The Urban Grid and its Consequences Assiut

Ref 077

An Egyptian Case-Study

Ahmed Mohamed Refaat Mohamed
University of Manchester, School of Environment and Development, Manchester, United Kingdom
ahmed.refaat-mostafa@postgrad.manchester.ac.uk

Frank Edward Brown
University of Manchester, School of Environment and Development, Manchester, United Kingdom
frank.brown@manchester.ac.uk

Keywords
assiut city; urban grid; co-existent; obstacles

Abstract
One of the most potent concepts recently to have emerged within the repertoire of space syntax is that of generic function. While urban space clearly derives its intelligibility and functionality in part from characteristics that are local and specific, the key properties that shape the urban complex are primarily generic: patterns of occupation and occupancy are rooted in shared fields of possibility. In the present study axial mapping is used to examine the spatial structure of the city of Assiut on the west bank of the Nile south of Cairo (GOPP 2000). Assiut can be traced back to 4000 B.C., but the modern city dates largely from 1800 A.D. Consisting of 14 distinct districts, the extant city exhibits a range of morphological types: from the deformed grid commonly associated with uncontrolled 'organic' growth to strictly orthogonal layouts. Many have been subject to growth and change over time. Assuit is seen to have widespread problems, most notably in the perpetuation of conflicting spatial patterns in various parts of the city. High levels of congestion remain seemingly unabated and in some cases by recent interventions, such as canals and railways. Axial analysis has been undertaken of the city as a whole at different phases. Unlike previous studies, which typically concentrated on specific problems in limited areas, the present study extended the mapping across the city as a whole to highlight the global patterns of integration and segregation, as well as the effect of the co-existent obstacles on the whole spatial structure. A number of findings may be noted to date. The canals and railways, and the variation of the spatial characteristics of different districts determine some parts of the city as the most accessible areas (integration core). These areas are located in the old part of the city, which typically suffers from a poor infrastructure, marked by narrow streets and difficulty of access. This explains the tendency for wealthy and high-class residents to be drawn to the periphery of the city, where new settlements are under construction. Overall, the analysis suggests the potential for use of strategic spatial interventions to alleviate morphological problems and create a more efficient grid structure at both local and global scale.

1 Introduction

Dating back to 4000 B.C., Assiut represents one of the oldest cities in Upper Egypt. Modern Assiut, however, dates mainly from 1800 A.D. and consists of 14 districts. The extant city exhibits a range of morphological characteristics, from the deformed grid commonly associated with uncontrolled 'organic' growth to strictly orthogonal layouts. Many have been subject to growth and change over time. Three main features, were identified as obstacles (GOPP 2000, 48), are found in the city structure: the railway, which divides the city into two parts, Al-Ibrahimya Canal, which separates the city from its northern suburban districts, and Al-Malah Canal, which separates the city from its southern suburban districts. Additionally, the city is surrounded by the Nile from the east and north direction, and the agriculture land and the Dorunka Mountain from the west and south directions see Figure 1. These hard boundaries reduce the edge effect in the case of Assiut city.

