



## Smart, Sustainable and Healthy Cities

The First International Conference of the CIB  
Middle East & North Africa Research Network  
CIB-MENA 2014

**December 14-16, 2014**

Abu Dhabi, United Arab Emirates

Edited by:  
Ahmad Okeil



# Smart, Sustainable and Healthy Cities

**The First International Conference of the  
CIB Middle East and North Africa Research Network  
(CIB-MENA 2014)**

**Editor**  
Ahmad Okeil

Abu Dhabi, United Arab Emirates  
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Ahmad Okeil, editor

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Ahmad Okeil

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## REVIEW PROCESS

The CIB-MENA 2014 conference followed a two stage double blind review process. In the first stage 130 abstracts were received from 28 countries from all continents. Authors received feedback to help them revisit and improve their proposals and make sure they fall within the conference theme. This was followed by the second stage in which full papers have been submitted. Based on a more rigorous double blind review in which each paper has been reviewed by at least two reviewers, decisions were made whether the paper should be accepted or not. A second set of feedback was sent to authors to help them further improve their papers and prepare a camera ready version. This book of proceedings includes the 50 papers that managed to pass through this process.

## EDITOR'S PREFACE

Cities in the Middle East and North Africa, like cities in other parts of the world, are experiencing an unprecedented wave of urbanization. This urbanization is forecast to continue and intensify in the next decades. Many old cities are mushrooming to incomprehensible sizes and are forecast to approach or exceed 40 million people in the coming decade. In other cases instant cities have emerged and developed from wilderness to full urban status within a single generation.

This rapid development poses a great challenge for all those involved in the design, planning, construction, and management of the built environment in order to provide sustainable, livable, equitable, and viable cities for all people. These challenges are so diverse and range from retrofitting existing building stock and infrastructure to the design and construction of new developments. They are also so diverse that they requires innovative interventions at different levels starting from urban and infra-structure planning on one end of the scale to interior design and material science on the other end of the scale with many other levels in-between including architecture, civil engineering, urban design, and landscape architecture. The challenges are also so diverse that sustaining cities will not be possible without interdisciplinary efforts. Decision makers will need to involve multidisciplinary teams of planners, architects, engineers, environmentalists, scientists and economists to sustain the growth of these centers that are shaped by global factors, and aspire to retain local identities. This conference will provide an excellent opportunity for everyone involved in the design, planning, construction, and management of the built environment to share international best practices, experiences, technologies, and policies applicable, and offering solutions to the challenges of cities in the 21st century.

Ahmad Okeil

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## UNDERSTANDING URBAN SEGREGATION IN CAIRO

### *The Social and Spatial Logic of a Fragmented City*

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**Abstract.** Spatial segregation intensifies social segregation. The current planning practice contributes to a spatial structure on the street and road network generating social and physical segregation between neighbourhoods. The spatial relationship between local centres and the overall metropolitan network fragments in comparison to the past. This contribution shows the implications of the spatial configuration of the street network on the socio-economic profile in neighbourhoods in Cairo.

The urbanisation process in Cairo is analysed in various periods from 1517 to 2012 using space syntax techniques to understand urban transformation processes and the emergence of urban centres and segregated areas. In a second step, available data from 2006 on poverty, literacy and unemployment are correlated with space syntax analyses from 2012.

As it turns out, social factors are significantly correlated with the spatial structure of the street grid on a metropolitan scale level. On a local scale, disadvantaged areas have a high locally integrated spatial structure, but lack accessibility to the surrounding areas and the whole city. Seemingly, the connection between a main route network and various neighbourhoods might influence a neighbourhood's social as well as economic integration. The current planning practice in Cairo, however, contributes to change this spatial structure through separating vibrant urban centres from the main route network. The effect is that this planning practice intensifies the social segregation processes between various social groups.

## 1. Introduction

Rapid urbanisation in Cairo during the last century has caused a fragmented spatial structure consisting of several small cities shaping the large metropolitan area. These small cities differ spatially, socio-economically as well as culturally from each other (Mekawy & Yousry, 2012; Elisa & Michele, 2013). This disordered development process, detaching different pieces of the city, produces a mosaic of urban areas without any proper urban centre (Deffner and Hoerning, 2011).

At the same time, there is an urgent need for policies reducing, or even mitigating, informal expansion. Mekawy and Yousry state that "... deprived informal settlements... need to be further studied on social and physical grounds for better comprehending and diagnosing, and subsequently for enhancing and refining policies and strategic interventions..." (Mekawy and Yousry, 2012: 11). What is lacking is knowledge on the relationship social segregation and urban spatial structure. So far, this knowledge is as fragmented as the problem at issue.

Segregation means separation or isolation. It is a spatial related term that cannot be fully understood in isolation from the built form (Legeby, 2010). Julienne Hanson (2000) argued that the spatial structure of built environments influences the degree of socio- economic interaction between people. Some built environments are able to isolate their residents from passers-by, which limit the potentials for activities and everyday life for the residents (Hanson, 2000). In general, poor accessibility separates particular groups from opportunities to participate and be a part of a society (SOU 1997 in Legeby, 2010).

Understanding social segregation requires also revealing the spatial layout of the location where it takes place. Moreover, the role of various scale levels

of the built environment – from the streets inside the neighbourhoods up to the metropolitan level – needs to be revealed for understanding how spatial and social segregation are interrelated.

Scholarship and research from Europe (Vaughan, 1999), South America (Hillier et al, 2000; Greene, 2002; Rodriguez et al, 2012), and Middle Eastern cities (Karimi and Parham, 2012) has shown that physical segregation can result in socio-economic isolation. As research so far has shown, a city's most highly spatially accessible parts are typically the most affluent quarters and the most isolated areas at a city scale tend to be the most deprived. However, in Third world cities like the Cairo metropolitan area, low income dwellers might be found in key economic locations (Sims 2003 in Piffero, 2009) due to Cairo's discontinuous development process (Abu-Lughod, 1971; Raymond, 2001; Sims, 2009; Mekawy & Yousry, 2012; Elisa & Michele, 2013). If so, why do the poor urban areas not benefit from their strategic location on the long run? Or, are the conclusions from previous studies not applicable for a fragmented metropolitan area like Cairo?

In her studies on informal settlements in Cairo, Elkadi (1987) identified several factors in provoking or impeding an urban development process: security of tenure, land prices, income, immigration, population growth rate, education and housing policies. Elkadi reviewed the causes behind the expansion of informal housing areas and identified their location based on socio-economic characteristics. However, the spatial structure of the street grid and its influence on the pattern of urban poverty is hardly addressed in her research.

Later, Amer (1990) correlated the various dimensions of Cairo's physical environment to social factors by tracing and analysing the urban transformations of Cairo along five decades (1947-1986). The results from her study indicated that the density of economic activities or "centrality component" as well as the "socio-economic status" played a role in producing "the spatial differentiation pattern of different social groups" (Amer, 1990: 7).

More recently, the studies of Mohamed et al (2013) show that the relationship between social and physical segregation in the Cairo metropolitan area is significantly related. However, the study was on a district level, where a discrepancy between the spatial structure and the administrative boundaries can be found. The administrative boundaries of some areas contain more than one urban pattern, while in other cases a single

spatial structure could be divided into more than one area. Moreover, Mohamed et al (2013) did not pay attention to the importance of spatial structure in directing urban growth.

