Studying Sustainable Actions of Syntactic Structures of Historic Hit Citadel: A Morphological Approach

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Abstract. This paper examines the morphological changes of Historic Citadel in Hit, Iraq, in relation to the changes in syntactic properties of street networks and land use distribution during the last century. Founded before 1600 BC, Historic Hit Citadel (HHC) has been considered as one of the most important fortified cores in Iraq. It consists of a rich variety of urban structures representing different historic periods of the city history. However, HHC was continuously deteriorated by a lack of urban development programs and maintenance processes since 1900s. The study thus covers the three remarkable changes of HHC in order to find proper sustainable actions for developing this historic site and to promote programs of economic diversity as a sustainable agenda. Methods use space syntax techniques and measures to describe the accessibility and connectivity of street networks based on syntactic properties of the built environment. Generated maps of syntactic structures helped to identify the integration and segregation urban areas on the city map. A discussion of the implications of integration areas, needed to be improved, and segregation areas, required to be developed, was conducted. Results have shown where the integrated and segregated cores were located and so helped to provide general improvements by adopting new activities, developing the existing spatial quality of the built environment.

1. Introduction

Located on a small hill on the western bank of Euphrates River, the fort of Hit, or Historic Hit Citadel (HHC), that has a unique urban fabric with old organic historic patterns, see Figure 1. Since it is one of the oldest forts in Iraq \cite{1}, built to counter invasions and protect caravans' route for many years, the HHC housed various civilizations; Babylonian rule through 1792 to 1750 B.C, Assyrian rule through 1392 to 605 B.C, Abbasid rule through 750 C.E to 1258, Ottoman rule through 12\textsuperscript{th} to 19\textsuperscript{th} century, British rule from the early 19\textsuperscript{th} century to the formation of Iraqi Kingdom in 1930s, and finally the modern planning influences through the mid of 1950s to the present \cite{1}, see Figure 2.

Although the history of urban form of HHC and its relationship with the modern urban extensions was studied many times (including professional reports and academic diplomas or theses), the morphology of syntactic structures of street networks in relation to spatial developments and socio-economic manifestations has never been studied to get a comprehensive understanding of the urban configuration of HHC. This understanding can potentially help overcome the current and expected future urban problems driven from unplanned developments combining with the lack of development programs and maintenance processes, which the city is continuously facing.
Figure 1. The Location of Historic Hit Citadel in Anbar, Iraq. Source: Prepared by authors.

Figure 2. Important landmarks of Historic Hit Citadel. Source: [1] and Anbar Municipality.

In this perspective, many researchers studied citadels and fortified cities and covered many urban topics related to the formation and transformation processes. Mohammed and Alobaydi (2020) have introduced a schematic model derived from studying the remarkable morphological developments of HHC [1]. Kosambi and Brush studied three Indian port cities morphologically to drive a model of this type of cities. They analysed the formation phases and explained precisely the role of Colonial power in re-faming these cities [2]. Lepage has conducted a historical study that illustrated how the medieval castles and fortified towns were adapted to meet political agendas and weapons technology by using the architecture and landscape of fortifications [3]. Akram et al. discussed and described how strategic adapted actions that applied on the development processes of Aleppo and Erbil Citadels can share
some common urban and cultural aspects. They have compared the two cases based on the urban development strategy due to identifying the positive and negative features [4]. Although the previous literature has addressed the urban form elements and topics of citadels and fortified cities, studying the morphology of syntactic structures using space syntax approach due to identifying appropriate sustainable actions has not been addressed.

This paper is aiming at bringing the scientific analytical approach of Space Syntax to the case under investigation, on the street networks of HHC and its three distinct spatial patterns: compacted organic, hybrid, and gridded modern in order to identify the integrated and segregated areas, which will be subject for sustainable actions, see Figure 3. While integrated areas need improvement, the segregated areas require much effort to be improved. This will help to surmount the lack of urban continuity among the two identified urban areas. The compacted organic urban forms were found inside the confines of the citadel as well as the attached surrounded areas, while the gridded modern areas were formed outside the old city walls. Hybrid urban areas have fallen in between the two previous urban patterns.

Figure 3. Important streets and places in Historic Hit Citadel [1]. Source: Anbar Municipality.

In recent years, there was a clear trend adopting programs of economic diversity (including culture, tourism, and nature) to develop the traditional historic suites and cities [5, 6]. In many developing countries, these programs of economic diversity have been broadly considered as an effective strategy to sustain the old historic sites and landmarks since they promote their local identity and work to reactivate the quality of urban life socio-economically [5, 6]. HHC was listed by the UNESCO as nominated site for conservation purposes and been considered an important site for human heritage. These efforts targeting tourist programs, local trades, and small businesses that encourage the national identity can be adopted by both the local and central governments to enhance the HHC. Thus, the Local Government of Anbar, has taken serious steps to use the heritage characters for tourist attractions and develop the quality of urban life of some areas in the historic site. These new developments and activities will gradually increase the tourism revenues which translate into broad-based economic development in the future. Many studies have set to integrate the sources of economic
diversity and the potentials of spatial configuration of historic cores; yet, the current study has set up in the same regard.