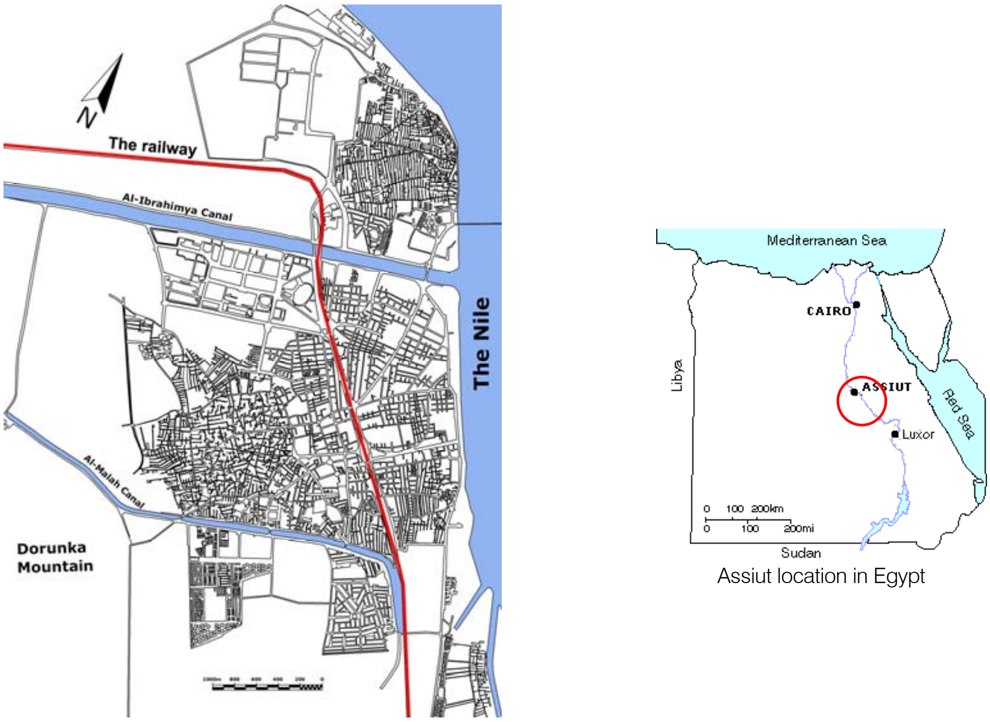

Figure 1
Map of Assiut city (CPAS 2007, 48)

The city is seen to have widespread problems, most notably in the perpetuation of conflicting spatial patterns in various parts of the city. High levels of congestion are seemingly unabated in the City Centre district. To solve these problems, The Egyptian government has invested about $40 million over the last 10 years to improve the condition of the urban grid through the establishment of new bridges and tunnels. These government projects, however, did little to resolve the problems of the urban grid that they set out to address. Furthermore, some of these projects have had additional drawbacks in terms of loss of identity and character of the spaces they occupied.

From this standpoint, the present paper proposes an alternative way of addressing the urban grid problems in Assiut. Unlike previous studies (Mahrous and Attia 2005, Nofal et al. 2000, Mahmoud 1994), which typically focused on how to address specific problems within the urban grid of Assiut, this study uses the space-syntax approach to disclose the inherited features of the urban grid and determine why it has experienced these problems. To attain these aims, axial analysis had been undertaken for the whole spatial structure of the city. The findings of this study show that it is the urban grid configuration itself which is largely responsible for these problems, and unless these problems are addressed from a global perspective, any local solutions will fail to produce appropriate and sufficient solutions.

2 Methodology

Axial-mapping techniques, introduced by (Hillier and Hanson 1984, Hillier 1996), were used to analyse the spatial structure of the city and to highlight its features. Maps of local and global integration were produced through 'Depthmap' software, while maps of the integration core were produced through 'Mindwalk' software (Turner 2004, Figueiredo 2002). To evaluate the effect of several factors, containing the presence of obstructions and the incompatibility of patterns, axial mapping of the city was undertaken at different phases: the analysis of the city in the case of removing its obstacles. Comparing the integration pattern and syntactic measures at different phases laid the basis for evaluation and comparison of the effects of different factors.

