SEARCHING FOR URBAN PATTERNS
AN ASSESSMENT OF HISTORIC EDGES AND ITS SURROUNDING CONTEXT: HISTORIC CAIRO AS A CASE STUDY

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Abstract
This paper analyzes the urban edges of historic cities. Managing these edges would enhance the success of any intervention projects inside the historic fabric. The paper develops and tests a method of analytical assessment framework that is applicable for quantitative analysis within an urban edge. It is capable of measuring micro and macro levels of analysis of historic urban edges with reference to their spatial configuration. In addition, the paper searches for repetitive spatial configuration patterns. The main case study is Historic Cairo. The paper reveals that there are apparent patterns of cause and effect of both spatial configurations and related activities along the urban edges, forming different type of barriers. The paper discovers the repetitive spatial, architectural, and land-use patterns that exist on various edges. These patterns enable the possibility of learning and acquiring from other successful interventions that have been applied to similar patterns, without being limited to cultural or contextual differences.

Keywords: *Urban edges; urban patterns; spatial configuration analysis; historic Cairo*

INTRODUCTION

Most research, in general, focuses on the urban form inside historic cities; however, the urban edge of historic fabrics is commonly ignored in the literature (Conzen et al, 2012, Kai and Gu, 2010; Unlu, 2013) and most regeneration interventions. Although the urban edges represent the transitional interrelation between the historic core and the extending modern urban growth, as well as possessing characteristics of both historic and modern features, they are mostly classified as non-historical fabric or as less important than the historic core. Hence, their development is ignored by both sides, the historic and the modern.

The paper aims to develop a method of quantitative analytical assessment framework that is capable of examining the urban edges of historic cities with reference to their spatial configuration, in this paper Historic Cairo's urban edges. Consequently, this assessment will help in developing appropriate regeneration plans for the site. Second, it enhances the process of comparison with other cases, in order to inherit those successful interventions that might fit according to base similarities, such as the urban form, architectural characteristics, spatial configuration, or other features. When analyzing urban edges, the paper introduces two hypothesis questions as follows:

1. Does the urban edge of the historic city form a 'barrier' between the historic core and the adjacent fabric?
2. Are there apparent patterns of cause and effect of both spatial configurations and the related activities along the historic fabric's path forming that barrier?

SCOPE

The spatial features of urban edges have a direct cause and effect on the economic conditions of the historic fabric, as more accessibility on the levels of both pedestrian and vehicle movements in non-residential areas would enhance the economic level of the place, whether through current traditional crafts or other commercial activities (Hillier et al, 2007). This paper focuses on the spatial configuration of the edge of the historic city in the foreground and considers its consequences on economic, cultural, and social aspects as its background interest.

Historic Cairo has been selected as a case study because of three main issues. First, it has evolved along different historical eras and consists of accumulated layers of development. Second, its defined boundaries make it effortless to analyze the cause and effect of spatial and social relationship inside the case study (micro-level) and test their connections with the macro-level (on the edge and outside the case study). Finally, the urban edges of Historic Cairo are in varying conditions. The northern wall fully exists, while the western part is semi-demolished and the western side is completely demolished. Moreover, the spatial configuration pattern inside the urban edges does not encourage heavy vehicle movement; it tends to depend on pedestrian movements (as an inner movement) rather than vehicles. Consequently, this suits the paper's aim of understanding the spatial and social relationships in a pedestrianized environment, with a mixture of stakeholders dealing daily with Historic Cairo. There are a variety of cross-sectional routes, in addition to the existence of varied architectural styles and historical buildings. This variation reflects on the range of socio-cultural activities within the same routes, providing a rich visual experience throughout the historic site.

LITERATURE REVIEW

Throughout history, boundaries have evolved and transformed, creating forms of distinction. Emphasizing those boundaries affects the social relationships that take a spatial form and over time will cause a changing social phenomenon (Madanipour, 2003). The urban peripheries of a historic city have become different from their original formatting as, today, they appear to be more complex and situated between historic centers and their adjacent urban growth. Francesca Governa et al (2004) view the periphery from two main perspectives: spatial characteristics and the socioeconomic point of view.

There are other terms describing the boundary of historic cities. Gallent differentiates between the terms 'edge' and 'fringe', suggesting that they describe two consecutive issues: the last zone considered to be more typically urban (or urban historic fabric) is described as an edge, while the landscape (or context) outside the built-up (historic) area represents a fringe, with various characteristics depending on its distance from the urban edge (Gallent et al, 2006).

The 'urban edge' represents a boundary between two kinds of areas (Lynch, 1960). It comprises buffer zones as an effective conservation policy for maintaining the interrelationship between the walled city and its settings, in addition to managing the development scale on both sides (Creighton, 2007a; ICCROM, 2008), where its size varies from one historic site to another. An urban edge is not a defined line based on walls, fences, and gates; it is more where the edge of a city becomes a zone that comprises gates, areas of social and commercial activity, and architectural character, rather than a rigid line (Bosselmann, 2008; Creighton, 2007a). At the periphery of a historic city, there is the 'urban fringe-belt'. This belt evolves developing an urban fabric over time with mixed land uses. It is less dense and differs from the main architectural character found in the historic core (Conzen, 2009). The urban edge has distinct patterns of spatial configuration, distribution of activities, and architectural features (Kostof, 2010), in which defensive walls cannot be analyzed separately from their surrounding urban patterns.

The paper reviews methods and theories for the analysis of urban edges. The urban fringe is one of the theories introduced to understand the growth belts (edges) around cities (Whitehand, 2007; Conzen, 2009; Gallent et al, 2004). In addition, realizing the context as one entity is

common in the literature in terms of using selective points or indicators for analysis (Bruce and Creighton, 2006; Abada, 1999); others use SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis with different indicators (Doratli et al, 2007). Reviewing the morphological analysis is crucial for fulfilling the research scope that highlights the urban structure, patterns, and form issues (Larice and Macdonald, 2012; Obrasli, 2000; Madanipour, 2003). The spatial configuration has many methods; space syntax is one of its quantitative methods, which emphasizes the relationship between social and spatial two-way interactions (Dalton and Holscher, 2006; Hillier and Hanson, 1984; Hillier et al, 2007). Mental and visual theories are introduced to highlight how people navigate, experience, and grasp spaces (Carmona and Wunderlich, 2012; Carmona and Tiesdall, 2007; Cullen, 1995; Lynch, 1981). Finally, physical environment theories are discussed to understand the way in which people shape their built environment through an incremental growth of parts that over time enriches the shape of the whole (Alexander et al, 1987; Trancik, 1986; Carmona et al, 2007).

Addressing the urban edges and city growth through visual descriptions rather than structural analysis has been argued to be a limited view of the morphological description and conceptualization of contemporary urban growth outside a city's borders (Serra and Pinho, 2012). From the previous theories and methods, the research extracts a number of indicators and establishes the selected type of analysis needed in the assessment framework of analysis.

HISTORICAL BACKGROUND OF HISTORIC CAIRO

Cairo consists of more than one thousand years of extended layers of history (Abu-Lughod, 1971). The problem with using terms and adjectives such as 'old', 'historic', 'Islamic', 'Fatimid', or 'Coptic' Cairo is not in their meanings specifically defining their edges; the problem is defining which layer(s) or edge(s) of history need to be included in any study (Daher, 2008). This paper uses Historic Cairo as a term, considering the World Heritage Committee WHC's suggestions (WHC, 2006), and the defined parts within the Fatimid and Ayyubid walls of Historic Cairo's boundaries are selected from Al Gamalia Qism and part of Darb Al Ahmar Qism, which is defined by Mohamed Ali Street (see Figure 1).

The walls of Historic Cairo were the main defined periphery at the early stage of Cairo's history. They were constructed in three main phases between the tenth and the twelfth centuries. The first and the second phases were in the Fatimid era; they started at the foundation of Cairo (AD 969) and continued until the end of the eleventh century during the period of civil unrest. The third phase was consolidating the existing Fatimid wall and constructing new parts, carried out Salah Al-Din during the Ayyubid era in the twelfth century (1170–1238 AD), in addition to the construction of the Citadel, which had a political as well as military stronghold (Siravo and Matero, 2004). The northern wall was extended westwards to the port of Al Maqs at the river Nile (currently, it is Ramsis square), and the eastern wall southwards to the Citadel. After two centuries since its construction, the area on the east wall was slowly declining and becoming increasingly marginal. The area outside the wall to the east was used as a dumping ground for the city's rubbish, which prevented the city's growth on the eastward side. The Al Hakim Mosque represents the physical edge of the northern extent of the city, although it was originally located outside the city's wall before the eleventh century refortification construction. The western city boundary wall has all but disappeared and the urban boundary was mainly a canal called Khalij Al Masri, which was filled in during the nineteenth century and converted to a route named Port Said Street; see Figure 2 for the spatial transformation of historic edge of Cairo.