Accordingly, this inquiry endeavoured to overcome the defects of previous work. On the one hand, this inquiry reveals how spatial and social variables are interrelated, and on the other hand the spatial drivers through Cairo's history are discussed with purpose to understand how this fragmentation patterns have emerged. Detailed statistical analyses at neighbourhood level are conducted to minimize the impact of discrepancy between spatial and administrative boundaries. In addition, three different neighbourhoods are analysed in detail for correlating quantitative spatial as well as socio economic variables with one another.

According to Bill Hillier, the spatial configuration of settlements can aggregate an upward socio-economic development spiral. According to the theory of "natural movement" (Hillier et al, 1993) and "movement economy" (Hillier, 1996) the spatial configuration of the street network generates the movement flows through built environments. Consequently, highly accessible spaces will attract movement-seeking activities (e.g. commercial uses), while non-movement-seeking activities (e.g. residence) will migrate to locations with low co-presence. The attracted uses will produce 'Multiplier effect' on movement since they will increase the importance of the locations themselves and will in turn encourage further uses. This dynamic process of configuration, movement, and attraction is what Hillier called 'movement economy' (Hillier, 1996).

First, the spatial analyses of Cairo's urban street network along five centuries are presented. The purpose is to show the emergence of centrality and fragmentation in Cairo's urban development. Second, this inquiry focus detailed on some of Cairo's informal settlements for analysing their level of fragmentation or integration into the larger urban fabric. Finally, the correlation of spatial as well as socio-economic indicators is analysed in detail for three different neighbourhoods in Cairo.

## **2. Methodology**

This paper employs two primary data sources for the case study to investigate the relationship of the spatial parameters and the socio-economic factors. These consist of: survey maps from *Le Description de l'Egypte*, ESA (the Egyptian Survey Authority) and GOPP (General Organization for

Physical Planning), and socio-economic data obtained from UNDP Egypt (2008).

A series of Cairo's historical maps were selected for analysing the major urban transformations from the medieval city from 1517 to 2012. The chosen periods are:

- 1517, which marks the end of the Mamluk era
- 1744, which represents the traditional city under Ottoman reign
- 1809, which represents the city after the French expedition and the accession of Muhammad Ali (1805-1848)
- 1888, which represents the city after Ismail's rule
- 1920, which represents the situation after the 1919 revolution
- 1933, which shows the city during the unrest of Britain's occupation that officially ended in 1936
- 1958, which reflects the situation after the 1952 revolution
- Finally the 2012 Cairo map as the current situation after the 25 January revolution. These events and their impact on society all influenced the city's shape and produced the current urban agglomeration.

First the spatial parameters of the street network are analysed with the space syntax method (a graph based theory developed by Hillier and Hanson, 1984), and then the results from the spatial analyses of the 2012 map is correlated with obtained socio-economic data from 2006.

In order to analyse the physical form of large metropolitan areas requires focusing on the spaces between buildings, shaped by buildings, which is the street and road network. The street and road network is represented as a set of the fewest and longest axial sight lines. This axial map can be processed with the UCL Depthmap software by calculating the total number of direction changes (topological distance) from every street to all others. The software can also calculate the angular relationship (geometrical distance) between street segments.

There are two main concepts to predict movement pattern in an urban system:

- 1) Integration (to-movement or closeness) shows how easy it is to reach a certain space from other spaces (Hillier, 1996). Spaces with maximum spatial integration will have minimum number of direction changes to all other spaces (Mohamed, 2010).
- 2) Choice (through-movement or betweenness) measures the potential flow of human movement through each space. The choice measure shows how many times a space will be passed through with the lowest angular

deviation from everywhere to everywhere else (Turner, 2005; Mohamed et al, 2013). A street segment that has a high choice value will be utilized by people wishing to follow the shortest path to their destination (Kostakos, 2010: 35). Choice measure can be normalised to compare urban systems of different sizes with each other (Hillier et al, 2012).

A spatial global integration analyses shows the relation of a street segment to all segments in a whole city. For example, global angular integration shows how each street segment is connected with angular weighting to all others within the whole metropolitan region. It is also possible to analyse how spatially integrated a street segment is on various local scales by using various metrical radii. A radius like 500-800 metres shows how integrated a street is on neighbourhood level, a radius like 2000-5000 metres shows how integrated a street is on town or city level, while a radius like 10000 to n shows how integrated a street is on metropolitan level.

The spatial analyses with a radius of 2000-5000 highlights the main routes going through and between various urban areas. This main route network is the spatial armature linking various urban areas together, and influence how and where commercial activities take place. To what extent a main route between or through urban areas function as a local integrator depends on the way this road or street segment is connected to its direct vicinity. One way of analysing how a main route network is connected to local streets is to calculate the number of direction change with angular weighting from the main routes to each street.

All angular segment maps, except the 2012 map which is acquired from a road-centre line map, were derived from axial line maps drawn in AutoCAD. In the case of the 2012 map, the study area includes only settlements which are located within the ring road of Cairo metropolitan [Figure1].

All calculated spatial relationships for the street and road network are done independently from socio-economic data, in which makes possible for revealing quantitatively on how a built environment's physical form relates to human behaviour. Various socio-economic variables such as literacy, percentage of people living beneath the poverty line<sup>1</sup>, Deprivation Index (DI) and unemployment rates<sup>2</sup> were then integrated into ArcGIS. The results from the spatial configuration analyses of 2012 map were then overlapped with maps with the socio-economic registrations using the JMP software to

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<sup>1</sup> Nations vary in defining poverty line. In this paper, poverty line stands for the proportion of the population living under 2 dollars (PPP) a day (UNDP, 2005).

<sup>2</sup> These indicators were selected according to data availability.



provide evidence on the correlation between the efficiency of spatial configuration and socio-economic conditions.

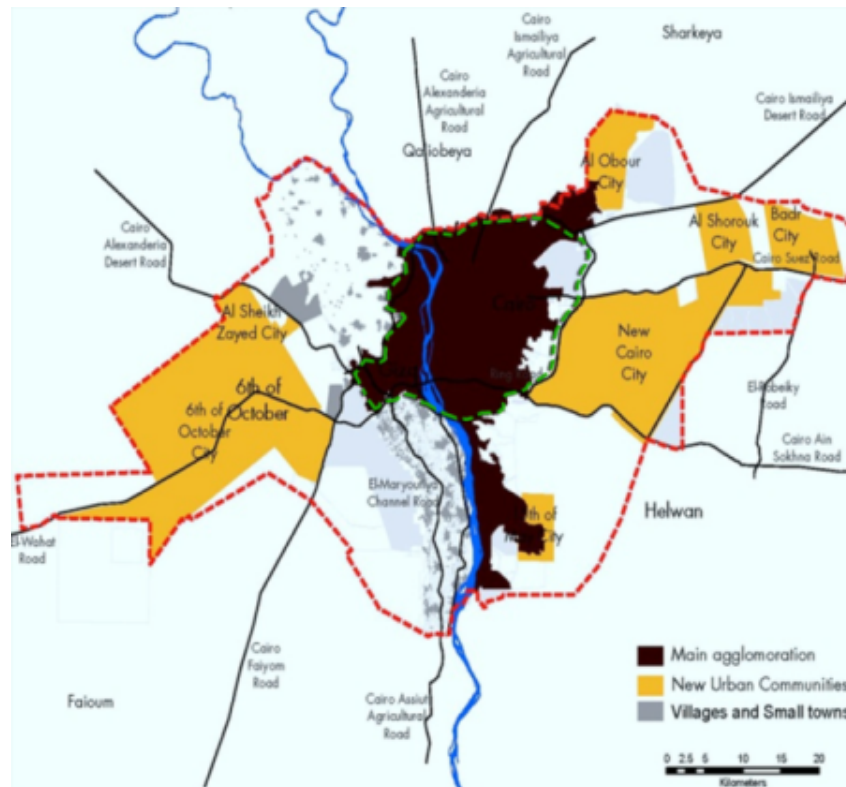


Figure 1 Map indicating the study area encircled in green within Greater Cairo Metropolitan 2012 (Authors based on a map by GOPP, 2012).