3 Implementation

3.1 Spatial characteristics of Assiut City

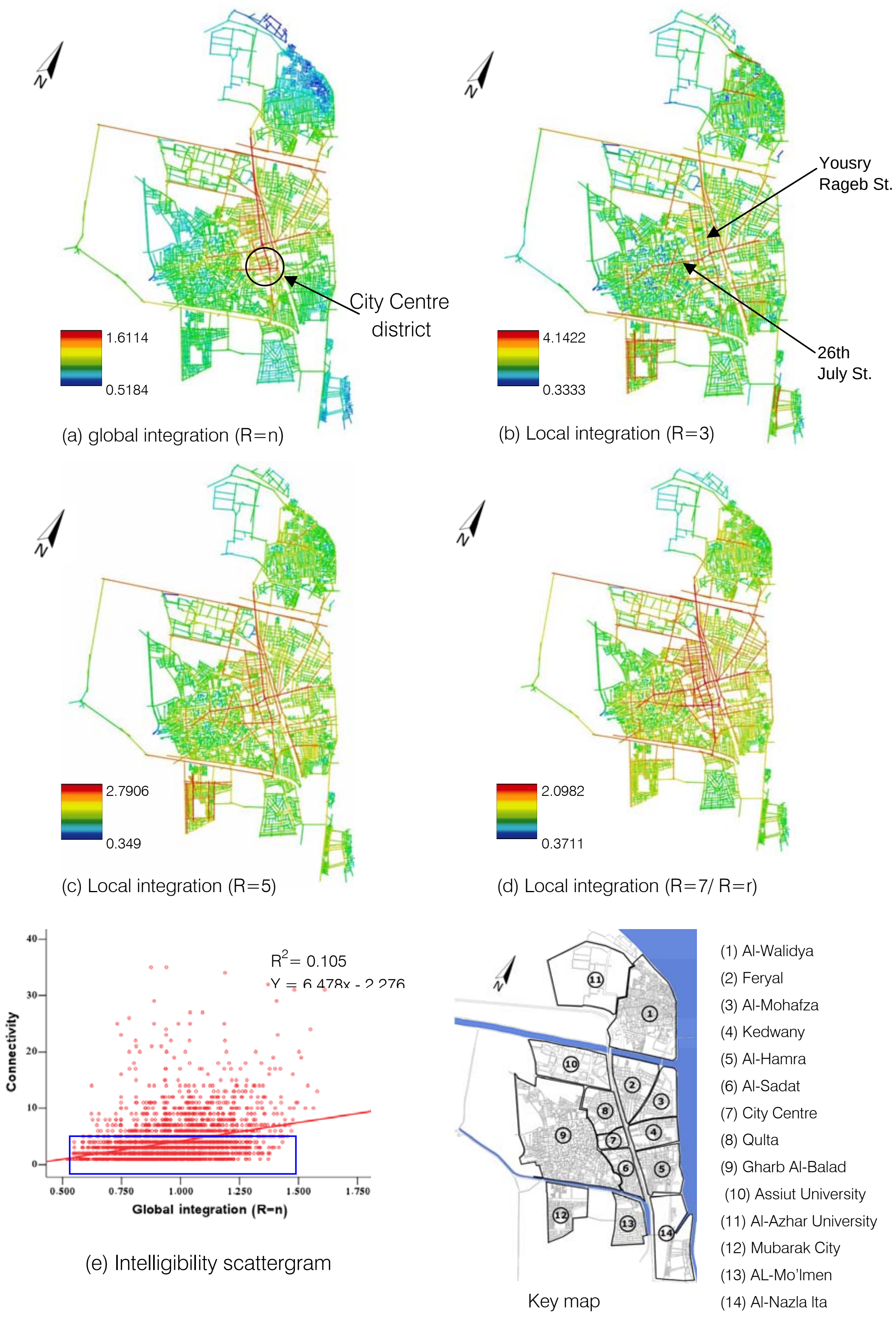

Figure 2
Axial maps and intelligibility scattergram of Assiut

Figure 2 shows the results of the axial mapping of Assiut city. In the global integration map, (r=n), the most integrated axial lines are located in the City Centre or extend from it, mainly to the north (Qulta district) and with a few segments to the east and west. Thus, movement and land uses tend to be concentrated in the city centre and its neighbourhoods. This reflects that the congestion and traffic jams the city centre experience are not merely a product of its narrow streets, but of its topological position in the city structure as well. Furthermore, it is notable that the eastern part of the city has very few high integrated lines in comparison to the western part. This is the result of the railway, which prevents highly integrated lines in the western part from reaching the eastern one. This shows that the most accessible area in the city structure is distinguished by its small size, which produces more pressure on the street network to accommodate the expected high traffic volumes. On the other hand, highly integrated axial lines encounter a similar difficulty in extension to the west direction. This occurs because of the incompatibility of the patterns of the City Centre and Gharb Al-Balad districts, this will be discussed later when we examine the characteristics of the integration core of the city.

The segregated axial lines are mainly concentrated in four districts: AL-Walidya, AL-Nazla, Al-Mo'lmen and Gharab Al-Balad. Additional to their topological position in the city structure, the inherited features of those areas contributed to the above result. The high break-ups feature of the meandering pattern of Gharb Al-Balad, for example, reduced the ability of its axial lines to be linked to many spaces and consequently these axial lines have low integration values. Similarly, because of the parallel pattern of Al-Walidya and AL-Nazla, their axial lines are connected to other lines only at their ends. As a result, these axial lines captured low integration values.

Turning to the local integration map, Figure 2b, all districts, except Al-Mo'lmen, are found to have a number of high local integration axial lines. This shows that the highest integrated axial lines are dispersed across the city structure and not concentrated in a specific district as the case of global integration. Two lengthy streets, Yousry Rageb St. and 26th July St., which have high global integration values, are found to capture high local integration values as well. This indicates the importance of these streets in the city structure at both local and global scales. This agrees with the real situation; Yousry Rageb St. represents the north-south spine of the city, while 26th July St. represents its east-west equivalent. Both streets represent the main context of different social and commercial activities and land uses. Additionally, the distribution of the most segregated axial lines at the local map is located in three districts: Al-Walidya, Gharb Al-Balad and Al-Nazla. This underscores the poor structure of these districts reported above. As the radius of integration increases, Figure 2c and d, more axial lines emerge amongst the highest integrated lines in particular in Gharb Al-Balad and Al-Walidya districts. This occurs because of the inherited features of the axial lines of these two districts mentioned above.

