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Reintegrating informal settlements into the Greater Cairo Region of Egypt through the regional highway network

Eman Zied Abozied [a] and Alice Vialard [b]

ABSTRACT

This study analyses informal settlements and the regional highway network in the Greater Cairo Region of Egypt to propose alternatives to reduce regional spatial fragmentation that may lead to spatial segregation. Findings indicate that the street structure of informal settlements provides a configuration that supports social interaction for their residents. While the regional highway network can act to physically disconnect the wider region by isolating or splitting neighbourhoods, some highways can act as an integrator. Analysis at the urban scale can identify points in the settlements' street networks where they can be connected to the regional transport network, which could have an impact on regional consolidation.

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informal settlements; regional highway network; regional consolidation; Greater Cairo; spatial fragmentation; spatial intervention

JEL classifications

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INTRODUCTION

Informal settlements are unplanned housing areas that exist worldwide. About 25% of the world's population lives in informal settlements (UN-Habitat, 2015), yet governments typically do not incorporate them into city-wide development plans. This can lead to spatial fragmentation, marginalization of residents, and can slow the social and urban development of the city (Huchzermeyer & Karam, 2006; Roy, 2004). Reintegration of informal settlements presents an alternative to their displacement by facilitating exchanges between their marginalized residents and the city (Devas, 2012).

Spatial fragmentation in informal areas has been addressed in other studies (Balbo, 1993; Inostroza et al., 2013). These highlight the role of accessibility to mediate spatial fragmentation (Dovey & King, 2011; Graham, 2001). While it has been established that highways can cause segregation in informal areas (Figueroa et al., 2019; Mohamed et al., 2014), their potential as integrators has not been studied using quantitative methods. With the recent creation of its

CONTACT

(Corresponding author) eman.abozied@northumbria.ac.uk, emanzied@gmail.com

[a] Department of Architecture and Built Environment, Northumbria University, Newcastle Upon Tyne, UK.

alice.vialard@northumbria.ac.uk

[b] Department of Architecture and Built Environment, Northumbria University, Newcastle Upon Tyne, UK.

regional highway network, Cairo provides a range of conditions in which the highway acts as a barrier and causes social segregation (Mohamed et al., 2014), but also conditions when the highway can act as an integrator between communities (Zied & Vialard, 2017). This paper explores this through the following questions:

- What role does the regional highway network play in regional consolidation or fragmentation in the Greater Cairo Region?
- Can a highway that was previously a segregator become an integrator?

To address this, this paper focuses on analysing the relationship between the internal street network of three neighbourhoods and the highways that are on the edge or run through each neighbourhood. Each neighbourhood has a different relationship with the highway, which may highlight how a highway can be a segregator or integrator.

Defining informality and the regional highway network's role in socio-spatial segregation

The emergence of informal settlements is due to demographic shifts through rural–urban migration and lack of housing for the urban poor. While informal settlements provide housing, they face issues such as exclusion from formal structures, insecurity of tenure and lack of public services (Rocco, 2018). When cities are a mixture of informal and planned areas, they can face spatial fragmentation (Balbo, 1993). Physical intervention in informal settlements can help alleviate these issues by increasing access to the city and the opportunities this affords (Abbott, 2002; Hegazy, 2016; Khalifa, 2015).

In Egypt, informal settlements offer an alternative to planned housing and tend to have high security of tenure and construction standards. Residents of informal areas are socially and economically heterogeneous (El-Batran & Arandel, 1998) and the housing is generally built on privately owned agricultural land (Sioufi, 1981). However, informal settlements can contribute to the fragmentation of the city and disordered growth, as they are not constrained by planning policy (Stewart, 1999).

Some argue that current planning policy reinforces spatial fragmentation of informal settlements by not providing access to main transport links, which contributes to social segregation (Arandel & Bartan, 1997; Mohamed et al., 2014). Although the highways are geographically traversing or bordering most informal settlements, they are not physically accessible. In Ard El Lewa, residents recognized the importance of having access to the highway network and built

Figure 1. Pedestrian and vehicular access to the Ring Road highway.
Source: Patelli (2016).

their own access ramp to the Ring Road Highway on the edge of the neighbourhood (Figure 1) (Patelli, 2016).