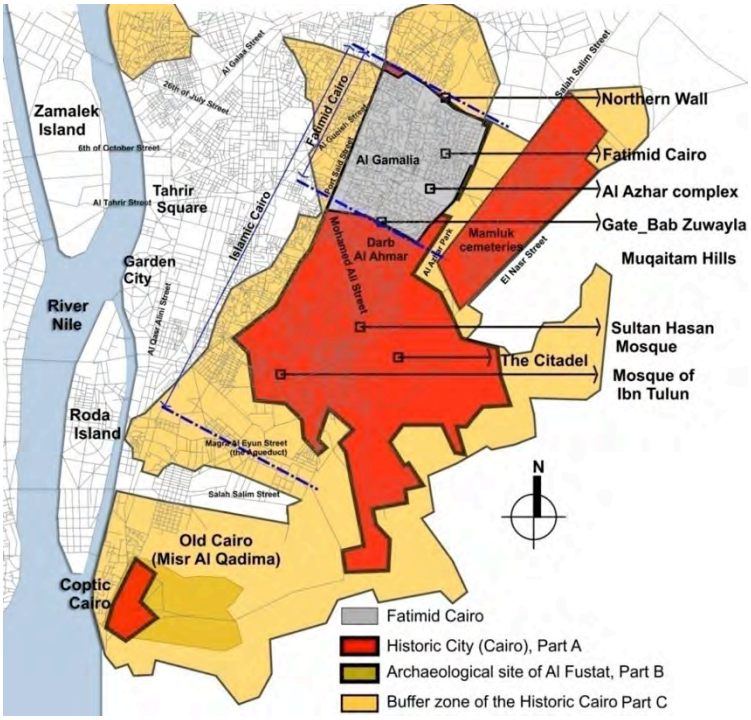

Figure 1. Boundaries for various terms defining 'Historic Cairo'; the highlighted areas are the delimited Law of 2008, which has delimitated the Historic Cairo boundaries (Source: Boundaries' information is from (URHC, 2012); base map and other graphics are by the author).

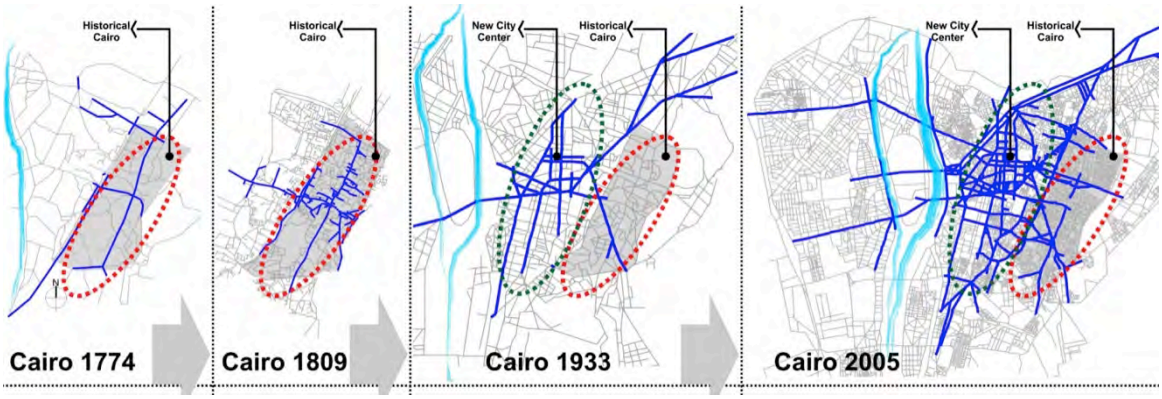

Figure 2. Highlighting the comparative analyses for Cairo in 1774, 1809, 1933 and 2005 showing the shift in important daily routes through different historic areas of Cairo. The lines shown represent the highest 10% potential selected daily routes for movement (Source: Mohareb, 2010).

METHODS OF ANALYSIS

The analysis depends on three main methods: spatial configuration, socioeconomic activities that are directly related to the land use typology and distribution, and the architectural features along the urban edges (Madanipour, 2003; Governa and Saccomani, 2004; Kostof, 2010). In this section, the paper expands in detail the theories and tools that are used in each method, highlighting the level of intervention in the case study stages.

The spatial configuration analysis adopts Hillier's theory of space syntax (Hillier, 1999; Hillier, 2005), in conjunction with Martin's examination of the block size and its effect on both the space and its inhabitants (Carmona et al, 2007; Carmona et al, 2010), and Bosselmann's temporal factors of movement experience (Bosselmann, 1998). The research will use each theory in combination to form the spatial configuration part of the framework.

The architectural features are categorized into their main usages: residential buildings; monumental buildings, whether they are religious or administrative buildings, or objects such as the defensive wall itself, if it exists; warehouses; and commercial buildings. Due to their location on the urban historic edge, the research expects to find different variations compared to the buildings located far from the edge on both sides of the wall. Therefore, the following main variables are considered for the analysis of these variations: the ground floor facade and whether it is an active or passive facade; the various architectural styles and their locations; the buildings' morphology; and, finally, the buildings' physical and structural conditions.

Land-use variables are interlinked with transportation, spatial configuration, and people's preferable movements, as source, destination and densities. These variables are mainly investigated through field surveys and observation, in addition to the GIS maps available for such data. The land-use analysis will also be linked to the previous investigating issues of spatial configuration and architectural features.

The main purpose of the framework is to be able to examine urban edges based on their spatial configuration, land-use, and architectural features. Moreover, it is meant to be used as a comparative analytical tool that can work across cultures, scale, and different spatial conditions.

It is clear that the framework depends more on the tangible and quantitative variables as the foreground of the analysis (see Table 1), while the other issues, such as cultural and economic factors, are only represented as a by-product of the spatial, architectural, and land-use analyses. This point of view might be considered as a limitation of the analytic framework; however, the research considers it as an advantage. The framework is a multi-layer of analysis; its base is designed as a quantitative investigation, in order to be used either as a single analysis of an urban edge or for comparing different cases in order to understand them. In both situations, the variations that might occur, even in different parts of the same case, do not limit the analysis as non-quantifying variables. Nevertheless, other layers could be added to the framework, according to the needs of the research. Therefore, the framework is flexible, as more layers of analysis could be added according to the case study situation, without the need to alter the entire framework, see Table 1.

Table 1. The analytical research framework (Source: Author)

Location	Urban form indicators	Variables	Measuring methods and tools
Historic Cairo in three different locations: **Section I** **Section II** **Section III** Each section is divided into number of subsections And each subsection is examined in	**1. Spatial features** - Measuring the degree of accessibility (visual and permeable) and locating integrated and segregated sectors	- Identify the urban edge	Using point-depth analysis FS, DR
		- Urban growth destination/ type	SSx, GIS
		- Type of spatial configuration - Inside the historic walled city; - On the edge; - Outside the walled city	SSx, GIS
		- Degree of accessibility - Visual accessibility - Permeability	SSx, GIS
		- Key accessible points/ locations	SSx, FS
		- Continuity of spatial fabric types	FS, GIS
		- Related facilities - Parking - Type of transportation	SSx, GIS

three different positions related to the urban edge itself.	**2. Architectural features** - Is there a style barrier? How, and to what extend?	- Architectural character/ style - Historic - Contemporary - Eclectic	FS, Sd, GIS
		- Level of architectural style continuity	FS, Sd, GIS
		- Architectural condition - Physical condition - Structural condition - The wall's condition - The surrounding buildings	FS, GIS
		- Degree of interaction to the surrounding context	- Ground floor frontages (passive/active) FS, GIS
	3. Land uses analysis - Is there an activity barrier? - What is the role of peripheral activities?	- Land use distribution (location, continuity)	FS, GIS, SSx
		- Land use categorization/ type - Concentration - Ground floor - Type	FS, GIS
		- Landmarks' location - Related to movements - Related to the edge	FS, GIS
FS, field survey; Sd, secondary data; SSx, space syntax; GIS, geographic information system; DR, data records			

ASSESSMENT PREPARATION

The assessed variables consist of three main parts: preliminary data; syntactical analysis on both scales, micro- and macro-scales; and an urban form analysis of the historic edges. The preliminary data investigates the edges' existing conditions and reviews the historic evolution to understand their current existing conditions. The location section identifies the security jurisdiction (*qism*) and the subdivision (*shiakha*) that the walls are located in. Finally, population distribution per *shiakha* is considered as a weighting factor in the analysis due to the various sizes of the *shiakhas*, as some have huge sizes that cover spaces beyond the studied urban edges, while others are just cemeteries, as in the northern cemetery of Bab Al Nasr.

The syntactical data highlights the macro-spatial analysis of Historic Cairo in general, including the surrounding context and the inner fabric, showing the different mean values of accessibility as a reference guide. On the micro-scale, each accessibility value, local integration R 500m, global integration Rn, local choice R 500m, and global choice Rn, is examined across three locations: both outside and inside the historic urban edge, with a buffer zone of 500m, in addition to the physical edge itself, with a buffer zone on both sides. This reminds that lower radius 500m is a pedestrian indicator, while a higher radius Rn represents longer trips using a vehicle.