### 3. Cairo's Urban Transformation through Time

How did Cairo develop spatially through history? Figure 2 shows the global angular integration analyses of Cairo from 1517 to 2012. As the city expand, the spatially most integrated core makes a shift towards the growth direction. In Cairo's northern part, no remarkable changes can be seen in the 1517 and 1744 analyses (during the Ottoman period). The city's plan, in general, consists of narrow and sinuous streets with frequent dead ends showing that the city's buildings were placed with no care about a street connectivity. Seemingly, the irregularity of the city's road network fits the absence of wheeled transport in Cairo at the time. Such a simple transport system with Cairo's great size explains why secondary centres were established and

pushed toward the periphery where suburbs tended to be at a distance from the city's central core.

In the 1809 analysis, the spine along the Khalij with the major crossing streets on both sides still has the highest integration values. In fact, the good linkage between Cairo's centre and the western suburbs contributed to a westward urbanization. Likewise, the southern sector had become densely urbanized. In contrast, the northern part of the city, the Husayniyya quarter, shows a low degree of urbanization, which corresponds to low spatial integration values on the street network. Such an unequal expansion displaced the central core of the city in an off-centre position in the far northeast sector causing partial spatial segregation in some parts of Qahira. Nevertheless, Qahira did not lose its vitality and remained liveable.

During the Khedive Ismail's reign (1863-1879), large urban changes took place in the entire city. Ismail wanted to modernize and westernize Cairo. His visit to Paris in 1867, as a special guest of Emperor Napoleon III, gave a large impact on Cairo's urban form. He observed the progress of Paris and admired Haussman's planning concept of then Paris as "the city of light". Moreover, the wide boulevards implemented on a labyrinthine street structure were a way to control riots. With his minister, Ali Mubarak, Ismail made plans to implement this new style from Paris for Cairo. His first step was to convey the seat of power from the Citadel, in the old city, to Abdeen palace, in the new capital (Ibrahim, 2001). Accordingly, Ismail constructed Mohamed Ali Avenue to connect old city with his new capital (Raymond, 2001).

In contrast to the narrow, crooked and anarchic street network of the previous spatial models, the 1888 analysis shows high spatial integration in the new improved areas. The Hausmann-inspired urban structure of the new capital, with straight streets and spacious squares, is different than the old city. In fact, the city expansion, with its important streets oriented westwards, indicates a relocation of Cairo's urban centre from the historic centre towards the new western areas. Nevertheless, the old centre of the city still has high integration values.

Continuously, there have been other waves of urbanization in the nineteenth and at the dawn of the twentieth centuries (Ibrahim, 2001). Specifically, Cairo experienced rapid growth from 1882 to 1937. For instance, the Heliopolis area was established in the northern-east and inhabited by the elite. Likewise, fashionable neighbourhoods were developed on Zamalek and Rawdah islands in the Nile. Another residential quarter for the wealthy is the Garden City located along the eastern bank of the Nile. Accordingly,

the overall silhouette of the city changed from the compact shape shown in the previous analyses to a branched structure (northeast, south and west branches), also stretching the core of integration. While the old historic area lost much of its global integration, the Khedivian city was still in the highly integrated core. Nevertheless, Cairo's global integration core moved to the northeast.

In the 1920 analysis, Abbas St., now Ramsis, has the highest integration values. Similarly, in the 1933 analysis<sup>3</sup>, the most integrated line of the city is El-Amir Faruq St., now El-Geish. In fact, few changes can be seen in the 1920 and 1933 analyses, except some urban expansions in the northern-eastern areas.

One major urban change that took place in Cairo after the 1952 Revolution was the large migrations from rural areas in the Nile Delta and Upper Egypt to Cairo (Ibrahim, 2001; Sims 2003). Since the 1960s, the city has more than tripled its size. The urgent demand for shelter and transport still remains. Furthermore, the urbanization process on the outskirts around the urban mass of the city engulfed adjacent villages and produced a vast urban periphery of informal areas. Remarkable differences in physical and social conditions can be observed in Cairo's urban form (GTZ, 2009).

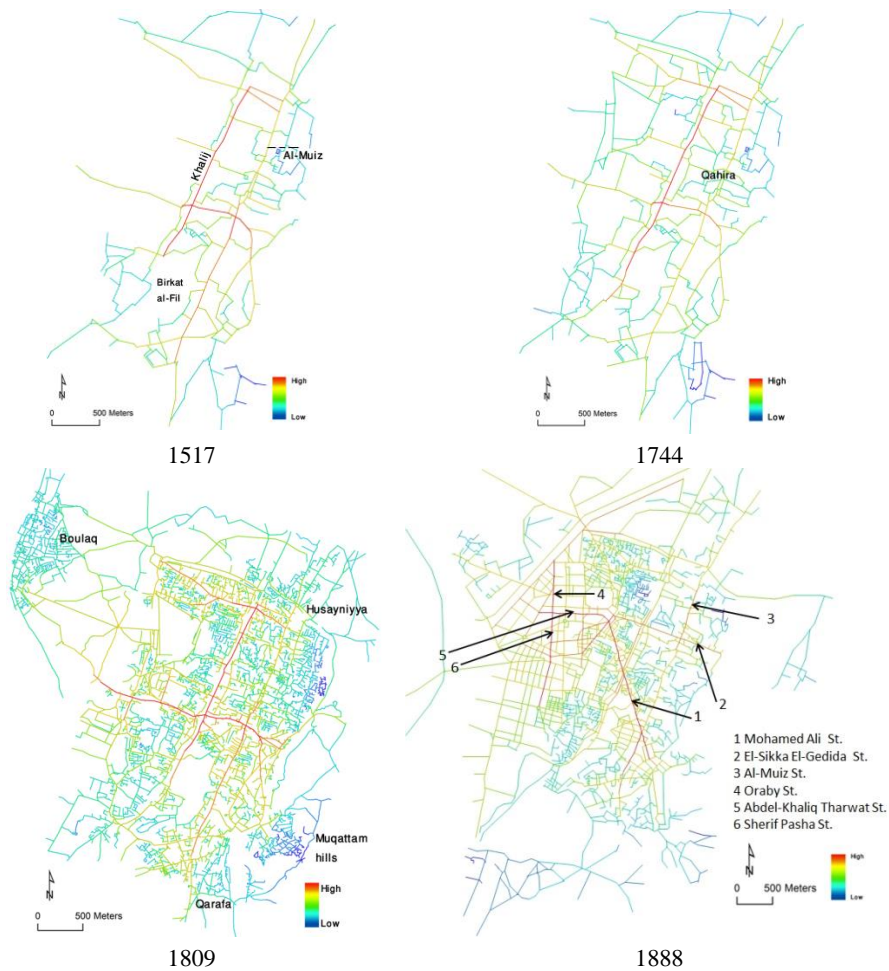
Syntactically, the 1958 analysis shows that two street corridors affected the city's further development. The analysis also shows that the integrated core of the city still corresponds to the triangular area of the Khedivian CBD. Its three furthest points are Ramsis Square in the north, Abdin in the east and Al-Tahrir in the west but with an emergence of other lower-hierarchy centres along the large integrated roads. Up to now, the south-eastern part of the city still had the most segregated values because of constraints of the cemeteries and Mokattam hills. Generally speaking, the shape of the conurbation in 1958 model remains a branched structure.