The literature shows that no highway access plays a role in the spatial segregation of informal areas, which can lead to city and regional fragmentation. However, it is unclear how a highway can act as integrator.

Case studies

In this study, highways are defined as principal roads that connect neighbourhoods in the Greater Cairo Region. They are smaller than roads between cities but larger than the primary roads within neighbourhoods. They tend to be the main integrator between neighbourhoods and can be built on the edge or through the neighbourhood. Cairo has lower vehicle ownership than socioeconomically similar cities, which can limit the access of the majority of residents to a vehicle-centred regional transport network (CAPMAS, 2015; World Bank, 2004). The highways have been classified as an integrator or a segregator based on their physical characteristics, which is levelled or elevated and traversing or bordering (Figure 2 and Table 1).

Located within the Ring Road highway, the case studies are selected to represent different highway conditions. In Ard El Lewa and Mit Uqba, highways are not connected physically to the neighbourhoods and split part of the settlement. In Heliopolis, the highway is accessible for both informal and planned areas.

In terms of urban form, Ard El Lewa represents informal growth on agricultural land (Sioufi, 1981). The Ring Road acts as boundary on the edge preventing its growth and the 26th July Corridor splits the neighbourhood into two. Mit Uqba is an historical informal neighbourhood, which had the planned Mohandisseen neighbourhood built around it. The 26th July Corridor traverses Mohandisseen with access but cuts through Mit Uqba with no access, leaving part of Mit Uqba segregated from the rest. The planned neighbourhood of Heliopolis is connected to its surrounding informal neighbourhoods, Ain Shams and Matariya, by the Gesr El Suez highway, which delimits the edge of each neighbourhood.

The differences in urban form of each neighbourhood are illustrated in Figure 3. The public spaces have different developments in planned and informal areas. In informal areas, the public space is considered the leftover space between the built-up urban blocks and not a strictly designed street network. In planned areas, the street network is planned at the same time as the urban blocks, so the street network and urban blocks are clearly defined.

DATA AND METHODOLOGY

The structure of the public space is analysed using space syntax, which has developed a quantitative configurational method to analyse cities based on the premise that the spatial configuration of streets condition social behaviour (Hillier & Hanson, 1984). The more spatially connected a street is to other streets in the network, the more accessible it is, creating potential movement and interaction. Networks of potential movement support the idea of community and can provide insight into the structure of the neighbourhood.

Research into the structure of informal settlements uses space syntax to study how the urban form affects the consolidation of informal areas into the city (Hillier et al., 2000) and the role of highways in the segregation of informal areas (Figueroa et al., 2019). Both studies use axial representation to study informal urban fabric. Axial representation allows for a more accurate representation of local pedestrian movement in the public space in informal urbanism which may not follow street centreline (Hillier et al., 1993).

The axial map translates public space into a series of lines representing potential for movement in open space (Figure 4). Each axial line depicts the maximum extension of a point in space. Using graph theory, the integration value for each of these lines (nodes) corresponds to how many steps

(links) are necessary in order to reach every other line in the network (Figure 3). Based on topological distance, this value is calculated using the specialist software DepthmapX. High integration means that the street is well connected to other streets and generates potentially more social interactions. In contrast, low integration means that the street is harder to reach, which leads to poor usage.