The urban form data on the three sections of the urban edges relies mainly on the field observation as a first-resource data and other available resources as secondary data. The urban form data includes spatial features, architectural features, and land-use analysis. The spatial features deal with the usage of space from the point of view of pedestrian movements. This highlights the degree of visual accessibility of the urban edge and its real condition of permeability to approaching various locations, in addition to monitoring the spatial fabric continuity across the urban edges and, finally, highlighting the daily facilities needed in terms of parking lots, appropriate spaces for walking, street furniture, and other relevant issues.

The architectural features' study considers whether there is an authentic architectural style or character along the studied sections, highlighting the continuing status of that style along that edge. Finally, the degree of interactivity of the ground floor with different users is emphasised –

passive means a solid or closed facade, while active means the existence of voids or land uses that interact with pedestrians.

Land-use analysis shows the overall type of usage: residence, commercial, or mixed usage. It also shows whether there is a concentration of usages, their continuity, and their location on main access routes. Finally, the analysis considers the existence of landmarks and their location on the edge.

The three sections, A, B, and C, are divided into subsections (see Figures 3, 4, and 5) in order to facilitate the analytical study and to thoroughly monitor the various conditions and variables along the urban edges. This would highlight any tangible or intangible barriers along the edges. In addition, these subdivisions would ensure that the study and its results do not focus on the main routes as the only potential tangible edges between different urban fabrics. The subsections have been selected according to the sudden changes in urban morphology along the edges. These concern the architectural character, specific land use, the cross-section of the route, or the existence of tangible barriers such as the walls, which exist partially in the cases of sections B and C.

Finally, the sums of the previous values are aggregated in each subsection, according to three main positions along the studied edge. First, there is an analysis of outside the historic fabric which, in some subsections, such as C(1), is also extended traditional fabric. Second, there is a consideration of the inner fabric inside Historic Cairo in terms of whether it is traditional or modern, such as partially in C(3). Third, the analysis investigates the edge itself, in terms of whether it is the wall or any physical edge, and it highlights the interrelationship between the edge and both its sides. Finally, the averages of the data from the previous three positions are aggregated to give a total overview average of the subsection edge.

OVERVIEW OF URBAN EDGES (SECTIONS A, B, AND C)

Reviewing the four subsections of section A (see Figure 3), the maximum accessible part is outside the historic fabric, particularly in subsection A(2), in addition to being the highest value in the urban form features, while the minimum part is on the edge of the subsection A(4). Inside the historic fabric, subsection A(1) represents the highest accessible part among the other inner fabrics. Subsection A(1) has the highest average of the urban form features (2.23), while A(4) has the lowest average (1.15); see Table 2. Subsections A(2) and A(3) have the highest interrelations between the inner historic fabric and the outer urban edges, nodes A(1/2) and A(3/4) in particular. Their main inner spine (Al Muiz Street) is connected to the outer context with a series of commercial activities along Amir Al Guyush Street and Gohar Al Qaid Street. Their inner fabric is segregated due to their residential nature.

Part B is located at the northern urban edge of Historic Cairo; see Figure 4. Subsection B(1) is partially walled, and B(2) is completely concealed behind the defensive historic wall, while B (3)'s edge is an archaeological site of the wall traces, with a width of 60m, juxtaposed to a modern gridiron fabric with no walls. Reviewing the three subsections of section B, the maximum average values and outside fabric accessibility, including the urban form values, are in B(1). It is a partially walled fabric, but connected directly to two main routes: Port Said Street and Al Banhawi Street. However, the inner fabric of subsection B(2) has the highest values among the others in terms of either inner or outer fabrics. The reason for this is not its connection by the two gates to the outside fabric, but its connectivity with the two main perpendicular spines to the north wall – Al Muiz Street and Al Gamalyia Street. Both streets possess commercial and daily life activities, while the fabric adjacent to the wall is less accessible, especially the section towards the east side, due to its introvert residential nature; see Figure 4. The walled subsections B(2) and B(3) have lower values in terms of both outer and on-the-edge accessibility, including urban form features; see Table 2.

Each subsection of section C has a unique character from the others. C(3) has a modern fabric with the minimum intervention of the archaeological site of the wall. In contrast, C(2) is the most isolated inner walled historic fabric compared to all other subsections, and on its other side is the Azhar Park, which is located on a higher topography. Finally, C(1) has no wall, but it is composed of different types of fabrics and land usages; see Figure 4. Reviewing the three subsections of section C, on the average scale, it is obvious that the non-walled subsections C(1) and C(3) have almost the highest aggregated values of accessibility and urban form features compared to the walled subsection C(2); see Table 2. However, on the individual subsection scale, C(3) has the lowest values in the inner fabric and the highest on the edge value. The walled part C(2) has the lowest outside value due to the existence of Al Azhar Park, which does not have any active connections with the inner fabric, while the inside historic fabric has moderate connections with the main inner routes; see Figure 5, Figure 6, and Table 2.

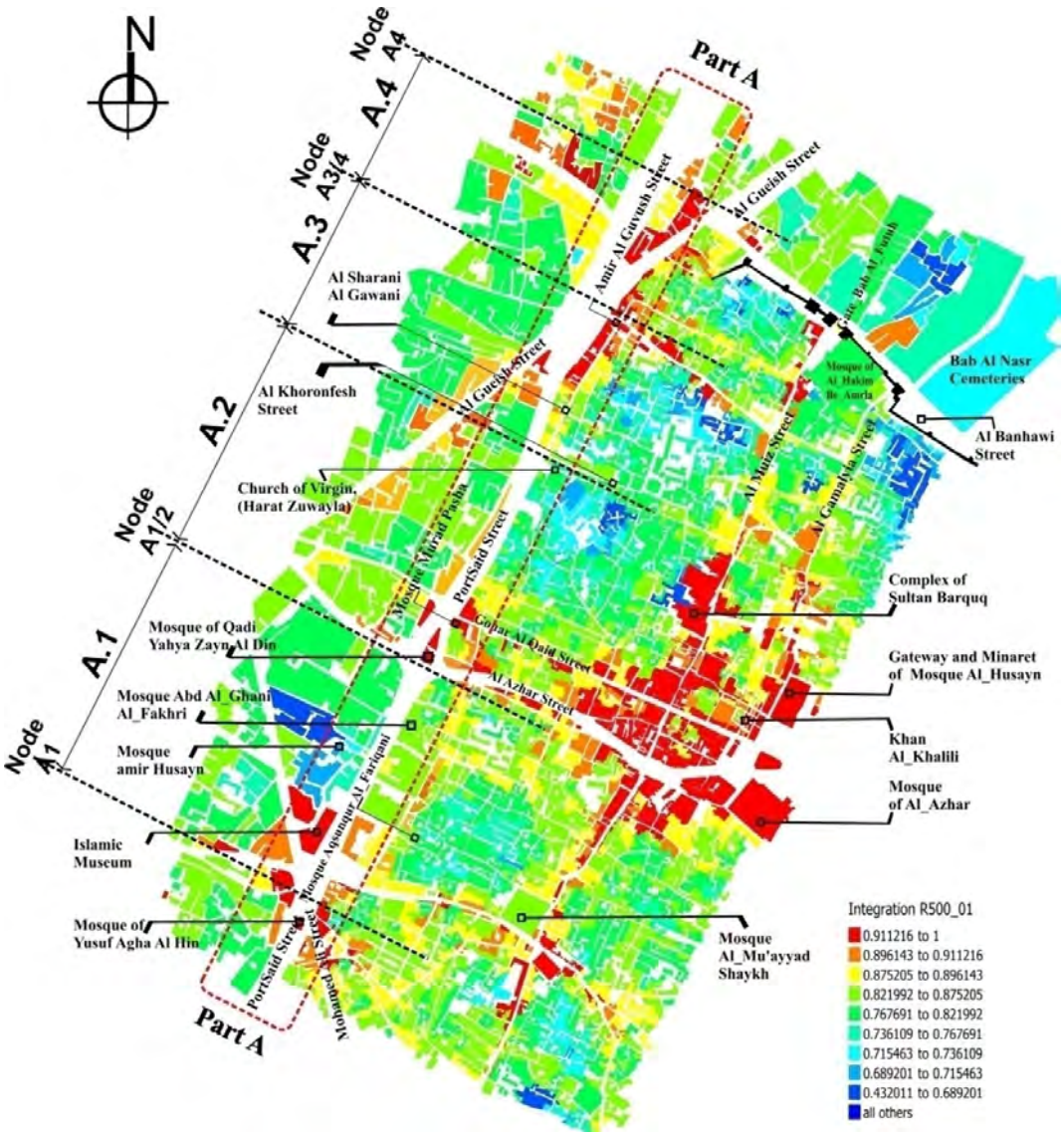

Figure 3 shows the integration R 500m analysis (potential pedestrian movements; shorter trips). Red colors indicate more accessibility compared to the blue colours, which indicate segregated parts (Source: Author).