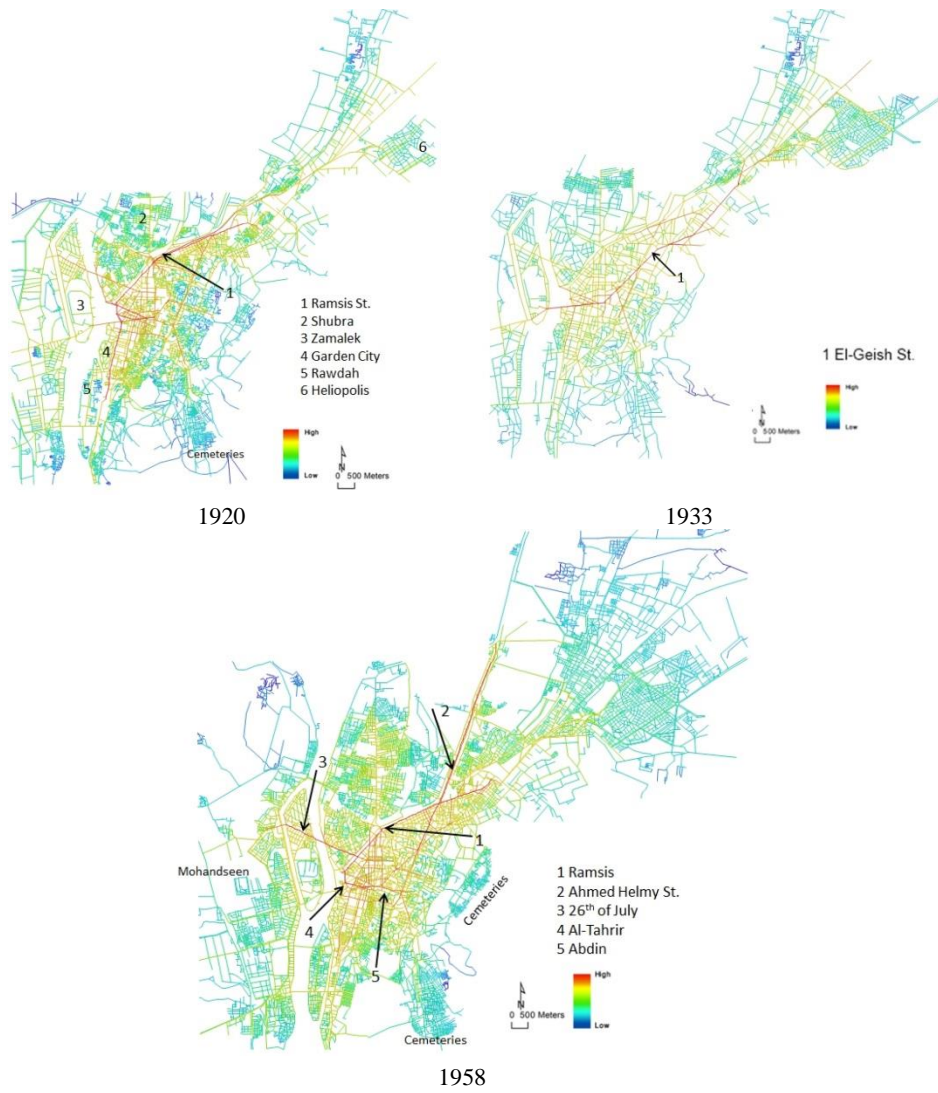
The 2012 analysis shows that Cairo's urban agglomeration is relatively fragmented. Furthermore, the segregated settlements are mainly informal and are located mostly on the peripheries and along the railway track, appearing vividly in green and blue colours in the space syntax analyses. Principally, these patches show large fragmentation of the city, and correspond to the settlement pattern of various social groups, which differ considerably from each other from a socio-economic perspective. Conversely, the spatial analyses show that the west-east corridor, starting

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<sup>3</sup> The historical map from which this model has been constructed is relatively simplified and it did not include many of the small alleys.

from Mohandseen in the west to Heliopolis in the east, is the most integrated. These highly accessible routes belong to elites' districts. Political decisions, social and economic changes influenced Cairo's urbanisation pattern through history. The pattern of central core changed and expanded as the city grew. Nevertheless, Cairo's CBD, excluding Fatimid city, always constituted a part of the metropolitan's integration core. This may explain why Cairo's CBD is still lively today as it was in the past.





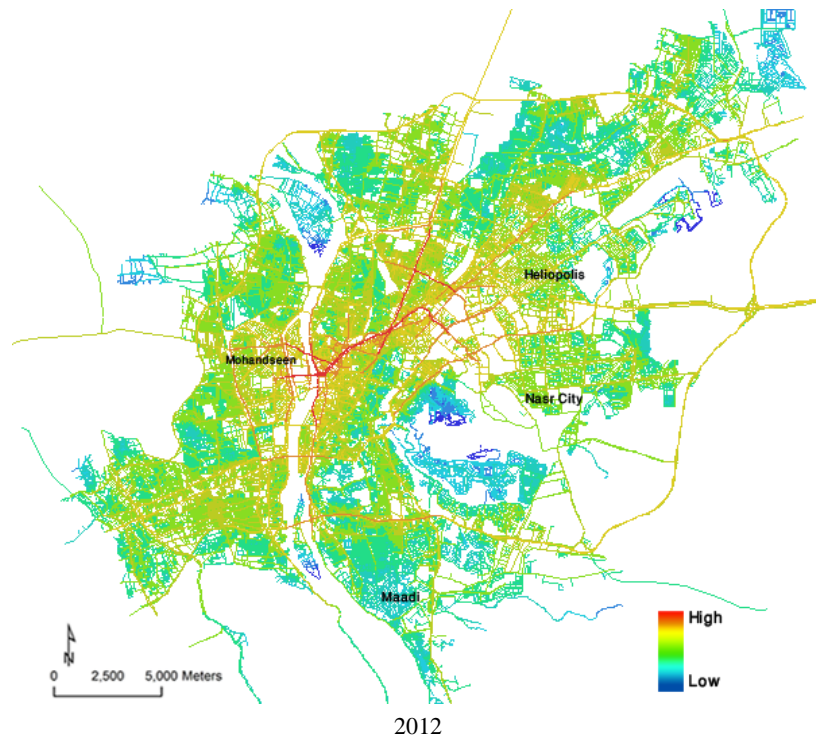


Figure2 Angular global Integration in Cairo through eight time periods.