Regarding the intelligibility of the city, as shown in Figure 2e, Assiut has a low intelligibility value, 0.105, which indicates its illegible spatial structure (the average value of intelligibility of Arab cities is 0.16 (Hillier 2001, 02.4). Because organic meandering and parallel patterns cover a wide area of the city, the majority of its axial lines are distinguished by their low and constant connectivity values. Thus, as shown in the scattergram, the majority of spaces form linear lines at its base which reduced the overall value of the regression line. Thus, the city is characterised by its illegible spatial structure.

Based on the foregoing analysis, two factors exert an influence role on the spatial configuration of the whole city: incompatibility of patterns and the co-existent obstacles: the railway, Al-Ibrahimya Canal, and Al-Malah Canal. The effect of these two factors will be examined in more details in the sections to follow.

3.2 The characteristics of the integration core

Figure 3 shows the integration cores of Assiut. As shown in Figure 3a, the integration core has a deformed-wheel shape in which the central core, City Centre and Qulta districts, is connected to the peripheral lines by several links extending outwardly from it. It is notable that the central core has a rectangular shape parallel to the railway and distinguished by its lengthy streets running from north to south and intersecting approximately at right angle, with short streets running from east to west. The shape of the central core unfolds several features of the spatial structure of Assiut city.

(a) Top 5%

(b) Top 10%: yellow colour indicates the new streets

(c) Top 25%: yellow colour indicates the new streets or areas appeared in top 25% core

Figure 3
Global integration cores of Assiut city

First, the railway prevents the short streets of the central core from extending to the east. Accordingly, the central core is located entirely at the western part of Assiut, which is distinguished by its narrow streets. This negative effect of the railway is evidenced by the way it disconnects Al-Hamra district from having any links to the central core despite their juxtaposition. Even when the integration core increases its proportion, Figure 3b and c, the district remains separate from the central core, except for a few lines which penetrate the district at the 25% map. Similarly, as the integration core increases from 5% to 25%, the growth of the central core tends to be towards the west and south rather than the east due to the effect of the railway. The integrated axial lines at the eastern part in Al-Mohafza district, in particular, is an outcome of the existence of two main links extended from the central core, No. 4 and 5, which encircled its internal streets. Second, the incompatibility of patterns prevents the extension of the short street of the central core to the west direction. Therefore, the central core ends at the outskirts of Gharb Al-Balad district, with the exception of link No. 2. This effect remains evident even when the core reaches to 25%. Only the Old Centre (area A in Figure 3a) was added to the integration core at the 25% map as a result of the two powerful links: No. 2 and 3, while other axial lines of the central core end at the outskirts of Gharb AL-Balad district.

Al-Mo'lmen and Al-Walidya districts represent further examples for the impact of the incompatibility of patterns. Despite that link No. 1, at the top 5% map, passes the obstacles of Al-Ibrahimya and Al-Malah Canals at the north and south respectively, the incompatibility of patterns emerges as a barrier preventing Al-Mo'lmen and Al-Walidya from connecting to the central core. Moreover, despite the increase from 5% to 25% cores, the extension lines of the central core could not penetrate Al-Walidya, except for a small part in the south, while it failed in penetrating Al-Mo'lmen at all, see Figure 3c. However, the inherited features of these two districts represent another factor which reduces their ability to integrate with their surroundings (Mohamed 2009).

Furthermore, the similarity of the City Centre and Qulta patterns results in the extension of the central core from the City Centre to Qulta rather than Gharb Al-Balad, which has a different pattern. Also, because of the relative similarity between the city centre and AL-Sadat patterns, the central core extended to the south to cover a large area of Al-Sadat district.

Third, the outer movement in the Ring Road, No. 6, has a direct access to the central core through link No. 1. This increases the traffic load in the central area of Assiut. The movement from the central area of the city to suburban districts or ring road is further restrained. For example, link No. 1 represents the only route which permits the movement from the central core to either the northern or the southern suburban districts. Also, links 4 and 5 are the only streets through which the movement can reach the Ring Road in the eastern direction. Thus, there are a few streets which can carry the bulk of movement across the city structure, and, in all the cases, the movement has to pass through the central core of Assiut.