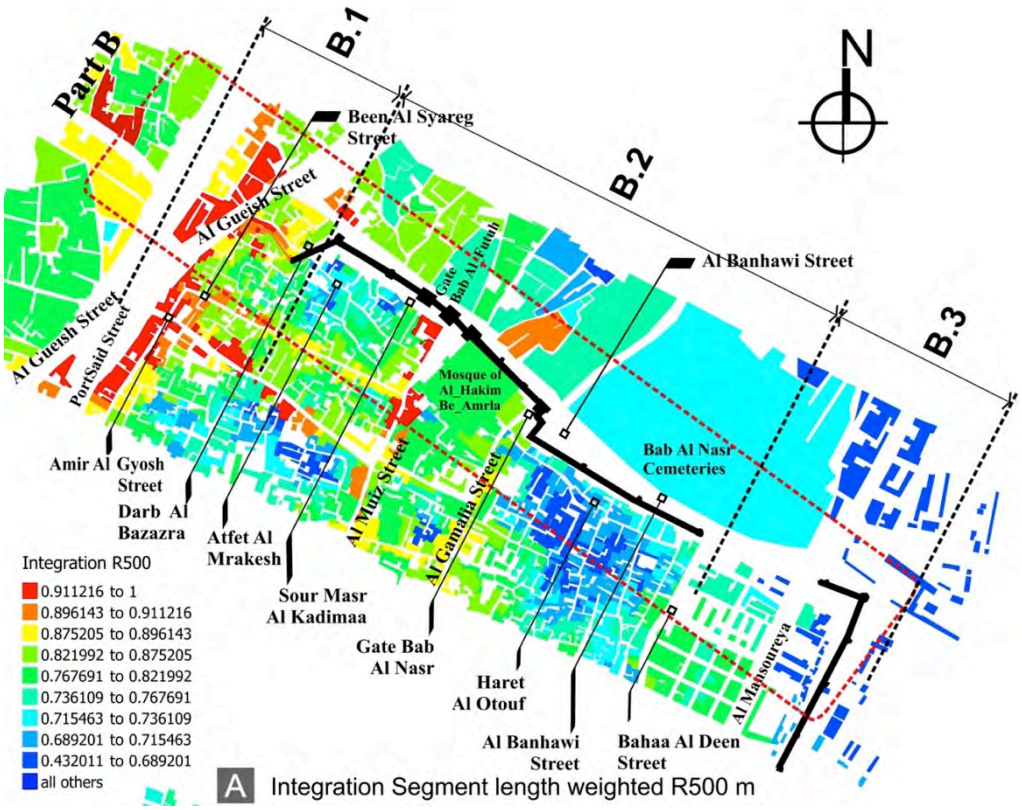

Figure 4 highlights the accessibility in the B subsections: B(1), B(2) and B(3). (A) shows the Integration R 500m analysis, while (B) illustrates Integration Rn. Red colours indicate more accessibility compared to the blue colours, which mean segregated plots (Source: Author).

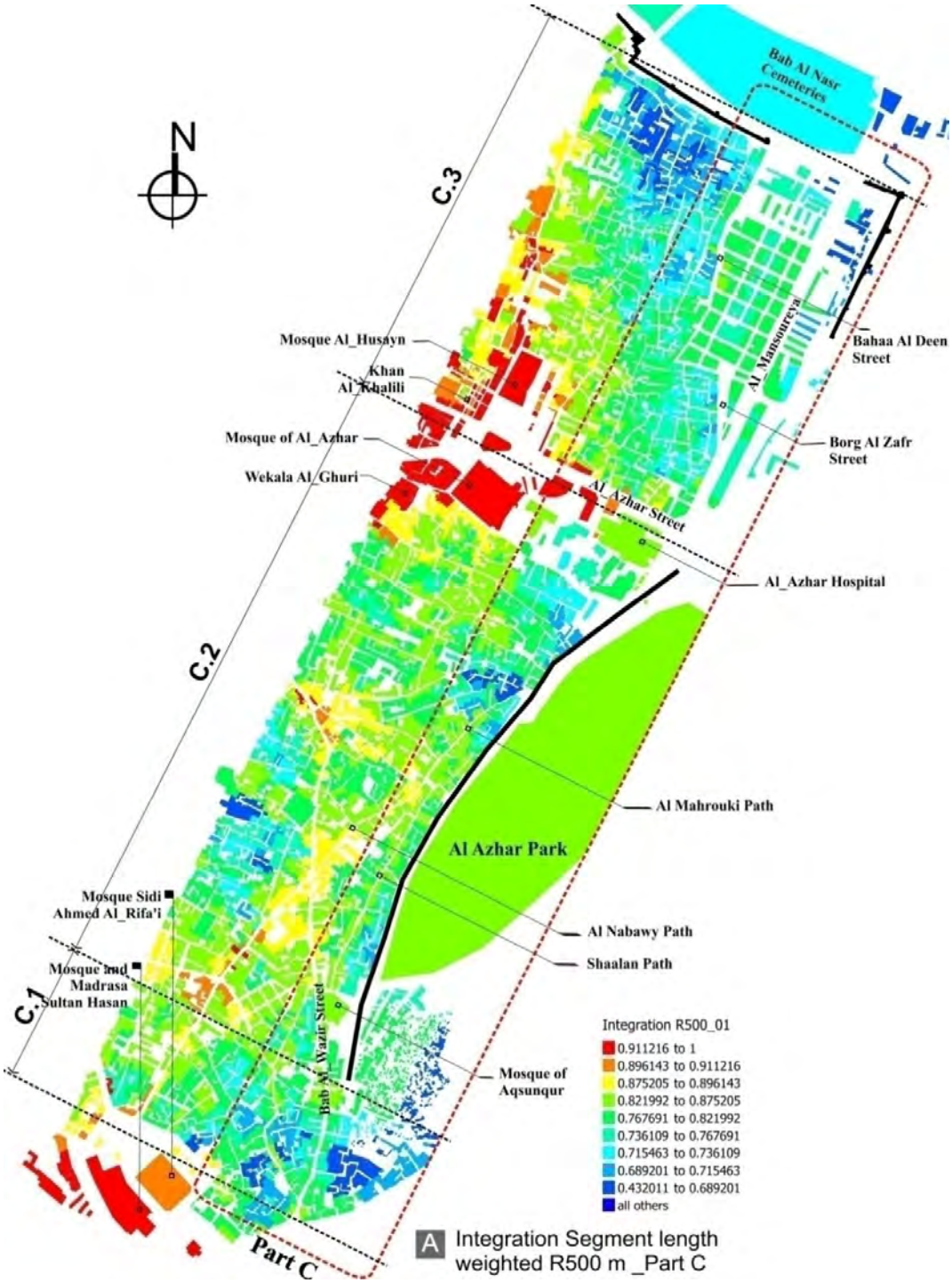

Figure 5 illustrates the accessibility in the C subsections: C(1), C(2) and C(3). It shows the Integration R 500m analysis, while (B) illustrates Integration Rn. Red colours indicate more accessibility compared to the blue colours, which mean segregated plots (Source: Author).

Table 2 highlights all the subsections' syntactical data (normalized average values for each measurement), in addition to the urban form features, architectural features, and land-use analysis of sections A, B, and C (the values used are 0, 0.5 and 1 to describe each point). The abbreviations used in the table are as follows: OTS for outside the urban edge; INSD for inside the urban edge; OEG for on the urban edge; and, AVRG for average values (*Source: Author).*