#### 4. Generative Spatial Structures in Cairo

As research with the space syntax method has shown, most cities have a dual network: the foreground network, composed of few numbers of longer lines; and background network, composed of larger number of shorter lines (Hillier, 2009; Mohamed et al, 2013). The purpose of this section is to analyse the foreground and the background networks of Cairo metropolitan area, and to highlight the spatial drivers of growth dynamics. The results of normalised angular choice (NACH) for Cairo's historical models show that new patches of grid tend to be generated along routes of high choice values (marked in red colour) (Figure 3). The models strengthen the significance of these routes in driving the directionality of urban evolution and in enhancing the emergence of new routes. The main connecting lines of an urban street grid are semi continuous /longer ones and mainly made up of horizontal and vertical routes along with diagonal ones. However, the first three phases lack diagonal lines and have not tendency for forming a wheeled structure. Conversely, the later four stages show that high choice routes form a

deformed wheel type with partial rim. Furthermore, the last phase shows that the main routes of the city tend to form a balanced deformed wheel.

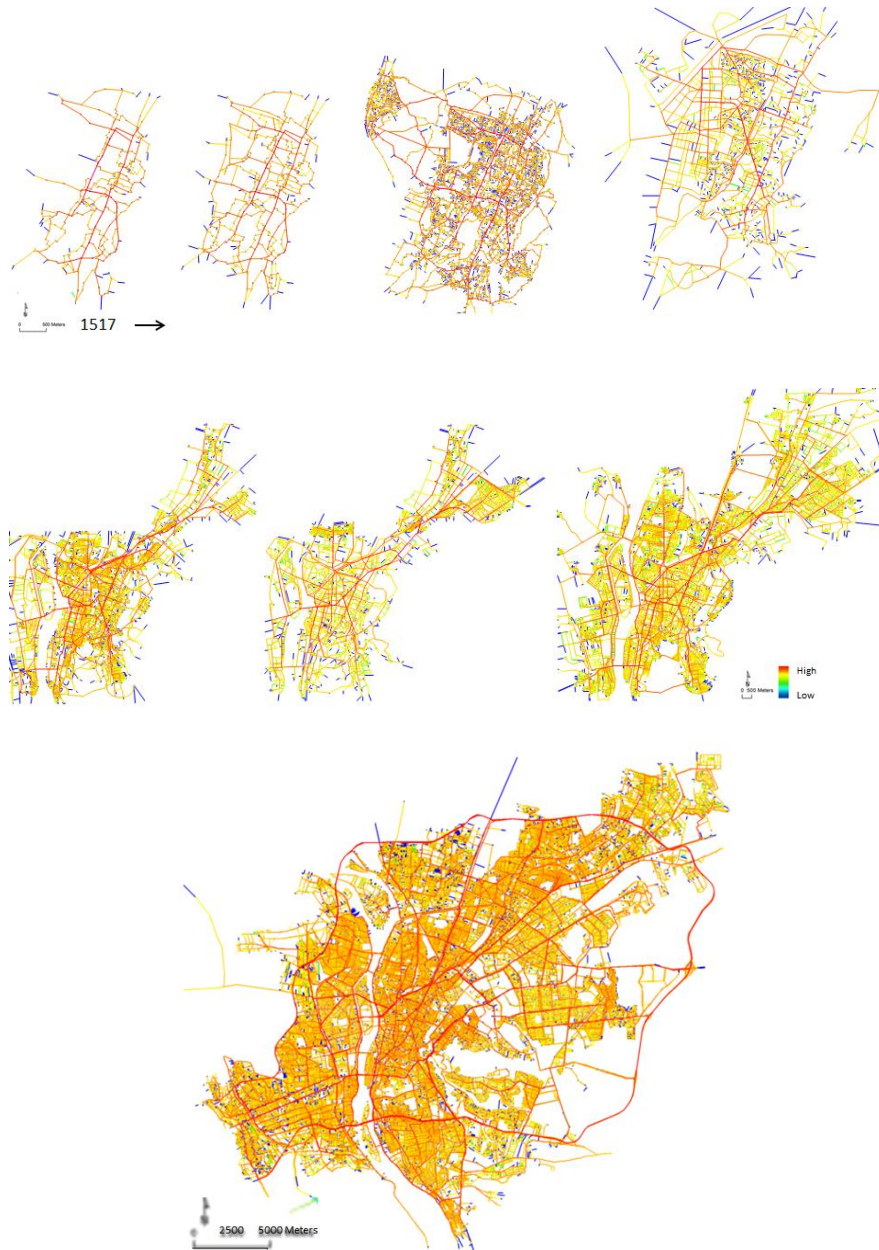


Figure 3 Normalised angular choice  $R_n$ .

The properties of the background network are calculated with a metric mean depth of radius 1000m (figure 4). Shallow or low metric depth values are marked with red colour, whereas segregated or high metric depth values are marked with blue colour. The maps highlight the location of local vibrant centres inside various neighbourhoods. Apart from the 2012 analyses, they include the historic part of the city as well as distinguished new added parts. The patchworks of local centres in 2012 correspond mostly to locations of informal neighbourhoods where organic and linear arrangements of shorter segments are manifesting. The informal areas have dense spatial structures forming distinctive hot spots, while formal districts such as Nasr city, Mohandseen and Maddi are less locally integrated, consisting of green and blue areas (Mohamed et al, 2013).

As the spatial analyses of Cairo's urbanisation process show, there is a change on the relationship between local streets and the main route network. In the past, the main route network connecting various neighbourhoods with one another was going *through* each neighbourhood. The various local streets inside neighbourhoods were well connected to these main routes. The newer neighbourhoods, informal ones as well as modern housing estates, tend to have main routes going *between* or *outside* the various neighbourhoods rather than through them. The local street network is poorly connected to these main routes, in which generate spatial segregated neighbourhoods, which again affect the degree of socio and economic integration.