Furthermore, because link No. 1 offers a direct access to the City Centre and its facilities, new projects are established at its northern and southern poles, areas B and C in Figure 3a. Despite they were once considered as marginal and poor areas, high-class people established luxury housing projects in these areas, which provide them with a direct access, by car, to the City Centre and its amenities. Because of its luxury nature, only individuals belong to high-class occupied these areas. Furthermore, these projects were designed as closed communities with their private accessible streets and gates. This imitates the notion of 'gated' cities but in a small and 'softer' way. If this type of housing continues to be developed, the notion of gated communities, which assert social exclusion, will be a feature of Assiut city. This is a result of the urban-grid configuration which encourages wealthy people to establish their own communities at the poles of the main accessible link of the city structure.

Finally, a considerable part of the Old City Centre, area A in Figure 3a, emerges as part of the central core. This indicates that the Old Centre catches both types of movement: to and through movements. As a result, the Old Centre retains its 'liveability' and attraction. Because of its narrow streets, however, the Old Centre barely accommodates this movement.

Normally, the integration core cannot cover all areas of a settlement. However, in Assiut, as shown above, the shape and extension of the integration core is influenced by two factors: the incompatibility of the different patterns, and the presence of the railway. In the next section a further analysis addressing the effect of different obstacles found in the city structure will be presented.

3.3 Spatial configuration and co-existent obstacles

As shown in Figure 3, the effect of the railway is evident in determining the most accessible areas in the city structure. To examine such an effect further together with the effect of other obstacles, Figure 4 shows the integration cores, top 5%, of the city in its different phases when obstacles were removed partially or totally.

Changes of the integration core shape at different phases will be discussed in three stages: Firstly when one obstacle is removed, secondly when two obstacles are removed, and finally when all obstacles are removed.

At the first stage, Figure 4b, c and d, it is obvious that only at phase (d) has the integration core been changed notably in comparison to phase (a). At phase (d) the integration core shape changed significantly from the rectangular shape, in phase (a), to the spine shape overlying the railway path. Consequently, more axial lines of the Kedwany and Al-Hamra districts become part of the integration core. This emphasizes the influence of the railway on the integration core shape reported above.

At the second stage, Figure 4e, f and g, significant changes of the integration core shape can only found in phase (g) and to some extent in phase (f). This reflects the importance of both the railway and Al-Malah Canal in shaping the integration core. Additionally, AL-Ibrahimya Canal has insignificant influence on the integration core shape. This is evidenced by the similarity between phases (g) and (h) even though AL-Ibrahimya Canal was not removed from the structure at phase (g).

At the final stage, Figure 4h, all obstacles are removed. In this case, similar to phase (g), the integration core shape changed drastically to form a main spine, instead of the railway path, and a secondary spine instead of Al-Malah Canal path. Thus, a lot of axial lines anchored to these two spines become part of the most integrated axial lines. The new shape of the integration core produces two important remarks.