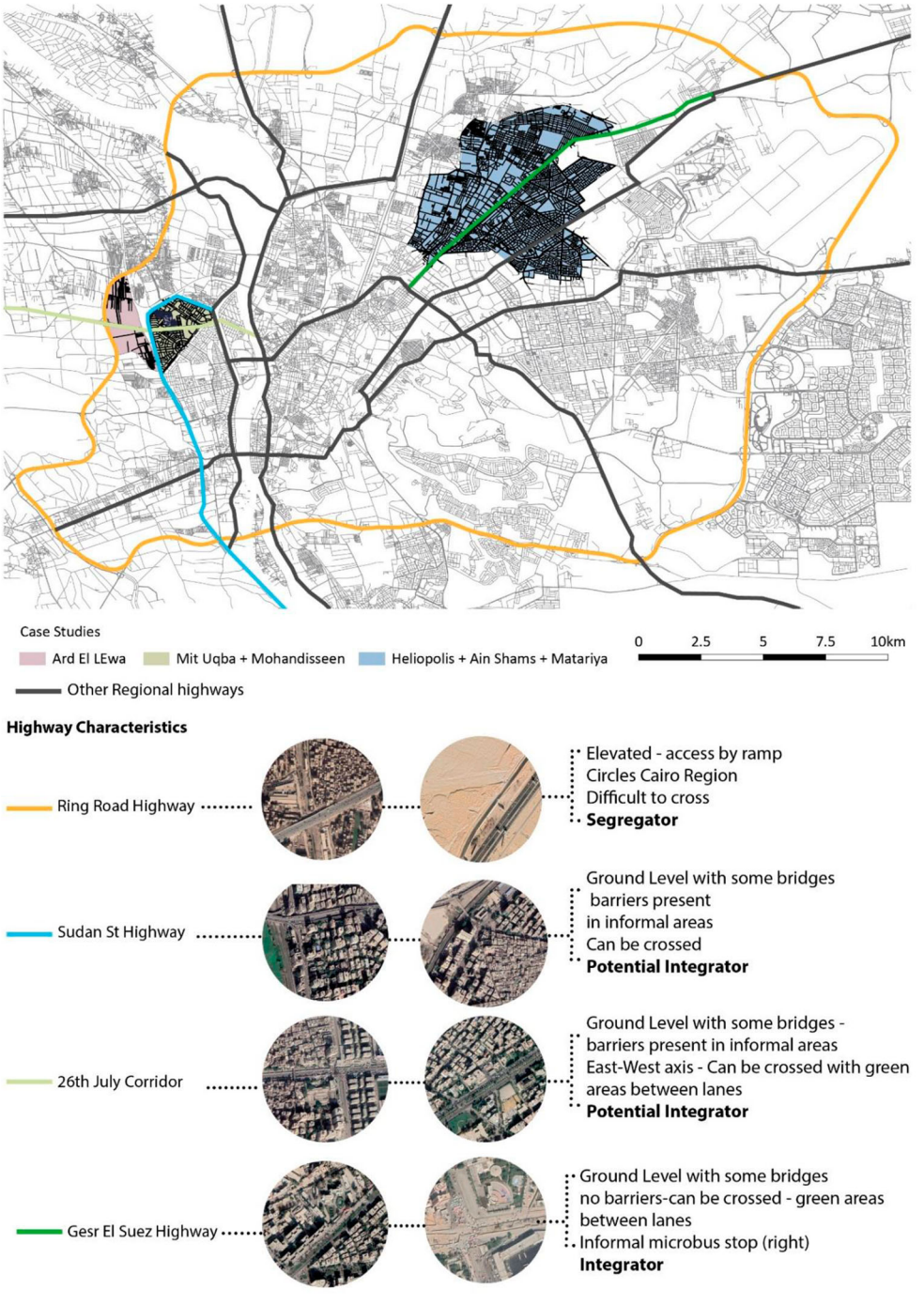

Figure 2. Case studies location and highway characteristics.