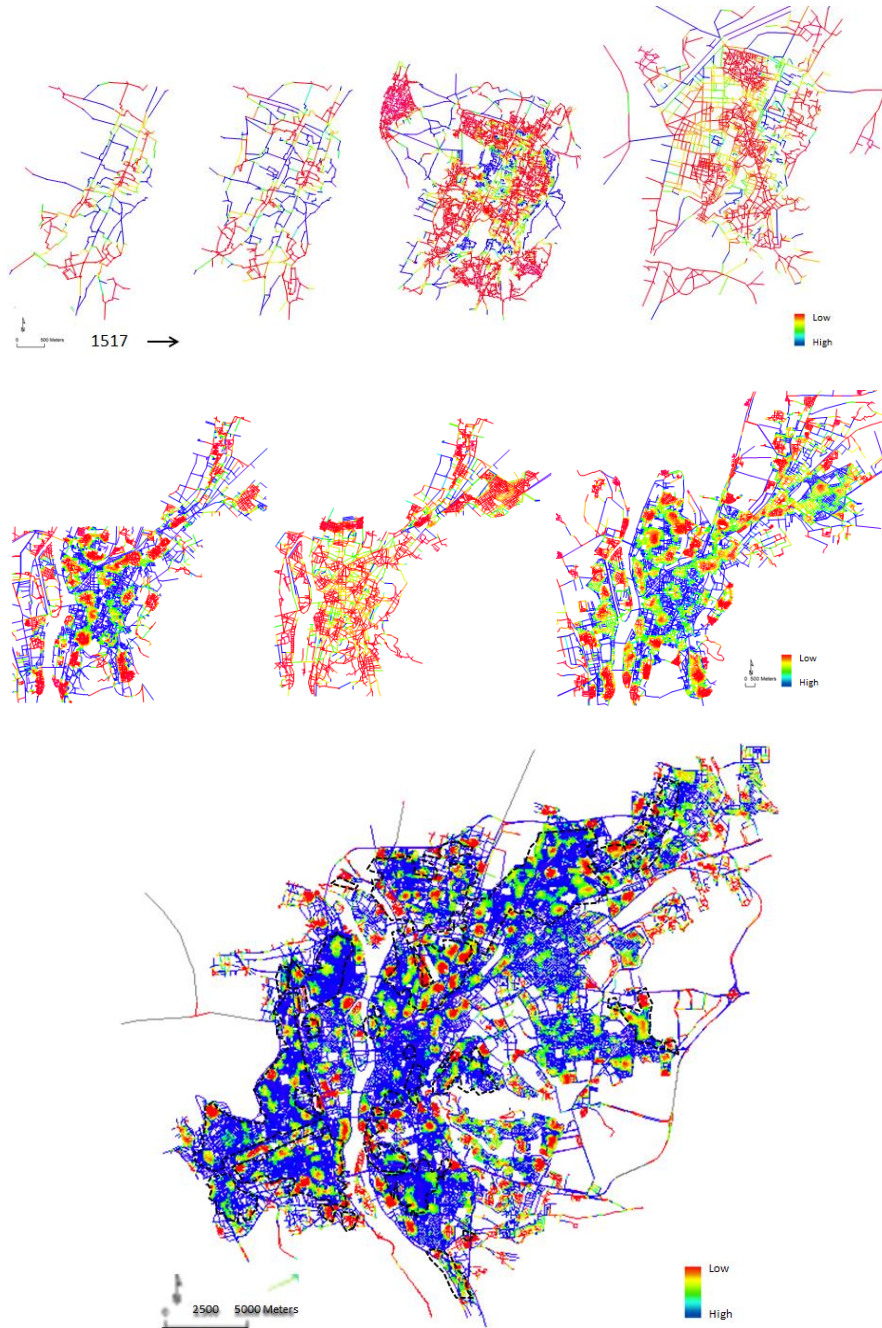


Figure4 Reversed metric mean depth R1000 m overlapped with location of informal areas in the map of 2012.

## 5. Cairo's Present Social and Spatial structures

Most demographic data, obtained from UNDP Egypt (2008), are available on neighbourhood level. Therefore, it is possible to reveal the socio-economic profile of various neighbourhoods of the Cairo governorate in terms of illiteracy rate, unemployment, percentages of people beneath poverty line, mortality rate and deprivation index. At least socio economic data from 275 neighbourhoods on the eastern part of Cairo could be compared with the results from the spatial analyses. The comparison is firstly done visually including ten equal quintiles with a colour range from dark red (for higher values) to light red (for lower values) for socio-economic attributes and from red (for highly accessible) to blue (for poorly accessible) for the spatial parameters.

As shown in figure 5a and b, the east-west corridor as well as the eastern part of the city shows the least percentages of illiteracy and people beneath poverty line. Conversely, the northern and southern areas (except Maadi) show higher values than the rest of the neighbourhoods. Obviously, this spatial division contributes to a separation of the various social classes.

Not surprisingly, there is a strong correlation ( $r = 0.9989$ ,  $p=0.000$ ) between illiteracy rate and the percentage of people beneath the poverty line [Figure 6]. In the scatter plot the affluent neighbourhoods cluster in the lowest levels of both illiteracy and poverty line. Oppositely, the impoverished areas stand on higher levels of both indicators.

The map of unemployment rate per district, presented in figure 5 (c), shows that the least percentage of unemployment is clustered in the central area of the city. Oppositely, northern and south-western districts show the highest levels of unemployment (the dark red areas in figure 5c). Remarkably, the regression analysis shows a significant inverse relation with illiteracy ( $r$  of  $-0.1779$ ,  $p=0.0031$ ) and percentage of people beneath poverty line ( $r$  of  $-0.1823$ ,  $p=0.0024$ ).

The Deprivation Index (DI)<sup>4</sup> was also registered in a GIS file. The thematic map presented in figure 5 (d) clearly mirrors the findings of the maps of

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<sup>4</sup> This indicator was built as follows (UNDP Egypt, 2005; 2008; UNDP, 2010):

$$DI = [1/5 (P1^3 + P2^3 + P3^3 + P4^3 + P5^3)]^{1/3}$$

Where:

P1 = Probability at birth of no surviving to age 60

P2 = Adults lacking functional literacy skills

illiteracy and poverty, where the least deprived neighbourhoods are concentrated on the east. Most strikingly, the neighbourhoods comprising Manshiet Nasser district have the highest rate of deprivation index. The statistical analysis shows that the deprivation index has a positive correlation with both illiteracy rate ( $r= 0.9254$ ,  $p< 0.0001$ ) and percentage of residents beneath poverty line ( $r= 0.9271$ ,  $p< 0.0001$ ) [Figure6].

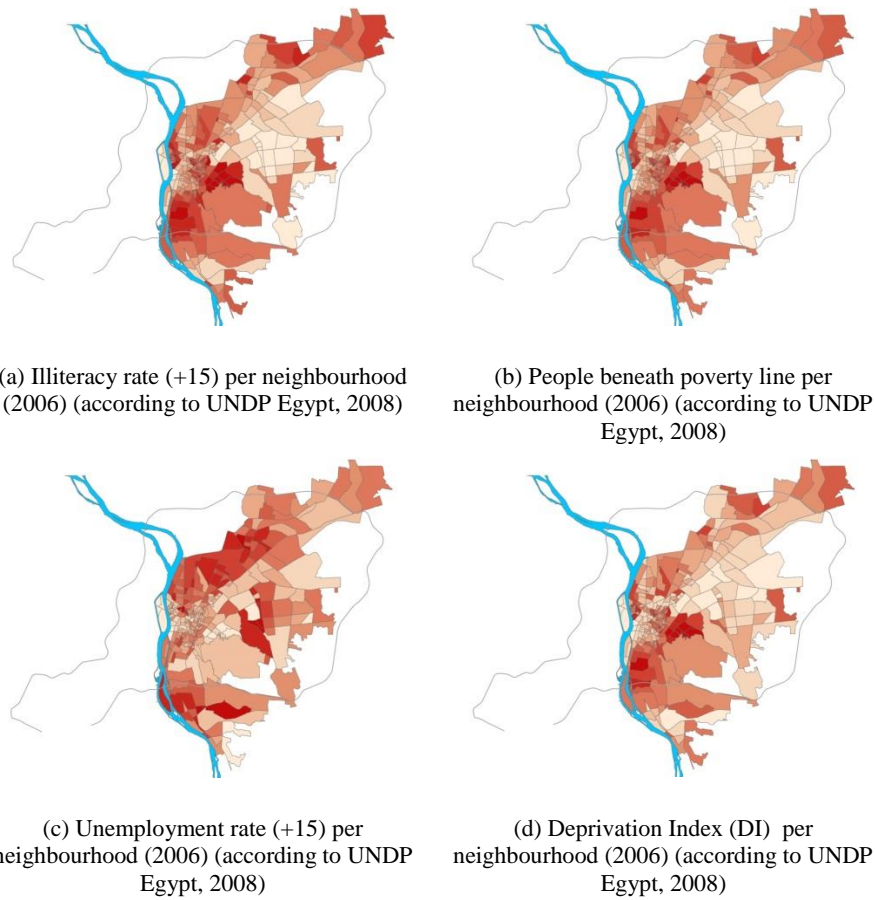


Figure 5 socio-economic factors at both district and neighbourhood levels. Dark red colour is for higher values, while light red is for lower values.

