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Environmental Analysis of the Residential Sector in Cairo

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1 ABSTRACT

Rapid demographic increase and transition in governmental policies influenced the patterns of Egyptian residential sector, services and urban fabric. The housing stock in Egypt is dominated by private owners, informally and high consumption rates. Studies attempted to classify historic periods that created the current urban pattern and led to an uncontrollable expansion of a metropolis. Political and demographic changes had a major role in the city's urban, architectural and legislative transformation, especially after the change of government policies in 1953. The article aims to evaluate the development milestones of the housing stock in Cairo before and after 1953, from an environmental sustainability perspective on a building and urban scale. Based on official statistics, maps from various periods and literature, the urban development of the city is assessed. The impact of governmental policies and strategic plans is analyzed, taking into consideration demographic growth, urban sprawl and environmental aspects. The residential stock is classified in two time phases (before and after 1953) and three dominant typological -urban and architectural- criteria. Based on this classificatory model, representative characteristics of different periods are assessed in terms of morphology, construction materials and environmental design. The results provide a critical analysis of Cairo's environmental and sustainability policies in the second half of the previous century. It provides an evaluation base for comparison with the city's current built environment and offers guidance for future scenarios.

Keywords: Building typology, Informality, Urban built environment, Residential consumption, Housing stock

2 INTRODUCTION

Greater Cairo Region (GCR) is composed of three governorates: Cairo on the east of the River Nile, Giza on the west and Qalyubia in the north. Each governorate has its own administration, governor, and boundaries. According to the national Central Agency for Public Mobilization and Statistics, GCR's surface are is 290km2, its population in 2016 was 22.9 million inhabitants divided as follows: 9.7 million in Cairo, 8.9 million in Giza and 4.3 million in Qalyubia. However, GCR is physically inseparable and it is hard to define a precise barrier that separates the governorates' environmental, physical and social boundaries.

Historically, urban growth started in the core city, Cairo; it is one of the most ancient parts of Egypt. The city's history is long and the region's background goes back to the times of ancient Egypt (31st century BCE) when its capital - Memphis - was not far away from the current location of Cairo, and GCR still hosts the great pyramids of Giza.

Like in many old civilisations, ancient Egyptian buildings were used as a source for construction materials and their stones were adopted to build the houses of Islamic Cairo (Singerman 2011).The first attempt to declare a city with a defined administration and boundaries, after Memphis, goes back to the 10th century. Cairo was founded as a capital for the Mediterranean empire of the Fatimids in 969AD with the arrival of Jawhar Al-Siqilli. Then, the Caliph Al Moizz a few years later made it his basis of rule. Thus, the first city was created according to the urban patterns and features of Islamic architecture (Abu-Lughod 1971).

3 CAIRO BEFORE 1953 | BACKGROUND

3.1 Islamic Cairo

Islamic architecture in Cairo passed through different periods: Fatimid, Ayyubid, Mamluks and Ottomans. In the beginning, the Fatimid architecture combined elements of eastern and western architecture and was strongly influenced by Mediterranean cultures. The city fabric was characterised by a human compact form with low-rise residences and narrow streets, which has the advantage of providing solar shading but minimises wind flows for urban health and social purposes (Sharon L. Harlanan December 2006). Compact cities have environmental, social and fiscal advantages; and in similar climates, the compactness of the city fabric proved to result in lower energy demand for artificial climatisation and have a positive influence on

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energy savings on a building and city scale (Frey 2003). In Islamic Cairo, the streets were oriented North-South to take advantage of prevailing wind that came from the north; it was characterised by winding streets of different sizes to decrease the potential effect of wind storm carrying dust/sand and provide shaded spaces. Early residential buildings were made with clay brick, which was and still is a commonly used building material in Egypt, then stone gradually took over and it became a major construction material. Morphologically, a typical dwelling apartment in the Fatimid period had a rectilinear plan that revolved around a central courtyard that provided natural lighting and ventilation (Safran 2000). Private houses included a ground floor and one or two upper floors. Exterior windows included sophisticated shading systems – Mashrabeya – that decrease light glare and block visual access from the exterior, providing privacy for households.