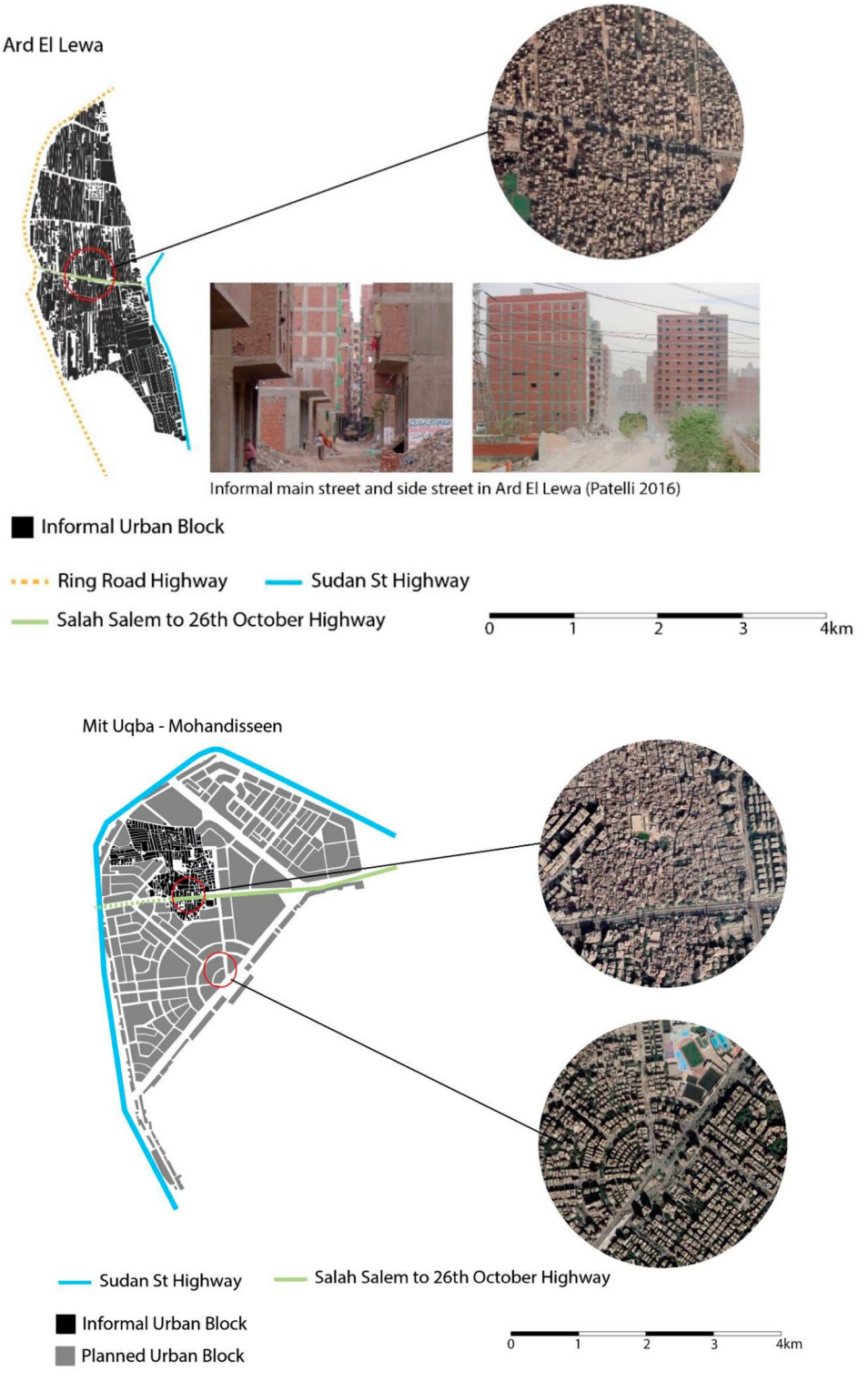

Figure 2. Continued.

Table 1. Case study details.

Case study	Emergence[a]	Type (Author elaboration)	Highway	Highway type[b]
Ard El Lewa	1980s	Informal on agricultural grid	26th July Corridor Ring Road Highway	Traversing Mostly levelled Bordering elevated
Mit Uqba (1) + Mohandisseen (2)	(1) 1900s (2) 1950s as villas, 1980s as high-rise buildings	(1) Historical village (2) Planned	26th July Corridor Sudan St Highway	Traversing Partially elevated Bordering levelled
Heliopolis (3) + Ain Shams (4) + Matariya (5)	(3) 1905 (4, 5) Became informal from the 1980s onwards	(3) Planned – affluent (4, 5) Planned, became informal	Gesr El Suez	Traversing levelled

Sources: [a]AUC Historic Maps Digital Collection; and [b]author's elaboration.