Part _A, B and C

Syntactical data (Normalised average values)	Section A.1				Section A.2				Section A.3				Section A.4				Section B.1				Section B.2				Section B.3				Section C.1				Section C.2				Section C.3			
	OTS	INSD	OEG	AVRG	OTS	INSD	OEG	AVRG	OTS	INSD	OEG	AVRG	OTS	INSD	OEG	AVRG	OTS	INSD	OEG	AVRG	OTS	INSD	OEG	AVRG	OTS	INSD	OEG	AVRG	OTS	INSD	OEG	AVRG	OTS	INSD	OEG	AVRG	OTS	INSD	OEG	AVRG
Local integration R 500m	0.76	0.83	0.84	0.81	0.83	0.81	0.84	0.82	0.83	0.81	0.83	0.82	0.87	0.87	0.83	0.86	0.85	0.9	0.87	0.87	0.78	0.77	0.78	0.77	0.65	0.77	0.73	0.71	0.63	0.82	0.81	0.75	0	0.82	0.82	0.82	0.67	0.78	0.77	0.74
Global integration Rn	0.62	0.58	0.65	0.61	0.71	0.54	0.66	0.63	0.62	0.59	0.62	0.61	0.65	0.72	0.68	0.68	0.53	0.5	0.52	0.52	0.51	0.64	0.59	0.61	0.64	0.59	0.61	0.61	0.57	0.6	0.5	0.59	0	0.52	0.52	0.52	0.68	0.51	0.54	0.57
Local Choice R 500m	0.84	0.85	0.86	0.85	0.85	0.84	0.86	0.85	0.85	0.84	0.85	0.84	0.85	0.81	0.84	0.83	0.81	0.82	0.82	0.81	0.82	0.85	0.85	0.84	0.76	0.83	0.82	0.8	0	0.83	0.83	0.83	0.84	0.83	0.84	0.83	0.83	0.84	0.84	0.83
Global Choice Rn	0.75	0.72	0.76	0.74	0.74	0.72	0.75	0.73	0.72	0.73	0.73	0.72	0.72	0.71	0.74	0.72	0.74	0.77	0.74	0.75	0.71	0.72	0.72	0.71	0.79	0.76	0.77	0.77	0.74	0.74	0.75	0.74	0	0.71	0.71	0.71	0.81	0.72	0.74	0.75
Population total	15375 (residents)				8045 (residents)				9255 (residents)				14379 (residents)				20939 (residents)				5382 (residents)				8957 (residents)				8997				11958				10549			
Population normalized (between 0-1)	0.13	0.13	0.13	0.13	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.12	0.12	0.12	0.12	0.18	0.18	0.18	0.18	0.081	0.081	0.081	0.081	0.078	0.078	0.078	0.078	0.08	0.08	0.08	0.08	0.1	0.1	0.1	0.1	0.091	0.091	0.091	0.091
A. Urban form (values 0, 0.5 or 1)	Section A.1			AVRG	Section A.2			AVRG	Section A.3			AVRG	Section A.4			AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG
A.1 Degree of visual accessibility	1	0	0.5	0.50	1	0.5	0	0.50	0.5	0.5	0	0.33	0.5	0	0	0.17	0	0	0.5	0.17	0	0	0	0.00	0	1	0	0.33	0	0	0.5	0.17	0	0.5	0	0.17	0.5	0.5	0.5	0.50
A.2 Degree of permeability	1	0.5	1	0.83	1	0	0	0.33	0.5	0.5	0.5	0.50	1	0.5	0.5	0.67	0.5	0	0.5	0.33	0.5	0.5	0	0.33	0.5	1	0	0.33	0.5	1	0.5	0.67	0	1	0	0.33	0	1	0.5	0.50
A.3 Key accessible points/locations	1	0.5	0.5	0.67	0.5	0.5	0.5	0.50	0.5	0.5	0.5	0.50	1	0	0	0.33	0.5	0.5	0.5	0.50	0.5	1	0	0.50	0	0.5	0.5	0.33	0	1	0.5	0.50	0	0.5	0	0.17	0.5	0.5	0.5	0.50
A.4 Continuity of spatial fabric type	1	1	0	0.67	0.5	1	0	0.50	1	1	0	0.67	0	1	0	0.33	0.5	1	0	0.50	0	1	0	0.33	0	0.5	0	0.17	1	1	0	0.67	0	1	0	0.33	0	0.5	0.5	0.33
A.5 Daily facilities	1	0.5	1	0.83	1	0	0.5	0.50	1	0.5	1	0.83	0.5	0	0.5	0.33	0.5	0	0.5	0.33	0	1	0	0.17	0	1	0	0.33	0	0	0	0.00	0	0	0	0.00	1	0.5	0.5	0.67
Average	1.00	0.50	0.60	0.70	0.80	0.40	0.20	0.47	0.70	0.60	0.40	0.57	0.6	0.3	0.2	0.37	0.40	0.30	0.40	0.37	0.30	0.50	0.00	0.27	0.00	0.80	0.10	0.30	0.30	0.60	0.30	0.40	0.00	0.60	0.00	0.20	0.40	0.60	0.50	0.50
B. Architectural Features (values 0, 0.5 or 1)				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG
B.1 Architectural Character/Style	0.5	1	0	0.50	1	1	0	0.67	0.5	1	0	0.50	0	0.5	0.5	0.33	0.5	1	0.5	0.67	0	1	0	0.33	0.5	0	0	0.17	0	1	1	0.67	0	1	0.5	0.50	0	0.5	0	0.17
B.2 Architectural continuity	0.5	1	0.5	0.67	1	1	0	0.67	1	0	0	0.50	0	1	0.5	0.50	0	1	0.5	0.50	0	1	0	0.33	0	0.5	0	0.17	1	1	0.5	0.83	0	1	0	0.33	0.5	0.5	0.5	0.50
B.3 Architectural Condition	1	0.5	1	0.83	1	0	0.5	0.50	1	0.5	0.5	0.67	1	0	0.5	0.50	0.5	0.5	0.5	0.50	0.5	0.5	0.5	0.50	0	1	0	0.33	0	0.5	0.5	0.33	1	0.5	0.5	0.67	1	0.5	1	0.83
B.4 Architectural form	0.5	1	0	0.50	0.5	0.5	0.5	0.50	0.5	1	0	0.50	0.5	0.5	0	0.33	0.5	1	0.5	0.67	0	1	0	0.33	0	0.5	0	0.17	0	1	0.5	0.50	0	1	0	0.33	0.5	0.5	1	0.67
B.5 Interactive ground floor facade	0.5	1	0.5	0.67	1	0	0.5	0.50	0	1	0.5	0.50	0	0	0	0.00	0.5	0	0	0.17	0	0.5	0	0.17	0	0.5	0	0.17	0	0	0	0.00	0.5	0	0	0.00	0.5	0	1	0.50
Average	0.60	0.90	0.40	0.63	0.90	0.50	0.30	0.57	0.50	0.90	0.20	0.53	0.30	0.40	0.30	0.33	0.40	0.70	0.40	0.50	0.10	0.80	0.10	0.33	0.10	0.50	0.00	0.20	0.20	0.70	0.20	0.37	0.50	0.40	0.70	0.53	0.50	0.50	0.50	0.53
C. Land use analysis (values 0, 0.5 or 1)				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG
C.1 Land use type	0.5	1	0.5	0.67	1	1	0	0.67	0.5	1	0	0.50	0	0	0.5	0.17	0.5	0.5	0.5	0.50	0	0	0	0.00	0	0	0	0.00	0	0.5	0.5	0.33	0	0	0	0.00	0.5	0.5	0.5	0.50
C.2 Land use distribution	1	1	0.5	0.83	1	1	0.5	0.83	0.5	0.5	0.5	0.50	0.5	0.5	0.5	0.50	1	1	0.5	0.83	0	1	0	0.33	1	1	0	0.67	1	1	0	0.67	0	1	1	0.67	0	0.5	0.5	0.33
C.3 Land use location	1	1	0.5	0.83	1	1	0.5	0.83	0.5	0.5	0.5	0.50	0.5	0.5	0.5	0.50	0.5	0.5	1	0.67	0	1	0	0.33	0	0.5	0.5	0.33	0.5	1	0.5	0.67	0	0.5	0	0.17	0	0.5	0.5	0.33
C.4 Landmarks' location	1	0.5	1	0.83	0.5	0.5	0.5	0.50	1	1	1	1.00	0	0.5	0	0.17	0	0	0	0.00	0	1	1	0.67	0	0	0	0.00	0.5	1	0.5	0.67	0	1	0	0.33	0	0.5	0	0.17
C.5 Land use continuity	0.5	1	0.5	0.67	0.5	0.5	0.5	0.50	0	1	0	0.33	0.5	1	0.5	0.67	0	1	0	0.33	0.5	1	0.5	0.67	0	0.5	0	0.17	0	1	1	0.67	0	1	1	0.67	0	0.5	0.5	0.33
Average	0.80	0.90	0.60	0.77	0.80	0.80	0.40	0.67	0.50	0.80	0.40	0.57	0.20	0.50	0.30	0.33	0.50	0.60	0.50	0.53	0.00	0.80	0.20	0.33	0.30	0.50	0.20	0.33	0.40	0.80	0.30	0.50	0.00	0.70	0.40	0.37	0.13	0.50	0.50	0.33
Sum of averages (A+B+C)+ Population	2.53	2.43	1.73	2.23	2.57	1.77	0.97	1.77	1.78	2.38	1.08	1.75	1.22	1.32	0.92	1.15	1.48	1.78	1.48	1.58	0.48	2.18	0.38	1.01	0.48	1.88	0.38	0.91	0.98	2.18	1.28	1.48	0.30	2.10	0.70	1.03	1.12	1.59	1.79	1.46
Sum of averages (A+B+C)+ population + syntactical data				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG				AVRG
Local integration R 500m	3.29	3.26	2.57	3.04	3.40	2.58	1.81	2.59	2.61	3.19	1.91	2.57	2.09	2.15	1.78	2.00	2.33	2.68	2.35	2.45	1.26	2.95	1.16	1.78	1.13	2.65	1.11	1.62	1.61	3.00	2.09	2.23	0.30	2.92	1.52	1.85	1.79	2.37	2.56	2.20
Global integration Rn	3.15	3.01	2.38	2.84	3.28	2.31	1.63	2.40	2.40	2.97	1.70	2.36	1.88	1.92	1.57	1.78	2.13	2.50	2.16	2.26	1.01	2.68	0.90	1.52	1.12	2.47	0.99	1.52	1.55	2.78	1.88	2.07	0.30	2.62	1.22	1.55	1.80	2.10	2.33	2.03
Local Choice R 500m	3.37	3.28	2.59	3.08	3.42	2.61	1.83	2.62	2.63	3.22	1.93	2.59	2.07	2.13	1.76	1.98	2.34	2.65	2.34	2.44	1.29	3.00	1.20	1.82	1.30	2.73	1.23	1.75	1.74	3.01	2.10	2.28	0.30	2.93	1.53	1.86	1.96	2.42	2.63	2.29
Global Choice Rn	3.28	3.15	2.36	2.97	3.31	2.49	1.72	2.50	2.50	3.11	1.81	2.47	1.94	2.03	1.66	1.87	2.22	2.55	2.04	2.33	1.19	2.90	1.10	1.72	1.27	2.64	1.15	1.68	1.72	2.92	1.95	2.22	0.30	2.81	1.41	1.74	1.93	2.31	2.53	2.21