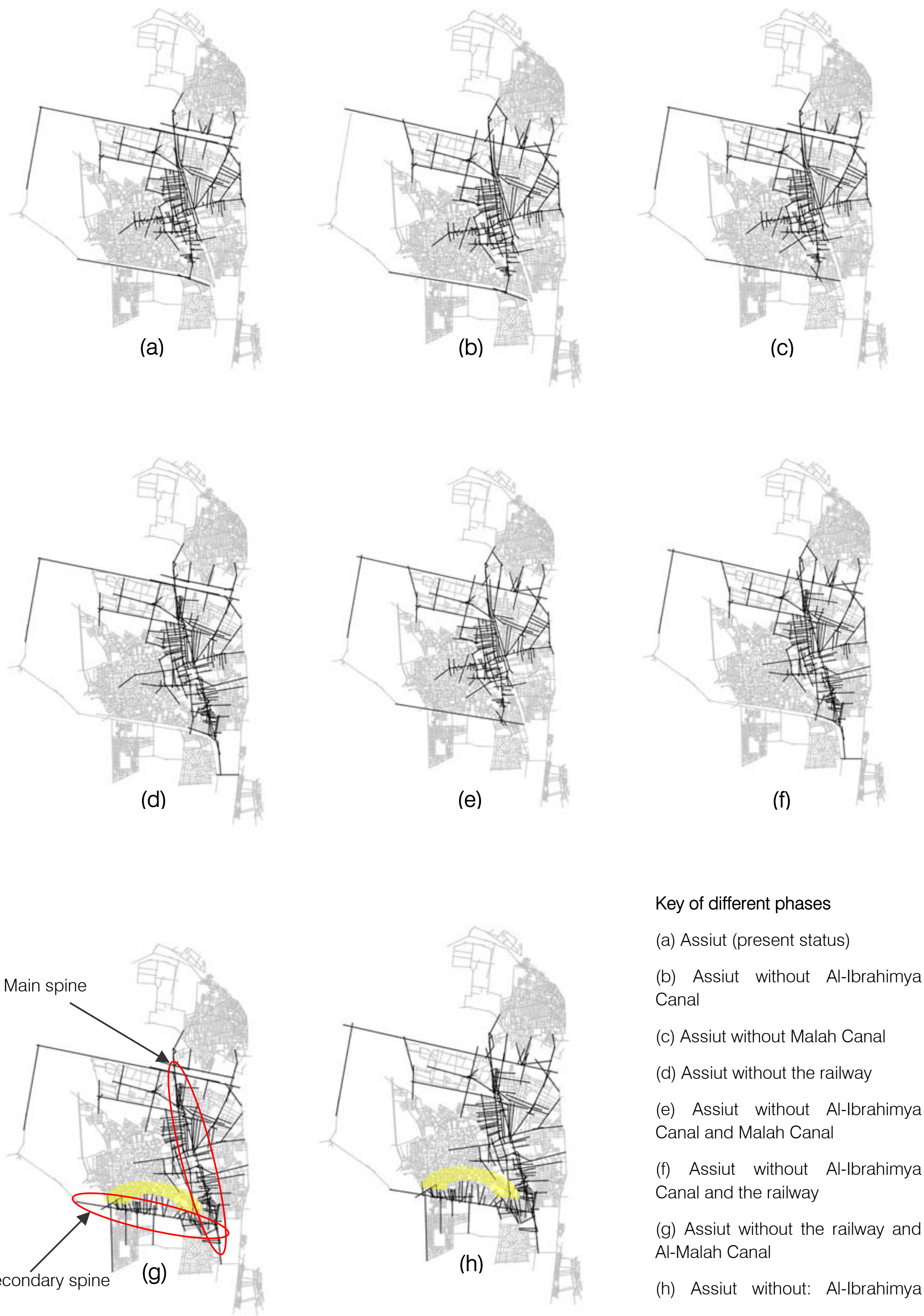

Figure 4
The integration cores of Assiut in different phases (top 5% at R=n)

First, the axial lines of Kedwany, Al-Hamra and Mubrak City, which become part of the integration core, reflect the negative effects of both the railway and AL-Malah Canal. Secondly, there is considerable evidence which advocate the influence role of the pattern incompatibility of the spatial structure in Assiut on its integration patterns. The links of the new core, for example, did not succeed in penetrating Al-Walidya and Al-Mo'lmen districts after removing all obstacles. This shows that the incompatibility of patterns is another factor which prevents the integration core from the extension to these districts. Also, the extensions of the new integration core whether from the main spine or the secondary one, Figure 4g, did not succeed in penetrating Gharb Al-Balad district. The invisible arch, marked by yellow in Figure 4g and h, reflects the effect of the incompatibility of patterns. The comparison of syntactic measures of different phases, as shown in Table 1, confirms these results. While there are no significant changes of local measures , there are tangible changes in the global and intelligibility values. These changes, however, are not significant at all phases, which suggest that not all obstacles have a similar effect.

Syntactic measures / Different Phases of Assiut City	connectivity	local integration (R=3)	Global integration (R=n)	Mean depth	Depth	Radius-Radius integration	Intelligibility (Con/Rn)
(a) Assiut (present status)	3.899	1.962	0.952	11.077	6.734	1.423	0.105
(b) Assiut without Al-Ibrahimya Canal	3.899	1.961	0.956	11.028	6.744	1.426	0.107
(c) Assiut without Malah Canal	3.920	1.978	0.961	10.971	6.724	1.440	0.109
(d) Assiut without the railway	3.943	1.987	1.008	10.545	6.259	1.567	0.119
(e) Assiut without Al-Ibrahimya Canal and Malah Canal	3.921	1.979	0.967	10.910	6.727	1.444	0.110
(f) Assiut without Al-Ibrahimya Canal and the railway	3.944	1.987	1.015	10.488	6.229	1.572	0.119
(g) Assiut without the railway and Al-Malah Canal	3.978	2.010	1.070	10.043	5.808	1.597	0.138
(h) Assiut without: Al-Ibrahimya Canal, the railway and Malah Canal	3.979	2.011	1.078	9.980	5.778	1.602	0.138