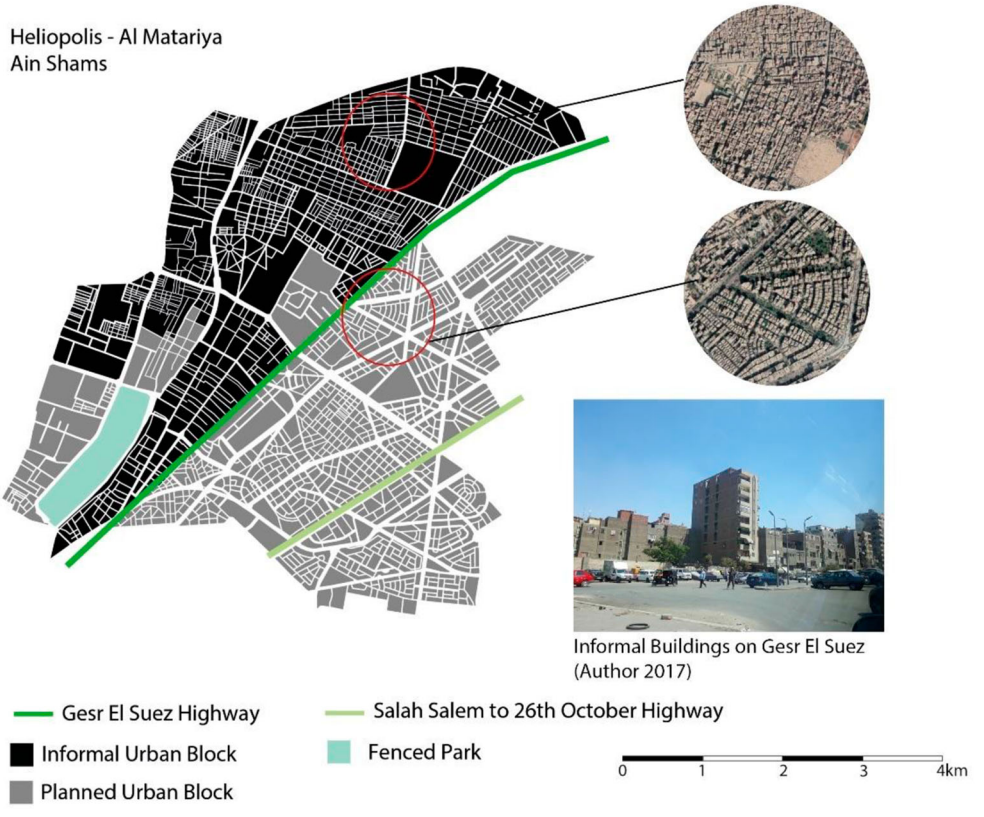

Figure 3. Figure and ground representation of the case studies (source: author); an aerial view (source: Maxar technologies, 2016); and their physical expression (sources: Zied Abozied, 2017; Patelli, 2016; and Tadamun, 2013).