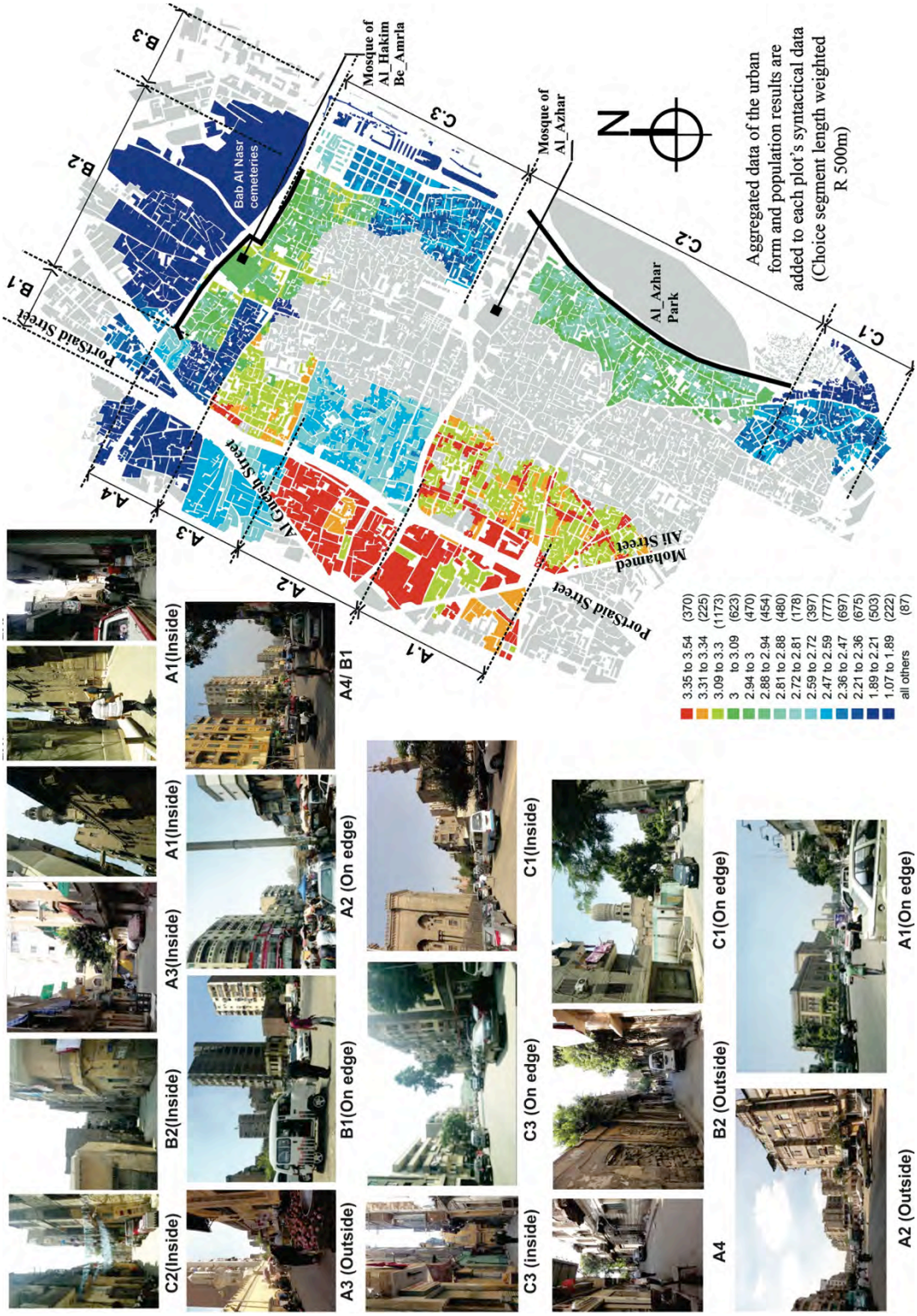

Figure 6 shows the aggregated data (highlights the main (macro) patterns) in the different sections A, B and C, while the base map is choice segment length weighted of R 500m (mainly for pedestrian accessibility). Similar colours means similarity in the urban form character, based on the results of Table 2. (Source: Author).

ASSESSMENT OVERVIEW

This section examines the relationship between the subsections and their degree of correlation, considering various values of urban form features, syntactic data, and population ratios. The result of the correlation discloses the similarities in the configuration of the case-study subsections. Correlating with more than one subsection would reveal, if they exist, repetitive spatial foreground patterns, accompanied by their urban form features as their background pattern. This assumption does not promote the exact existence of identical spatial or urban form patterns; however, it highlights the existence of similarities in conditions. These similarities would help urban regeneration developers to adopt best practices from other similar projects, while, at the same time, forecasting the success and the failure of their selection. They would also help researchers compare and choose similar projects and evaluate their intervention results, knowing that the selected projects have similar genotypes and phenotypes for analysis.

This research reviews the results of the previous individual assessments of each subsection and compares these results in three different ways. First, the urban form and population results are added to each plot's syntactical data in the GIS map; see Figure 6. The aggregated results would highlight the accessibility patterns in a GIS holistic map of Historic Cairo. The second method is a comparative assessment according to the edge position (as a value) – whether inside, outside or on the edge – and the total average; see Figure 7. This analysis reveals the similar values between subsections based on the same position condition. Finally, the assessment highlights the possible correlation between subsections, also according to their positions; see Figures 7 and 8.

COMPARATIVE RESULTS

The comparative GIS assessment, Figure 6, shows that some subsections apparently have similarities on the plot level. This is obvious in inner fabric subsections behind walls, such as C(2) and B(2), and, partially A(3), although it is not a walled fabric. In addition, subsections C(1), C(3), and B(1) have similarities and they are all adjacent to a walled fabric.

Generally speaking, within each subsection, there is apparent correlational consistency between the five points of analysis in the charts of Figure 7: the syntactical data and the urban form, with the population averages. This correlation might suggest that there is direct interrelation between the spatial configuration (syntactic data) and the urban form features, which would facilitate the urban-edge analysis by using the spatial analysis as a base investigation in any early or pilot studies.

The traditional and partially traditional urban fabrics that are directly exposed to the outside modern fabric context, such as the subsections on edge C(3) and B(1), can interrelate positively with their surrounding context, despite the apparent differences in their fabrics; see chart (C) in Figure 7. Traditional inner fabrics have almost the same spatial and urban form features, despite their location and the type of edges that they lay behind; this is obvious inside subsections A(1), A(3), C(1), B(2), and C(2); see chart (B) in Figure 7. Modern urban fabric outside Historic Cairo have higher spatial and urban form values than the outside traditional fabrics, and this is obvious in the outside fabric of Port Said Street in subsections A(1), A(2), A(3), and B(1); see chart (D) in Figure 7. The edges that are exposed to the intersections of major routes tend to have the same spatial and urban form behavior on their edges, such as subsections A(1), C(3), and B(1); see chart (C) in Figure 7.

Historic fabric behind the wall as an edge have the same patterns of spatial and urban form behavior, regardless of the number of entry points (gates) that might connect them with the outer context, for example, subsections C(2) and B(2); see chart (B) in Figure 7. Comparing the results of both different types of physical edges, the defensive historic wall and the main routes, it is obvious that the routes, despite their morphological consistency, are not acting as one homogenous edge along their length. Each part of that route might have different interrelations

with the surrounding context – for example, the route of Port Said Street (subsections A(1), A(2), A(3) and A(4)) – therefore, they cannot be treated as one unit, contrary to the wall's situation. The historic fabrics behind the walls have similar syntactic and urban-feature behavior on the average (macro) scale and when examining the micro-scale.