Table 1
Syntactic measures of Assiut in different phases

At the global level, changes of global integration and mean depth values at different phases are smaller than changes of depth values. This occurs as a result of incompatibility among different patterns around the obstacles length. Thus, when these obstacles were removed, changes of the spatial structure were maintained at a minimum in terms of the global measures. Depth values, however, show greater changes, in particular at (g) and (h) phases in Table 1, because of the significant changes which occurred in the integration core shape. As shown in Figure 4g and h, the more the integration core extends, the more axial lines attached to its peripheral increase. Thus, the axial lines of small depth values are increased. As a result, the average depth of all the axial lines in the structure was notably reduced, producing a shallower structure.

On the other hand, radius-radius integration values of phases (b), (d) and (g) show significant changes in comparison to phase (a). This shows that the obstacles, in particular the railway and Al-Malah Canal, prevent the spatial structure of the city from adding more parts of the city to its well integrated areas. Regarding intelligibility, the intelligibility has increased by approximately 24%

in phases (g) and (h) in comparison to phase (a). This also confirms the negative effect of the railway and Al-Malah Canal on the legibility of Assiut.

To sum up, the above analysis produces two main results. First, not all obstacles have a significant effect on the integration core shape. Only the railway and Al-Malah Canal showed significant effects on the spatial structure of Assiut. Second, incompatibility of different patterns exerts a significant role in shaping the integration core and its extensions.

4 Findings and discussion

Through the spatial analysis of the urban grid of Assiut, it was possible to identify their inherited features and their consequences on the urban grid effectiveness. These features can be summarised as follow:

- The axial lines of Assiut city are distinguished by their shortness, and low and constant connectivity values. As a result, the city has a low intelligibility value (0.105) in comparison with the average value of Arabic cities (0.16). This occurs because of the existence of two patterns covering large parts of the city: organic meandering and organic parallel patterns. The axial lines of these patterns are distinguished by their shortness and prevalence of right-angle intersections which increase the depth of the whole spatial structure and reduced its legibility,
- The spatial structure of the city is distinguished by its variety of urban patterns. The prominent feature is the incompatibility of these patterns which prevents the integration of several districts with their surroundings. As a result, different districts of the whole spatial structure work independently and accentuate separation rather than collaboration,
- The diversity of the spatial structure of different districts on one hand and the effect of obstacles on the other play a significant role in determining the most accessible area in the city structure in a small area. Thus, this area, the City Centre, experiences high volumes of traffic producing congestion and traffic jams,
- Similarly, the spatial structure provides a number of streets with their importance at both local and global scales: Yousry Ragheb St. and 26th July St. Also, these streets represent the only links which connect directly the majority of different districts in the city. As a result, these streets represent the main links in the city structure which host different land uses, different social activities, and different types of movement. Consequently, problems of congestion, traffic and mix of pedestrian and vehicular movement are more evident in these two streets than other elsewhere in the city.
- Furthermore, because of the small number of these links, inhabitants have few options to use when moving from one district to another. This increases their problems of congestion and traffic jams. Thus, unless inhabitants are provided with alternative routes, these problems will be perpetuated and possibly increase over time. On the other hand, areas which host the intersections among these main links (City Centre district) represent a focal node in the whole structure through which all movements have to pass (see next point),
- The City Centre represents the main node through which the majority of trips from any district to another in Assiut have to pass. Therefore, the district experiences high rates of movement and a high concentration of land uses. Hence, unless having proper spatial configuration and physical condition, this district will maintain its congestion and traffic jam problems see Figure 5,
- From Figure 5, because of the poor structure of some districts such as Gharb Al-Balad (node No. 9), movement tends to depend on more legible and direct paths which pass through the City Centre (node No. 7). For example, movement from node 12, and 6 as well, to node 8 or 10 tends to pass through node 7 instead of node 9 because of the poor structure of the latter. Also, the poor physical condition of the street network of node 9 is another factor which lacks the accessibility of vehicular movement. This increases the stress on the street network of the City Centre, and
- There are two factors which exert an influence role on the spatial structure efficiency in Assiut: the incompatibility among different patterns and the co-existent obstacles. Addressing the effect of the incompatibility among different patterns, the most evident

example of this effect is the falling of the integration core links at different percentages (top 5%: top 25%) to enter Al-Walidya and Al-Mo'lmen districts even after removing Al-Ibrahymia and Al-Malah Canals.