This study is organized in three main phases. The street networks will be studied in three historic development processes showing the important morphological changes: a sole HHC analysis, a HHC with compacted surrounded vicinities, and a HHC with the outwardly modern developments. Having that said, the analyses will spatially identify the most integrated and segregated streets and the areas around them. In the current phase, identifying the existing land use distribution will help to propose new programs of economic diversity to be adopted around the boundaries of most integrated and segregated streets due to improving their values of accessibility and connectivity. Finally, deriving some guidelines of sustainable actions for developing segregated urban areas of HHC will improve the urban life quality in the field of urban design and planning not in the HHC but also other Iraqi fortified cities.

2. Space Syntax

The chosen analytical approach to be applied on this research is space syntax. It is an analytical computational approach consisting of a set of concepts, methods, and techniques offering a variety of measures that inform on socio-spatial characteristics of spatial organizations producing specific, quantifiable data mainly with the concepts of integration and segregation [7, 8, 9, 10]. Space syntax applications are given more prominence due to its success in studying large scales of urban grids and describing interactions and transactions processes, by which derived from the socio-economic data and socio-spatial behaviour.

There are several types of space syntax analysis including the axial map analyses, the convex map analyses, and the visibility graph analyses. Most of urban studies have been widely used the axial map analyses to understand and describe the organisation of the spatial configurations [7, 8, 10, 11]. For this reason, this study uses the axial map analyses that considered as an important technique helped to represent the spatial layouts, ranged from a single building to the entire city.

There is a significant literature has demonstrated how the connectivity and accessibility of spatial layouts have been used to explain and describe various patterns of movement density, land use distribution, and socio-economic allocation [7, 8, 9, 10, 12, 13]. However, comparative approach that applied to examine the syntactic properties of street networks of fortified cities in Iraq is still rare. As noted above, this study used the integration measures of space syntax, which is described below with details.

One of the most important measures that space syntax analyses relied on its outcomes is the integration, that informs how connected (accessible) a line is in relation to all the rest lines in the axial map [7, 8, 9, 10]. Thus, lines with high integration values refer to lines that have better connections with other lines, while lines with low integration values identify all lines that have fewer connections with other lines. Both sets of lines are graphically represented by scale of heat coloured form the red to the blue, in the axial map. Lines in red colours refer to highly integrated streets, but lines in blue colours identify the highly segregated streets. There are several radii that can be used to compute the integration values. For instance, the integration value at radius-n of a line considers the n-steps needed to cover all the lines in the whole system. The integration value at radius-3 of a line uses only those lines that are three steps away for the given line; the integration value at radius-5 uses only those lines that are five steps away for the given line; and so on [7, 10, 11, 12, 13], as shown in Figure 4. The integration value thus computed at a lower radius describes a more local syntactic property than that computed at a higher radius. Note, however, that the most local of any syntactic property of a line is its connectivity value, which is the number of lines directly connected to the line. More clarifications of the integration measure values can be found on the previous studies of Hillier and his followers [14, 15, 16, 17, 18, 19, 20, 21].
3. Methods.

3.1. Data Collection

The available data (photos, maps, and satellite images) of HHC’s urban forms and land use distribution were collected based on the historic evolution. The historic data of all collected maps were suggested three main phases: 1900s, 1960s, and 2020s showing remarkable changes. These phases were identified based on several criteria:

3.1.1. Selected maps were relied on the high level quality of the drawn figures as well as the basic urban elements: streets, plots, and land use must be exiting.

3.1.2. The information pertaining to the basic urban elements needed to contain the drawing scale and the symbols’ legend was verified.

3.1.3. Only maps certified by the Iraqi scientific institutions, agencies, and departments were adopted.

3.1.4. The size of studied maps was covering an urban area of 1sq/ km including the historic citadel, the close historic organic urban fabrics, and the modern urban developments.

3.2. Data Digitization

After the preparation of maps, the current stage incorporates the following steps:

3.2.1. Preparing and digitizing collected data were conducted by using ArcGIS (ArcMap 10.1 software) and GIS technology for the three examined phases of HHC.

3.2.2. Georeferencing techniques were applied due to the cartographic differences and used the landmarks and historic features for assigning spatial coordinates. These landmarks and features are those that have not been changed from one phase to another.

3.2.3. For each phase, the axial maps were generated by using the AutoCAD-2020 software to draw a network of intersecting lines that best describe the existing open spatial layouts (including streets, intersections, and open places), see Figure 5. To create this type of maps one needs to follow two simple rules: a) all axial lines should be drowning on the basis of using the longest

Figure 4: Showing different Rs of integration maps including a: Rn [HH], b: R3, and c: R5 of the current phase of HHC. Source: Generated by authors.
and fewest numbers of lines; and b) the connection between the first point and last point for each line must not be blocked by any physical element and feature, see Figure 6.