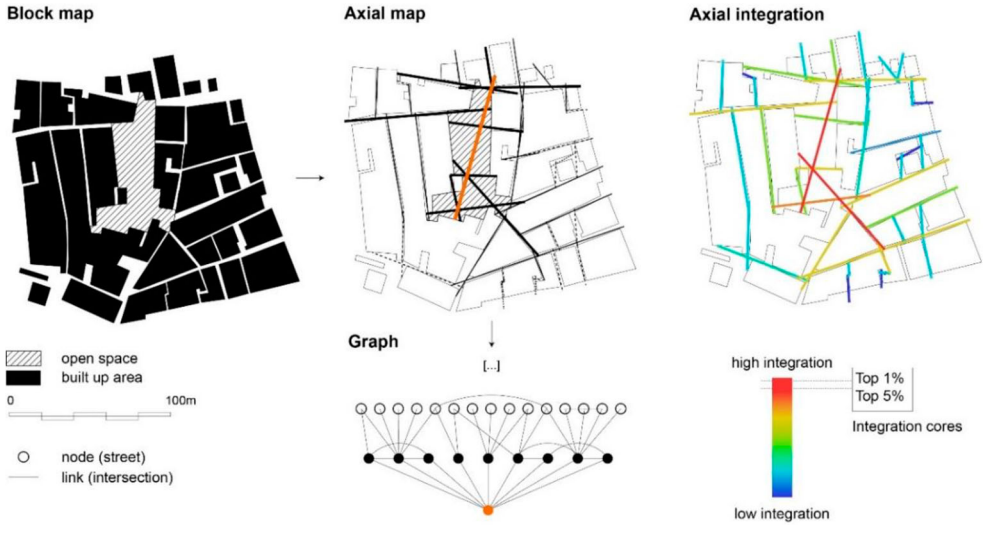

Figure 4. From block map to axial integration showing the different representations/interpretation of an open space.

Urban configurations conducive to social interaction

Through the analysis of multiple settlements, studies have identified two recurrent urban configurations that are conducive to social interaction based on axial integration values. The integration core is the set of the most integrated streets that have highest potential for movement, which usually corresponds with the neighbourhood centre (Hillier & Hanson, 1984) and can take various configurations. In this study, integration core is the top 1% and 5% of the most integrated streets (Figure 3). The integration core can present as a deformed wheel or live centre. The deformed wheel consists of a highly integrated core, integrated peripheral streets (edges) and branches connecting them (Hillier & Stoner, 2010). This is a healthy network as it allows access to its centre while connecting to the surrounding neighbourhoods through the peripheral streets. The live centre consists of a long and straight street, usually the high street, intercepted by many streets. Live centres can join different local street networks and in this case interactions and movement take place more intensely (Hillier, 1999). A dispersed core can occur when there is no clear structure. Identifying these structures in informal settlements can highlight where potential activities occur and where connection to the regional highway system should be made while preserving the spatial structure of the community.

From urban block to axial integration

Before undertaking the axial analysis, some data limitations had to be overcome to create the axial representation models. Available surveys of the informal settlements were only partially representative of the built-up area due to the fast-growing nature of this urbanization. The first step was the creation of vector maps, which was undertaken by using satellite imagery (Google, Maxar Technologies, 2016) to validate existing surveys (CAPMAS, 2018; OpenStreetMap Contributors, 2018) and update them where necessary. For each neighbourhood, an urban block map was produced representing the built-up area, which was then used to create the axial maps for space syntax analysis.

Two-step integration analysis: splitting neighbourhoods

In order to assess the role of the highway between neighbourhoods, each area was analysed as an independent system of streets and then combined into one system to include the highway. The first analysis highlights the degree of integration of the settlement, the location of its core

and the presence of deformed wheel, live centre or dispersed core. Once established, the same analysis is run on the combined neighbourhoods, showing the change of integration and configuration due to the highways.

ANALYSIS AND RESULTS

Ard El Lewa

When analysed independently, both parts of Ard El Lewa reveal partial deformed wheel integration cores (Figure 5). In the north part the core consists of three main streets approximately in the centre of the neighbourhood with branches that reach the edges. The south part also has an incomplete deformed wheel core that has branches and edge movement. Both have good integration values with the south area being less integrated than the north (Table 2).

When analysed together, both areas maintain their internal network and a weak core appears on either side of the central highway, which indicates that if the highway was connected to the internal street network it has strong potential to become a live centre.

Mit Uqba and Mohandisseen

This analysis first shows Mit Uqba before and after the highway was built through it, and then within the planned neighbourhood Mohandisseen. Mit Uqba does not have access to the highway due to barriers and pedestrian crossings are limited to bridges. Before the highway addition Mit Uqba

Figure 5. Syntactic Structure of Ard El Lewa.
Source: Zied Abozied (2019).

Table 2. Integration values for Ard El Lewa.

