and (b) second morphological phases of Al- Khadimiya historical center

Source: Authors

- The intelligibility factors in the spatial organization of the urban structure showed a lack of intelligibility of the space network, and this network cannot be realized from its local

characteristics, particularly in the current phase, as a result of the low space differentiation in the spatial organization of the urban structure of the study area. That is, the lack of intelligibility of the space structure formally and spatially (Fig. 11).



Intelligibility = 0.102

Intelligibility = 0.076

**Fig. 11:** Comparative analysis of synergy on the (a) first morphological phases and (b) second morphological phases of Al- Khadimiya historical center

Source: Authors

The research finds that the LUS for the study area in the first phase of the study are characterized by high local integration, and are linked by a strong relationship with the spatial organization of the structure of the Al- Khadimiya historical center. This is due to the nature of the compacted organic fabric of the study area, as well as the impact of OS permeability to the main axes of high global integration in the study area. This makes them vital and attractive spaces (livability) and include the daily activities of the residents.

**Table 2:** Results of the first and second morphological phases

Source: Author

| Criterion           | 1920     | Currently       |
|---------------------|----------|-----------------|
| Integration [HH]    | 0.609564 | <b>0.877598</b> |
| Integration [HH] R3 | 2.05892  | <b>2.95563</b>  |
| Control             | 4.16667  | <b>3.41667</b>  |
| Connectivity        | 2.5298   | <b>2.8190</b>   |
| Choice              | 3.91827  | <b>1.5705</b>   |
| Mean Depth          | 2.7381   | <b>2.84211</b>  |
| Number of Axes      | 1591     | <b>1575</b>     |
| Synergy             | 0.275    | <b>0.322</b>    |
| Intelligibility     | 0.102    | <b>0.076</b>    |

## Conclusions

This research has relied on the visual analytical system, and therefore differs from other recent studies that have used the metric systems in analyzing the historical city centers, (Al-Saaidy & Alobaydi, 2021)

- The urban structure represents a pattern of elements associated with each other in the internal relationships resulting from its own uDNAs and defines the fundamental features and elements of the structure. Any change or transformation of any element of the urban structure transforms the rest of the elements and relationships of that structure.
- Longer-lived urban structures (Al-Kadhimiya Historical Center) had their own uDNAs, and had acquired the ability to reproduce themselves and with deliberated changes or developments as a result of the assimilation of the uDNAs of the external and internal stimuli of the urban structure.

- uDNAs is an urban model produced chronologically and spatially in a coordinated and independent manner formed according to the urban structure. Understanding the spatial characteristics of the urban pattern is subordinate to the understanding the uDNAs, which contributes to the diversity of planning decisions and urban design and the improvement of the urban and space structure. It is the product of generative rather than determinable processes, and leads to the integration of an urban structure.
- uDNAs can be used to produce urban forms or urban structures that are an extension of the original structure and interact with it. They are compatible with the behavior of its inhabitants, as the morphological changes or modifications in space relations between the axes of movement OS and LUS that are not compatible with uDNAs lead to the separation of the relationship of these spaces with each other and to the isolation of them from their urban structures.
- Unexamined morphological changes have affected the social spaces of LUS of the historical centers, thereby diminishing their function as surfaces for the meeting between the residents and the users of the historical center. This furthermore affects the hierarchy of the spatial structure of the historical center.
- The change in the spatial structure of the historical center is due to the disintegration of the relational system of LUSOS due to the transformation of the function of LUS. This has made OS to appear as deep and unclear spaces.

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