By comparatively examining the three different positions, in addition to their averages in all the subsections, it is obvious that subsection A(1) has the highest values in every position (average, inside, outside, and on the edge), despite its apparent physical form; see Figure 7. Reviewing the morphology of this subsection, it has a wide street cross-section and huge, modern blocks on its immediate periphery, which conceal the historic patterns behind it. As a result, it should act as a segregating edge; however, it acts otherwise. The reason for this is the typology of the inner fabrics. They generate source- and destination-attractors for pedestrian movement (see Figure 6) based on their commercial and daily usage activities (the A(1) subsection has the highest average land use value; see Table 2). Therefore, the land usage typology has altered the physical form of this part of the Historic Cairo edge.

Finally, the use of a justified graph is to interpret the analytical results recorded, which show the correlation between subsections. The process of arranging the graph by the number of connections is the main description of the term 'justified' (Ostwald, 2011). Therefore, the results would provide a further step beyond highlighting the one-to-one correlation of two subsections to a holistic understanding of the relationship with all subsections. It also spots any correlation with more than one subsection that indicates the existence of repeated patterns.

Reviewing the correlation results (connectivity) of all the positions together in Figure 8, it is obvious that the inner historic fabrics are more correlated with others than the other positions. The most correlated subsections are from sections C and B: C(1), C(2), B(2), and B(1). These results indicate that the inner historic fabrics near to the edges are still homogenous; see the four, five, and six connection levels in Figure 8. Considering their physically segregated locations, concealed either by the historic wall or by cemeteries, they represent repeated patterns having correlated conditions inside Historic Cairo. The subsections that are the least correlated with others (having one connection) are from the on-the-edge position of the historic fabric. They are from the same sections of B and C. This indicates that the edges are unique and not repetitive; they act as one continuous edge. On the other hand, the outside positions of the historic fabrics have some similarities; most of these have two to three similar correlations with other subsections. However, they could not form a pattern with their few connections. Therefore, each subsection outside the historic fabric should be reviewed separately.

By examining each position on a separated base, it is clear that A(1) is more correlated with others, which supports the previous conclusion that it is not a segregated edge. C(1) has the highest number of inside connections (six connections), and it is connected with various typologies of inner fabrics of other subsections, such as B(2), A(4), C(2), and C(3). On the edge of Historic Cairo, three isolated fabrics are not interrelated with other subsections except each other's: A(4), B(1), and C(3). The reason for this might be their common urban form configuration, which is not repeated with the other cases. They are all located on wide streets, where historic and new fabrics are exposed directly to those streets with multiple entry points. They have a mixture of traditional and new architectural features with fewer commercial activities.

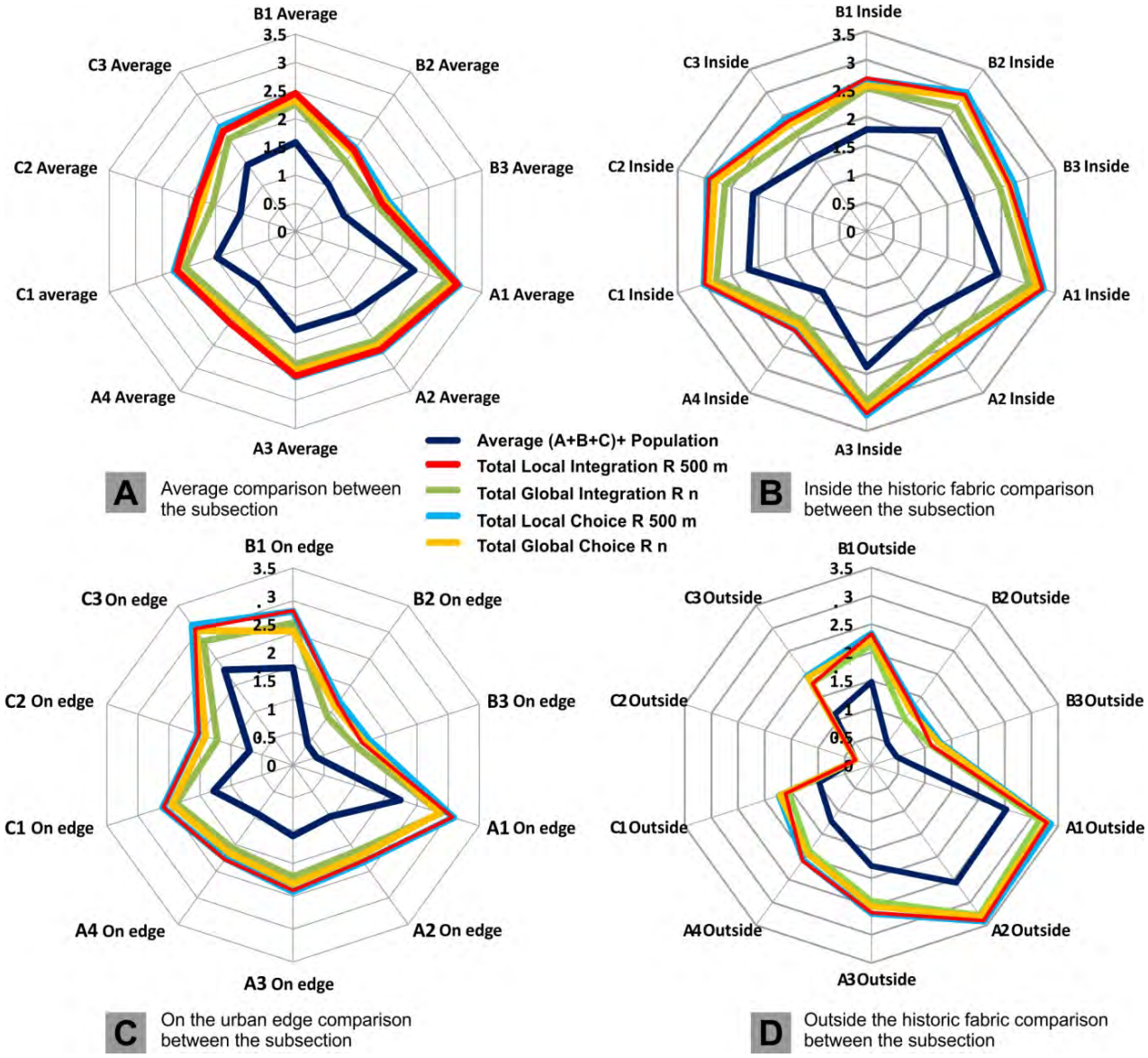

Figure 7 (A, B, C and D) highlights the urban-edge assessment at the three different sections – A, B and C – and their subsections. Each figure includes multivariate average values (local and global Integration, local and global Choice, and the average mean values of the three sections A, B and C, in addition to the population densities) distributed in the three sections. (A) shows the average multivariate values in all subsections. (B) illustrates the distribution of the average multivariate values inside the historic fabric. (C) highlights the distribution of the average multivariate values on the edge of all subsections. (D) shows the distribution of the average multivariate values outside the historic fabric (Source: Author).

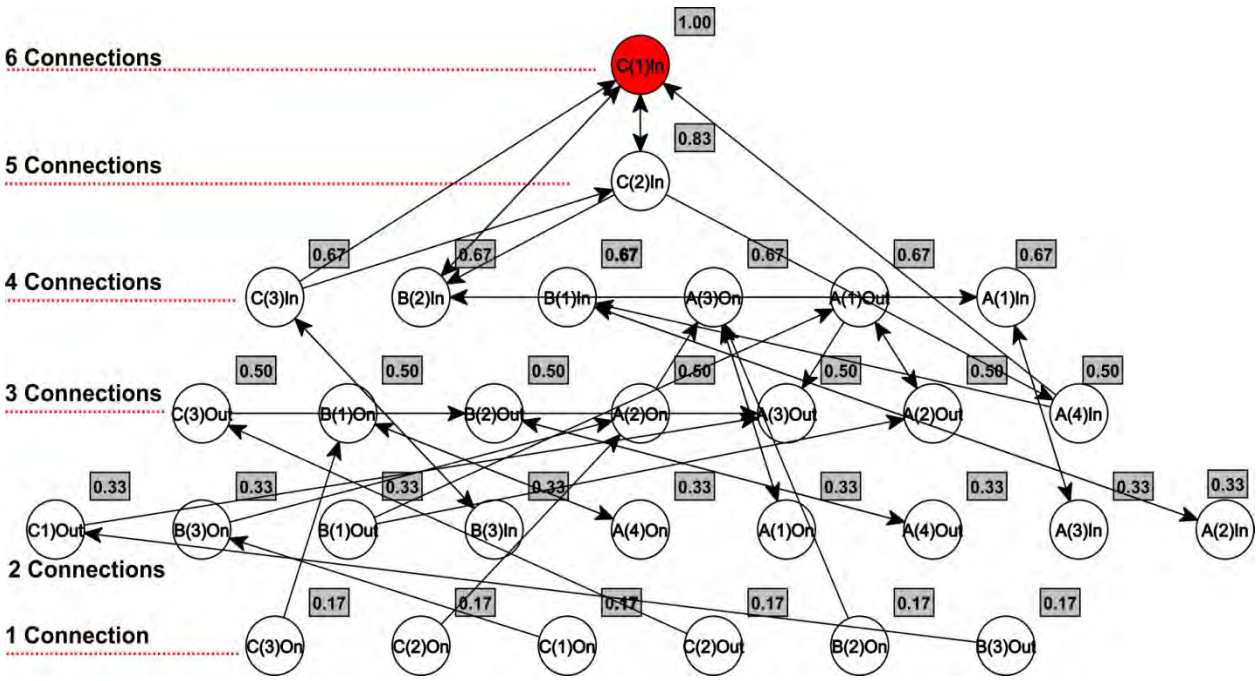

Figure 8 shows the justified graph of all the subsections (inside, outside and on the edge of Historic Cairo of sections A, B and C). It highlights the number of correlations (connections) of each subsection with the others, categorised by the number of connections, which indicates the degree of similarities. The value beside each subsection name is the result of the number of connections that each position has, divided by the maximum number of connections of all cases (in this case six connections) (Source: Author).