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P3 = Rate of long-term unemployment  
 P4 = Population below income poverty line  
 P5 = Gap in living standards

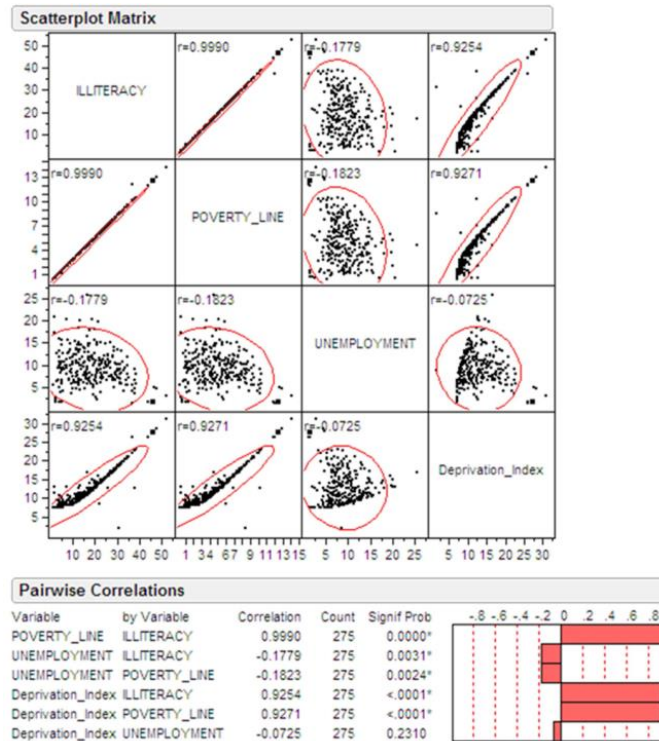


Figure 6 Correlation between social variables.

In order to correlate the social indicators with the spatial structure, the previous spatial syntax analyses are converted into choropleth maps using the neighbourhoods as common spatial reference. For these maps with the angular global and local integration measures [figure7], the mean for each configurative parameter was calculated by isolating the segments within or partially within administrative boundaries of each neighbourhood.

In this new visualization, the angular global and local integration measures again show that Cairo's downtown is spatially accessible, while this is not the case for the city's outskirts. Meanwhile, some strategically located areas such as some parts of the old historic Cairo are physically segregated on a metropolitan scale. Some neighbourhoods have at the same time very high values on the global angular integration analyses and very low values on the local angular integration analyses. Often these areas consist of large highways poorly connected to their vicinity. A strong west-east corridor contributes to high values in the global angular integration analyses. This corridor runs through the locally integrated geographic centre of Cairo.

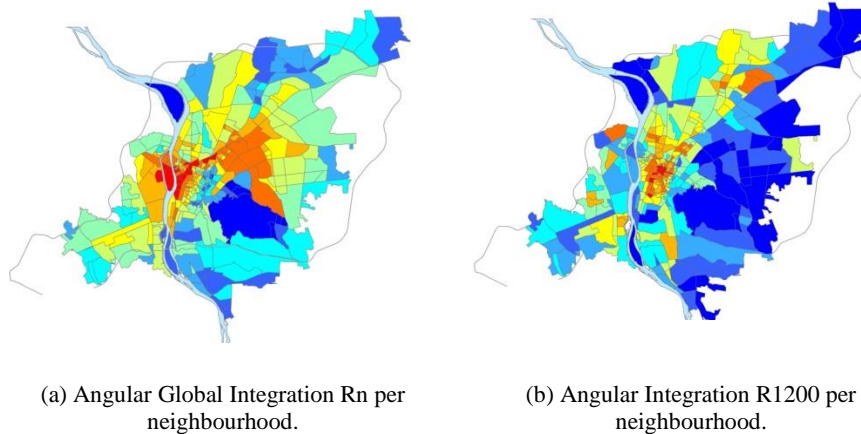
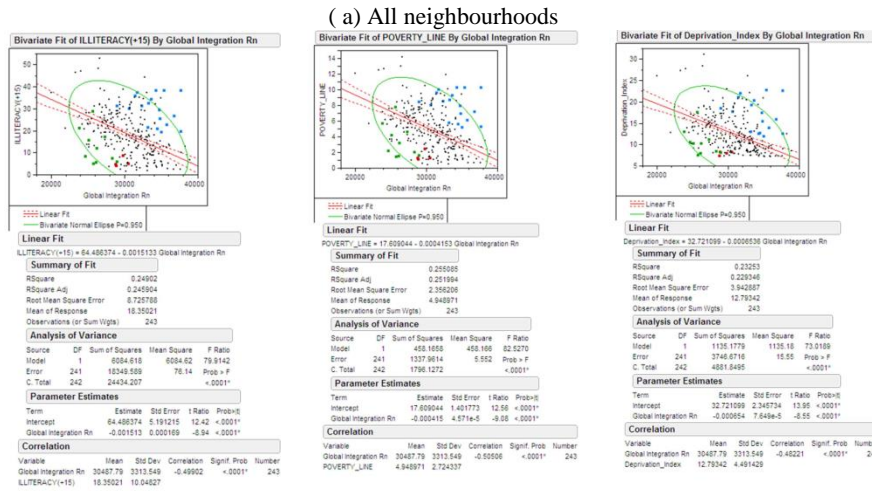
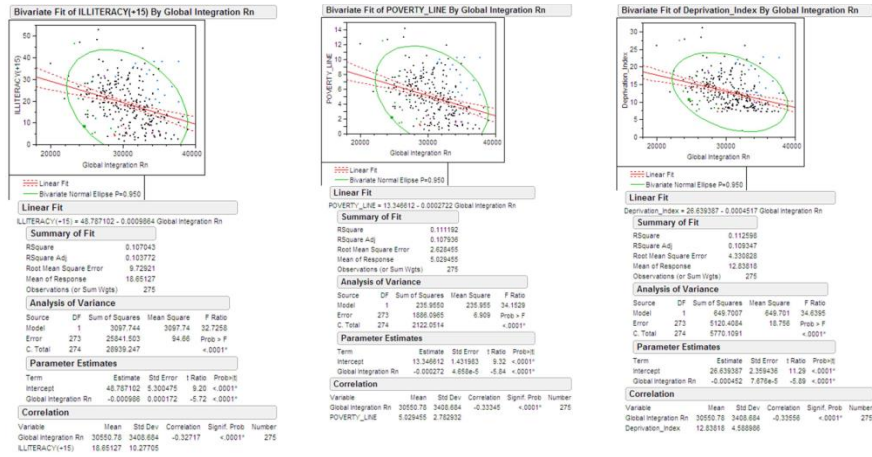


Figure 7 Syntactic measures on both district and neighbourhood scales. Colours signify degree of spatial accessibility, red is integrated and blue is segregated.

How are the socio-economic and spatial parameters interlinked? Figure 8 (a) shows the outcomes from the statistical analyses between social and spatial factors, which indicate a correlation between some social attributes and global integration. For example, the research indicated a significant negative correlation between illiteracy rates and global integration ( $r$  of  $-0.4033$ ,  $p < 0.0001$ ). Likewise, global integration correlated inversely with the percentage of people beneath the poverty line ( $r$  of  $-0.3908$ ,  $p < 0.0001$ ). This means that affluent settlements will be more integrated, while poor areas will be more segregated. In addition, global integration correlated negatively with deprivation index ( $r$  of  $-0.3908$ ,  $p < 0.0001$ ).