1		Average	Minimum	Maximum	SD	Top 1%	Top 5%	*n*
Ard El Lewa (North)	Informal	1.966	0.97	3.45	0.43	> 3.18	> 2.82	405
Ard El Lewa (South)	Informal	1.227	0.75	1.84	0.19	> 1.71	> 1.57	534
Combined	Informal	1.29	0.79	2.28	0.24	> 1.89	> 1.72	941

had a clear core and branches that reach the neighbourhood and higher integration values. After the addition of the highway the core is the same, but the branches terminate at the highway and integration values are lower. This shows how the addition of the highway with no access disrupts the street network structure. However, the location of the highway means that, with reconnection, it has the potential to encourage edge movement and wider access to Mohandisseen. Within Mohandisseen, the integration core generally follows the main vehicular routes with small potential for movement either side of the highway in Mit Uqba. The integration values are higher but have a higher standard deviation, indicating that there are more segregated areas (Figure 6 and Table 3).

Heliopolis

When analysed individually, the informal neighbourhoods Ain Shams and Matariya have a clear core with branches and some edge movement. The planned neighbourhood has a dispersed core that follows main vehicular roads. In both neighbourhoods the highway represents a path for

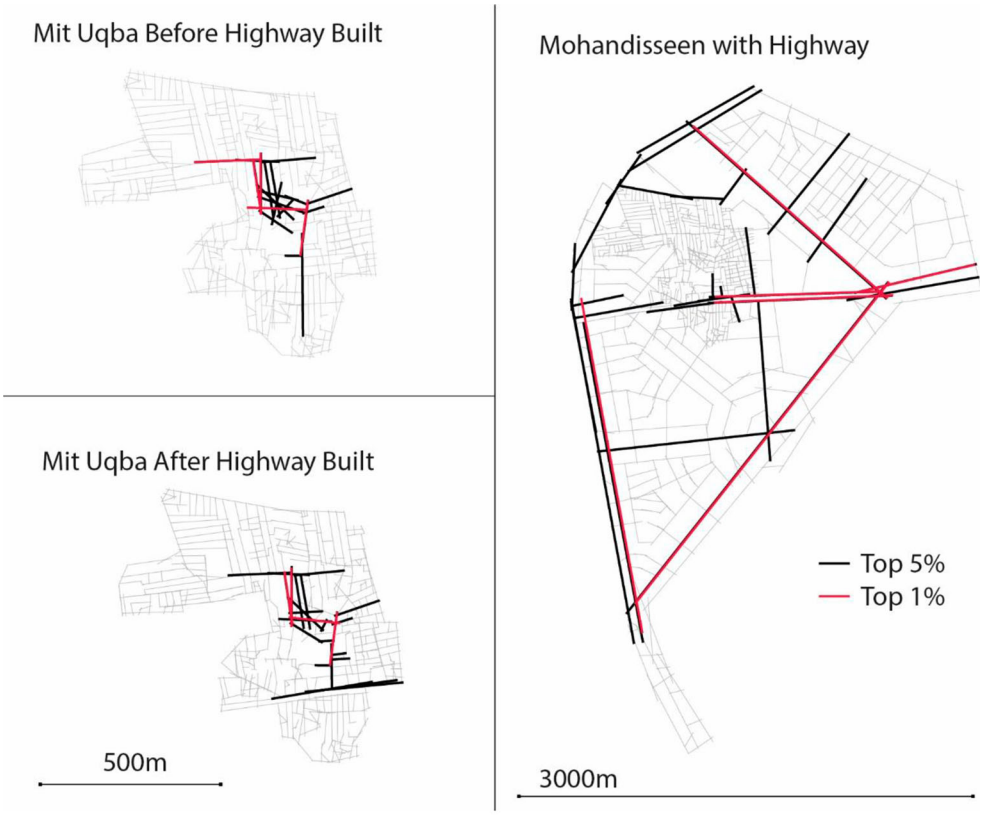

Figure 6. Mit Uqba and Mohandisseen syntactic structures.

Table 3. Integration values for Mit Uqba and Mohandisseen.

		Average	Minimum	Maximum	SD	Top 1%	Top 5%	*n*
Mit Uqba before highway	Informal	1.133	0.781	1.763	0.190	1.710	1.491	398
Mit Uqba after highway	Informal	1.064	0.621	1.630	0.191	1.570	1.399	400
Mit Uqba and Mohandisseen	Informal + planned	1.378	0.856	2.286	0.229	1.991	1.795	616

edge movement. When analysed together the highway presents as a live centre that connects the two different street networks in each neighbourhood. As it is a ground-level highway that can be crossed, it can be considered an integrator (Figure 7).