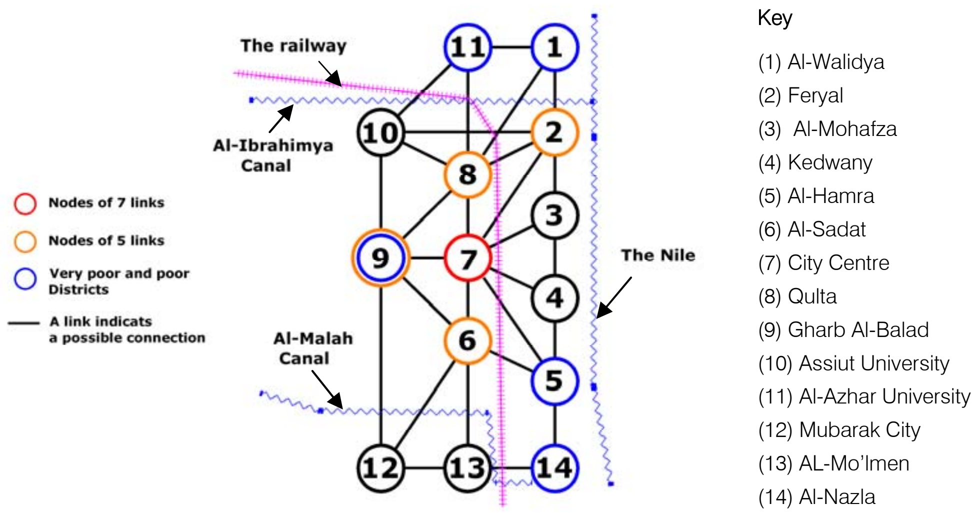

Figure 1

Graph map of different districts in Assiut (Mohamed, 2009)

Considering the effect of obstacles, the present study shows that the effects of obstacles can be classified into two categories. The first category represents the obstacles which have a significant influence on the urban grid configuration: the railway and Al-Malah Canal. The results of the analysis show that removing these obstacles from the city structure enhanced significantly its integration pattern and syntactic measures. However, the results show that the influence of the railway is higher than the influence of Al-Malah Canal. The second category, including Al-Ibrahymia Canal, represents the obstacles which have insignificant effect on the configuration of the urban grid. The analysis shows that removing Al-Ibrahymia Canal from the city structure did not enhance significantly its syntactic measures or the shape of its integration core.

This result should come to the fore as there are several requests from urban experts in Assiut to establish a new bridge across Al-Ibrahymia Canal. Such a project, as shown in the present study, will not enhance the urban grid effectiveness unless enhancing the inherited features of Al-Walidya taking into consideration the overall configuration of the city structure. Otherwise, the project will represent another misuse of money and effort as previous projects, which depended largely of the local features of the district under investigation and ignored the overall configuration of the spatial structure.

To sum up, through spatial analysis of Assiut city, it is evident that it is whole structure and its interactions with the co-existent obstacles, which determine the effectiveness of the urban grid. The spatial structure determines which areas are the most accessible within the city structure. On the other hand, the co-existent obstacles prevent the extension of the integration core. As a result, the majority of movement, land uses and activities are located in a small area, which, in consequence, suffers from congestion and traffic problems.

5 Conclusions

Based on the results of the present study, it is evident that the problems of the urban grid in Assiut, which are generally considered as a result of local structure of specific areas, are in fact the result of the configuration of the whole spatial structure. Thus, efforts should focus on the global relationships of spatial structure if sustainable and effective solutions for these problems are aimed. Only through this way, urban grid problems can be solved and urban life can be created

(Hillier et al. 1987). Thus, proposals to enhance the urban grid effectiveness should attempt to give people more options to move across the city and break the monopoly of movement and land uses in specific small area.

Also, enhancing the spatial structure of some districts should be implemented taking into consideration their global context and enhance their ability to integrate with their surroundings. Finally, as the analysis show, not all obstacles exert an influential role on the effectiveness of the urban grid in Assiut. Thus, future proposals to enhance the urban grid proficiency should focus on the means of overcoming the effect of significant obstacles. In this context, space syntax approach can be used to evaluate the effect of proposed solutions through mapping the spatial structure of the city in different phases as implemented to evaluate the effect of different obstacles in this study.

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