CONCLUSION

The paper developed the framework of analysis to understand the urban edges of Historic Cairo. The assessment did not depend on one method only, but rather used multiple techniques, including GIS analysis, space syntax spatial configuration, field survey, and finally, multiple interrelationship analysis. This assessment highlighted the spatial and urban form repetitive patterns that might exist in different locations inside, on the edge, and outside the historic fabric. The following points are the findings of this paper.

Urban edges of Historic Cairo cannot be treated as one unit when considering urban regeneration projects. It is a historic fabric apparently isolated from the surrounding context, by either the historic wall or ring roads, and it has a monotype of spatial patterns. However, this apparent overview contradicts the paper's assessment, which shows its interaction with the surrounding context in specific conditions and locations. It also has different types of repeated spatial patterns of urban form and spatial configurations.

The fabric behind the historic wall (as a physical edge) is not necessarily an isolated urban form or fabric; it depends on how it is linked to other main inner routes as suggested by Bosselmann (2008) and Creighton (2007a). Moreover, the linkage has different features of architecture, land usage, or spatial continuity, as suggested by Kostof (2010). Therefore, the degree of integration with the surrounding context is essential when comparing or adopting other regeneration experiments. It is crucial for researchers to select the appropriate case studies that correlate with their own experiment.

Reviewing the macro analysis of Historic Cairo reveals that a physical barrier exists in many forms. The defensive wall as a physical barrier exists on the northern and eastern sides, along with the spatial barrier of the main route of Port Said Street, with a massive urban form on its edge compared to the inner urban form of the historic fabric. Although these barriers visually

conceal the inner fabric on both sides of the wall or the existing edge (from the field survey and analysing the urban blocks), they do not prevent the interrelations between the inner fabrics with each other and with their edge context. This is obvious in the subsections A(1), C(1), and partially A(4), as they are all former paths of the defensive wall. Despite this, the inner fabrics behind the wall interact positively with their adjacent inner fabrics when connected to the main inner routes (mainly commercial or religious-oriented activities). This point reflects on the first hypothetical question of the paper.

In the detailed analysis of Historic Cairo, despite the location and type of edges that the traditional inner historic fabric lies behind, there are apparent similarities in the spatial and urban form features (see Chart B in Figure 7), which responds to the second hypothetical question. This issue is clear in the justified graph analysis, which reveals that the inner historic fabrics on the edge of Historic Cairo are more highly correlated with each other than the other fabrics. This outcome suggests that the inner historic fabrics on the edges are still homogenous.

The consistent correlations between the syntactical data and the urban form, in addition to the population averages in the comparative assessment of the subsections in the Historic Cairo case study, suggest a direct interrelation between these factors (see Figure 6). Furthermore, this justifies the decision for using spatial analysis as an initial preliminary investigation in the urban edge analysis.

The edges of historic fabric, which are converted in most cases to ring roads surrounding the historic cities, attract more global integration as a potential destination, followed by the values of global choice as possible selectable paths for vehicle movements. This result implies that the route edges do not act as a bypass network, avoiding or isolating the historic city; on the contrary, they interact as potential destinations for longer vehicle trips. If the results of the detailed case study of Historic Cairo are considered along with the previous macro-scale observations, the interaction is found in selectable parts that have attractive commercial or administrative land uses (see Figure 3). Adding to this, on the shorter (pedestrian) trips, choice (through-movement) accessibility is higher in the examined sections than integration (to-movement) accessibility, meaning that pedestrians navigate through these edges and not only on their outlet peripheries. This result would count as quantitative-based evidence of the magnitude of land-use typology over urban edges with regards to the selected case studies. However, in the detailed study of the Historic Cairo subsections at the three different edges, the local accessibility (both integration and choice) is higher than the global accessibility if the urban form assessment is added to the syntactical data. This would imply that urban edges are spatially global destination-oriented, but, when including the other factors, they turn out to be more local-destination attractors.

For land-use typology in general, commercial and public facilities is a key factor in the active interrelation between the historic and modern fabrics, despite the form of the urban blocks and the direct visual exposure to the main modern routes. This result was clear in the subsection A(1) on the edge of Historic Cairo. This is in contrast to the situation of the historic residential activities that are directly exposed to the modern extended fabric on the edges. These are introvert activities, and their active or passive connections depend mostly on their spatial configuration and their degree of visual and accessible exposure to the outer context. This was observable in the residential subsections A(2), A(4), C(1), and C(3) in Historic Cairo. A monotype of activities, particularly residential, tends to act as an interactive barrier on the edge of historic sites. This issue is obvious in subsections C(3), B(1), and A(4). Therefore, understanding the current and suggested land-usage typology is crucial in any intervention projects; they hold economic values and attract more potential movements that play an important role in blending or segregating these urban edges from the surrounding context.

The fabrics in close proximity to the walled edges are less accessible, with lower-quality living conditions. They are, in most examined cases, residential quarters. This result was expected, due to the isolated nature of these fabrics starting from the wall towards the outside

context and from the historic fabric on the inner side. However, the results were altered when the focus of the analysis was oriented towards examining the interrelationship between the peripheral walled fabric and the inner accessible routes. Reviewing the results from the detailed subsections B(2) and C(2) of Cairo reveal that, if the residential walled edges are well connected with the main inner accessible routes, they became accessible by themselves and well interrelated from the inside. The previous result was not considered in the AKTC intervention in Darb Al Ahmar; this represented one of the main obstacles in the project. The project suggested a direct connection between the segregated residential quarters proximate to the historic wall and the outside context of Al Azhar Park. The linkage was not successful because the two segregated entities were not connected with both the inner and outer accessible routes, in addition to the other financial and political problems that led to the disruption of the intervention project.

In walled Historic Cairo, the residential fabrics are the main typology adjacent to the wall. The northern side stands free due to major fabric clearance (from the 1940s until recently in the 2000s), while the eastern side is still attached closely to the historic inner fabric. There are many reasons for the previous demolition action; one was giving the wall, as a monument, a stand-alone vision. Most of the residential buildings have no matching significance. Reviewing this point of view reveals the problem addressed by Daher (2008) and recent conservation charters, in considering which layer of history should be preserved or even considered in regeneration projects (Daher, 2008). The preservation vision should have a holistic contextual vision of the urban edge and not only the beautification or restoration of the outer skin of some buildings, which was one of the problems with the AKTC project.

One of the most important indicators of a walled city's land use is the location of cemeteries. As a result of beliefs and religious considerations, transferring the bodies of the dead or moving cemeteries in general is something very difficult in Arab and Islamic countries. It would need a religious, legitimating 'fatwa' (Islamic religious ruling) permitting that transport, and a long period of time before starting the process. Consequently, the current locations of old cemeteries often define the outer edge of historic walled cities. They limit the interrelation between the inside and the outside fabrics and, in some cases, attract poor living conditions affecting the spatial integration, architectural features, and the surrounding land uses. Therefore, they represent another type of barrier.

To summarize the previous concluding points, they are related to the research objectives, the hypotheses, the findings, and the analysis of the selected case studies as follows:

- Physical and visual barriers do exist in different forms along the urban edges. They can be altered by paying attention to the type of link between both sides of the edge, considering spatial interrelation, architecture continuity, and land-use typology.
- Spatial analysis would be highly beneficial as an initial preliminary investigation in urban edge analysis, particularly if the primary data is not all available.
- Architectural features form a visual enclosure or a stereotypical image and do not alone form an apparent effective physical barrier.
- Land-use typology plays an important role in binding or segregating the urban edges with the surrounding context as it holds economic values and attracts various potential movements.
- A ring road that might surround the former walled path does not act as one homogenous edge. This point would affect the decision-makers' policies in any regeneration intervention.
- There might be related similarities (patterns) in different parts of the urban form features, despite the location and type of edges that the traditional inner historic fabric lies behind.
- The proposed analytical assessment framework is capable of measuring micro and macro levels of analysis in walled cities. It has the potential to become a valuable tool for decision-makers in evaluating the current situation and in measuring the success of their intervention projects.

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