Both neighbourhoods have similar integration values with the planned neighbourhood slightly higher. When analysed as one system (Table 2) the entire area becomes more integrated – the standard deviation is lower and maximum values are higher due to the live centre. Highway connection for both planned and informal areas lead to good overall syntactic structure; the most integrated routes are accessible by both settlements and north–south and east–west movement present in both areas (Table 4).

DISCUSSION

This limited analysis shows that informal neighbourhoods tend to naturally produce deformed wheel integration cores that facilitate social interaction and pedestrian access, and planned neighbourhoods tend to have dispersed cores that follow vehicular routes. Heliopolis shows that highways can become live centres if they are levelled and crossable and have multiple street intersections. Even though they may segregate the region, there is potential for them to become a regional integrator with minimal intervention. Live centres can preserve the local structure and act as regional centres by linking spatial communities.

Figure 7. Analysis of Heliopolis–Ain Shams–Al Matariya showing the live centre and syntactic structure of Heliopolis–Ain Shams–Al Matariya.
Source: Author (2019).

Table 4. Integration values for Heliopolis.

		Average	Minimum	Maximum	SD	Top 1%	Top 5%	*n*
Ain Sham and Al Matariya	Informal	1.961	1.12	3.349	0.363	> 3.024	> 2.584	960
Heliopolis	Planned	2.003	1.092	3.745	0.378	> 2.997	> 2.581	823
Combined	Informal + planned	1.784	1.061	3.506	0.348	> 2.647	> 2.458	1604

Analysing informal settlements' street networks can identify points where they can be connected to the regional highway network to improve regional consolidation. However, each neighbourhood should be analysed individually to identify the most suitable reconnection method. While traditionally highways may have negative effects when passing through a neighbourhood, in the Greater Cairo Region the positive effects of reconnection to the regional network may outweigh negative effects. Egypt's planning policy can exclude informal settlements from large-scale regional transport networks, therefore policy changes such as reconnecting informal settlements to transport networks could reduce spatial fragmentation in the region.

CONCLUSIONS

In Greater Cairo, the regional highway network can act as a connector between neighbourhoods that have access to it while acting as a segregator in neighbourhoods that do not have access. In most cases, the neighbourhoods that do not have access to the highway are informal and may have been excluded from the regional highway network. While highways were designed to be segregators, their atypical usage in Greater Cairo means that they can become connectors if they meet certain criteria such as being crossable and at ground level. This study shows that the settlements' relationship with the regional highway network varies if the settlement is planned or informal.

In Ard El Lewa, one highway acts as a boundary preventing growth and the other cuts the neighbourhood into two parts. However, if the highway were accessible it would create a live centre. In Mit Uqba the highway disconnects part of the neighbourhood, but again could become a live centre if it is accessible. In Heliopolis, both planned and informal areas are connected to the highway and this creates a live centre which is conducive to social interactions and community and may increase access to the wider city. The relationship to the highway may have more of an impact than the internal structure of the neighbourhood and connecting settlements to the highway can increase regional consolidation. However, this is a limited set of analysis and further study is required before generalizations can be made.

These results have implications for policy-makers. This study can inform both urban and policy interventions in informal settlements and could lead to their recognition as a legitimate type of urbanism in the region and their integration into the wider regional network. Beyond Cairo, policy-makers should be aware of transport network placement and access points and include informal settlements in planned regional transport networks. This can lead to legitimization and integration of informal settlements, which could benefit the city as a whole by reducing spatial fragmentation. In existing informal settlements, small, incremental and resource-efficient interventions to reconnect settlements can be an alternative to large-scale removal. There is high potential for future scholarship in this area for academics as it is understudied, and practitioners can use these data to inform design on a regional scale.

DISCLOSURE STATEMENT

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ORCID

Eman Zied Abozied http://orcid.org/0000-0002-7984-3793
Alice Vialard http://orcid.org/0000-0002-6719-7122

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