3.2.4. Based on the historical evolution, all digitized urban layers (streets, plots, and land use) were arranged.

3.2.5. Each axial map was analyzed by using the DepthmapX (an open source formerly UCL Depthmap 0.30) software program which is included, but not limited to, the key measures: Choice, Connectivity, Entropy, and Integration applied. It was applied to define the integrated and segregated values of syntactic properties of the axial maps.

3.2.6. Mapping the integrated and segregated axial lines on the current map of HHC to identify their locations and then the activities around these, see Figure 7. This will help to properly suggest sustainable actions for development purposes.

![Figure 5](image)

**Figure 5**: The open space structure of Gassin, France shown in black with buildings shown in white on the left; the representation of the axial map of Gassin shown in a set of intersecting lines on the right [22].

![Figure 6](image)

**Figure 6**: Generating the axial map; a: streets and plots, b: axial maps with spatial layouts, c: the whole axial map. Source: Generated by authors.

4. Results and Discussion

An apparent look at the resulted integration maps of HHC makes it clear that there was an important move from the integration core, formed initially inside the citadel with a tree pattern, into the modern developments, formed outside the walled citadel towards southwest in the second phase, see Figure 7. Yet, the segregated cores for all phases are distributed in a consistent manner at the urban edges and cul-de-sacs spread in residential uses. An experienced urban designer can note that the distribution of the integration and segregation lines of axial maps in relation to the land use developments seemed to follow regularities of spatial structures. For example, the majority of land uses of the depth-maps appeared around segregated streets was residential or agricultural uses, while a mixture of land uses was almost always outlined by integrated streets. In this regard, adopting a mixture of uses such as local cultural and commercial activities could be an impressive action promoting sustainability. Most
of super-grid streets with highly integration values were those that are highways, which were bounded by commercial and institutional activities.

There were slight variations in the distribution of integration core across the first sixty years of the study, but in general, it was clearly evident that this distribution moved out the walled city towards the East for the new city development, in which the commercial and mixed land uses have formed.

It was also obvious that the clear extension of integrated streets has associated with the variety of commercial activities, distributed in the East and South axes outside the citadel, with a distinct pattern that formed a T letter, see Figure 7. Thus, the spatial analysis has explained the relationship between syntactic properties and the land use distribution; it is suggested that repeating this type of activities alongside the directions of the integrated streets can be a good sustainable choice to develop these areas, in particular those that were located close to the segregated areas; adopting programs used

![Image of maps showing syntactic structures and land use distribution over different decades](image-url)
economic diversity will revitalized these isolated areas. The integration core of the current phase has formed a super-grid pattern of integrated streets that surrounded the HHC itself as well as the modern urban grid located towards the East, see Figure 7.

The results of segregation cores have shown that the residential uses were spread along spatially segregated streets dispersed at the periphery in the first phase and at the citadel edges towards the West in the second phase. In the current phase, segregated streets were divided into two sets; first, those that found inside the citadel and found around the dense residential clusters, then, those that were spread at the modern urban edges towards the South in the second phase. In sum, the program of economic diversity can be a key sustainable action, not only on the level of improving the integrated urban areas, but also on the level of developing the segregated urban areas into livable ones, if the local government will effectively adopt this economic program for its agenda and planning process.

5. Conclusion

This paper has investigated the locations and values of syntactic properties of the whole street networks around the HHC for three historical morphological developments. It has helped to reveal the potentials of space and how it could be considered as a subject for sustainable vision originated from investing in the good quality of urban settings in the historic fortified cities.

Although previous studies focused on addressing the deterioration of the historic nuclei inside cities, have made many attempts to revitalise and sustain the urban life over the last century in Iraq, they have not been employed the advantages of syntactic properties for spatial configurations that seem to be importantly linked to the land use development, contributing to this type of sustainable actions.

The results have shown that the integrated streets in the first two phases were located inside the boundary of the HHC, while the last ones were placed towards the southwest where modern developments formed out of the HHC. While the accessibility of the first two phases relied on the relation with the residential clusters, the last phase has indicated how well-connected streets have an impact on people's lives and the whole city configuration.

It is important to note that the space has an explanatory power over the formation and persistence of sustainable activities that distributed in and around well-connected traditional urban areas with highly integrated streets, formed inside the walled citadel for the first two phases and outwardly at modern developments of the current phase. The segregated urban areas with least integrated streets were formed at the urban edges, in the first and last phases, or around cul-de-sacs inside the walled citadel, in the second phase and needed to be reconnected with the whole street network. In addition, new programs of economic diversity approach included small business projects and mixed-land uses will be a valuable fix around these isolated areas.

The next steps of this type of studies would be to study another key measure that is the choice due to consider the impact of people's choice on social interactions and transitions in relation to the syntactic properties of spatial configurations.

6. Research Limitations

The analysis was only examined three morphological phases of the evolution of HHC and focused on studying the correlation between the integration values of streets and land use distribution. So, studying other key measurers, like ‘Choice’ or ‘Connectivity’, of syntactic structures as well as the rest of urban forms (including social classes, cultural customs, landmarks, and human density) can influence the results and interpretations.

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