It is noteworthy that such correlations rise when neighbourhoods comprising older districts such as Boulaq are excluded ( $N = 257$ , R square of  $0.19$ ,  $0.20$  and  $0.18$  for the relation of illiteracy, % of people beneath poverty line and deprivation index with global integration respectively) [Figure 8 b]. Furthermore, excluding more outliers such as the rich local authorities in the east (e.g. the neighbourhoods comprising Al-Nozha) and south (i.e. Maadi) strengthen the relations ( $N = 243$ , R square of  $0.25$ ,  $0.26$  and  $0.23$  for the relation of illiteracy, % of people beneath poverty line and deprivation index with global integration respectively). The reason for excluding these outliers is their partial independence from the city. Boulaq has always belonged to the outskirts of Cairo and is still not integrated to the metropol. Maadi, for example, was established in 1904 and is about 12km upstream from Cairo CBD. Progressively, Maadi have been engulfed by the city but still maintains certain independence. Cairo's development process is and has been "patchy" (Raymond, 2001). Surprisingly, considering only the neighbourhoods ( $N = 15$ ) comprising the districts of Al-Nozha and Maadi

shows strong inverse relations of angular global integration with illiteracy (r of -0.6584,  $p < 0.0075$ ), percentage of people beneath poverty line (r of -0.6583,  $p < 0.0075$ ), and deprivation index (r of -0.6413,  $p < 0.01$ ). However, this is not the case when considering the Boulaq's neighbourhoods (N= 19).



(b) excluding neighbourhoods comprising districts of Boulaq (blue), Maadi (green) and Al-Nozha (red).

Figure 8 the relation of illiteracy, % of people beneath poverty line and deprivation index with global integration at a neighbourhood level.

To sum up, these results show that both physical and social segregation are closely related. The findings also show that some districts such as Maadi and Boulaq are poorly embedded within Cairo's entire agglomeration.

## 6. Conclusion

As the results from the socio-economic and spatial analyses of Cairo show, spatial segregation contributes to social segregation. Conversely, spatial integration contributes to integrate various social groups with one another and shape possibilities for micro economic interactions to generate income for living.

The spatial analyses of Cairo through history show that the location of Cairo's main centre has shifted at least twice in the last 200 years. It all depends on in which direction the city expands and on the implementation of planning paradigms such as European ideal city models, and political decisions. Interestingly, the results of the historical analyses show that longer axial lines of high choice values play a significant role in steering the city's expansion. Furthermore, spatial analysis at a neighbourhood level indicated that Cairo's informal areas are locally integrated, but poorly connected to the rest of the city.

To what extent do the correlation between spatial and socio-economic parameters in Cairo deviate from previous studies? First of all, poverty issues can overrun the spatial parameters. However, to what extent the poor can participate in the socio-economic life in cities on the longer term seems to depend on the spatial structure of the main route network of the city and its relationship to local neighbourhoods. On a metropolitan scale, the main route network shape a deformed wheel pattern running from Cairo's central areas. On a neighbourhood scale, there exists also a small deformed wheel structure on main streets running through the various neighbourhoods. In some old urban areas, this small main route network is also a part of a metropolitan main route network, while in other urban areas these local main routes are separated from the metropolitan main route network. This separation seemingly contributes to isolate some neighbourhoods from their surroundings.

When revealing Cairo's current planning practice, the way in which new roads are constructed contributes to a further separation of the surrounding neighbourhoods. Combined with the current poverty problems in Cairo, a spatial separation on various scale levels contributes to a further social segregation between the rich and poor. Cairo has several urban areas with their own centres, both informal and wealthy ones. However, their degree of vitality depends on how the metropolitan main routes are able to bring in potential customers to these centres for the stimulation of locations of various micro scale economic activities.

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## **THE ROLE OF SUSTAINABLE URBAN DESIGN PRINCIPLES IN DELIVERING SUSTAINABLE HIGH DENSITY MIXED USE SCHEMES IN JORDAN, USING AMMAN AS A CASE STUDY**

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**Abstract** - This research seeks to define and explore the implementation of sustainable urban indicators in high density mixed use developments in Amman, Jordan. Sustainability; the use of resource and materials as well as the delivery of resource efficient spaces, products and services, are an increasingly important factor in the evolution of urban environments. High density mixed use developments are increasingly used in major cities in the Middle East, and around the world, as the means to deliver high volume housing to increasing conurbations and polycentric cities. This is to address housing demand for increasing population and migratory trends into cities. The primary research aim is to explore the applicability of defined sustainability indicators in the Amman context and using these indicators, to investigate policies and strategies to deliver high density mixed use sustainable developments within the city. Using existing literature, this paper will review global sustainable urban indicators as it applies to the Amman context and highlight the constraints, solutions and the planning strategy to their delivery in high density schemes in selected case study areas. Context-derived data and statistics analysed together with the Amman Master Plan will then be used to explore the guidelines for the implementation of sustainable urban design principles using HDMU, by exploring the factors that affect the successful and effective delivery of the HDMU schemes in the specified areas, such as; the suitable indicators, constraints, solutions and planning strategy to manage this process. The paper will conclude with a series of multi-faceted recommendations based on lessons learnt from previous schemes such as Curitiba, and current HDMU projects in Amman.

## 1. Introduction

The research examines the role of sustainable urban design principles in delivering sustainable high density mixed use schemes in Jordan: the case of the Amman Master Plan. This study has selected the city of Amman to apply of sustainable urban design principles, using urban sustainability indicators. The need to undertake this kind of research is that Amman is a new city, albeit with Roman roots, it was created in 1921 and named the capital of Jordan in 1921. It also is a bustling and growing city that has been able to blend its rich natural and cultural heritage and with modern urban development (Potter, et al., 2009; Abu-Dayyeh, 2004; Al Rawashdeh and Saleh, 2006). It also proposed to develop the master plan at several periods. In recent years, the city has witnessed exponential growth, especially since early 1990s, doubling in size in the space of a few years as a result of an influxes of nationals from neighboring states following the 1991 Iraqi invasion of Kuwait and the subsequent war, the 2003 second Gulf War, and more recently due to the war in Syria. As a result, there emerged some problems which affected the urban form for the city, such as; transportation, water access, misuse of lands, and material used in the building construction. Therefore, it has become necessary to propose and implement a master plan which addresses these issues whilst using the opportunity to integrate sustainable solutions as well.

## 2. Literature Review

This research will be built on previous work carried out by Canadian researchers on the master plan. The outcome of their work was to propose sustainable high density mixed use developments in three areas in the city of Amman. My research will take this work further by exploring the factors that affect the successful and effective delivery of the HDMU schemes in the specified areas. At present, there are no clear guidelines for the implementation of the scheme.

A number of authors such as, Pearce, Barbier, Al Waer and Lehmann have proposed frameworks for sustainable urban design (Lehmann, 2010; Al Waer, et al, 2013; Pearce, Barbier, 2000). Al Waer, et al. (2013, p. 8) pointed out that sustainable communities need to be developed within an inclusive framework. They affirm that such framework needs three key factors to be used effectively; (1) providing a broad variety of indicators and measurements, (2) identifying the consequences of actions, such as; constraints and solutions to overcome the challenges facing the implementation of this process and (3) anticipating process pathways through a planning strategy for managing the process to the desired future