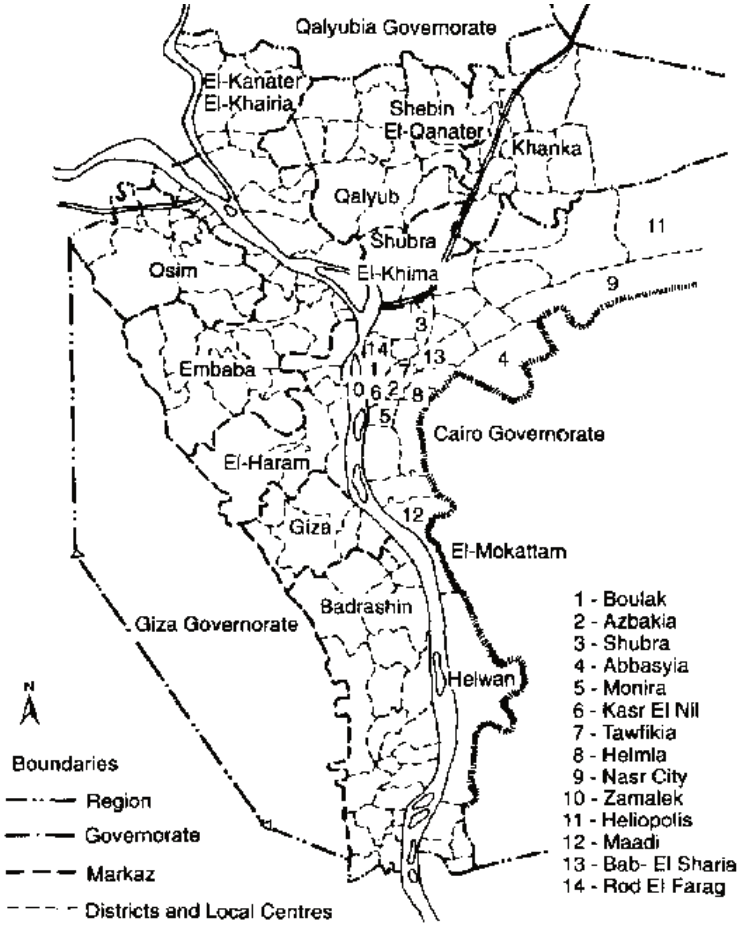

Fig. 1: Greater Cairo Region (Yousry, 1997)

The inexistence of advanced technological tools forced architects to develop solutions that guaranteed thermal comfort without affecting the surroundings negatively. Islamic architecture did not oversee the important concepts of physics and fluid dynamics like air buoyancy and thermal convection. It was based on the use of solar energy, heat conduction and convection, ventilation, evaporation and passive cooling methods to provide high comfort levels for inner spaces (Nermine Abdel Gelil Mohamed 2014) (Yahya Lavafpour 2011); In addition, the correct application of local building materials worked as an efficient way to increase comfort levels and drastically reduce the environmental impact of construction (J.C Morel 2001).

Light-coloured materials with high reflectivity were chosen to decrease the temperature and decrease the dry weather effect. Nermine Abdel Gelil and Waleed Hussein listed the materials commonly used in Cairene Islamic architecture: Stone was a widely used construction material during the Ayyubid and Mamluk eras (12th-16th century), and marble was used by the Mamluks (13th-16th century). Traditionally, limestone was used for the construction of ground floor load bearing walls. External walls were built of at least 50cm thick limestone, which contributed to the thermal insulation of indoor spaces and provided high thermal mass effect. During summer, the heat was stored in the walls during the day and released into indoor spaces at night when temperatures were lower, and spaces could be cooled by natural ventilation (cross ventilation and stack effect). In addition, due to the light colour – and the high reflectivity- of the limestone, it deflected

solar radiation during hot days. Wood was used for building flat horizontal roofs, mashrabeyas, takhtabushes, windows, malqafs, shokhshekhas and scaffolding during the construction of walls; it was also used for shading purposes (Nermine Abdel Gelil Mohamed 2014). Red Brick was used for compact forms, like vaults and domes, which have low surface area to volume ratio and hence provide minimum heat gain and minimum heat loss through the building envelope and imply higher thermal comfort conditions.

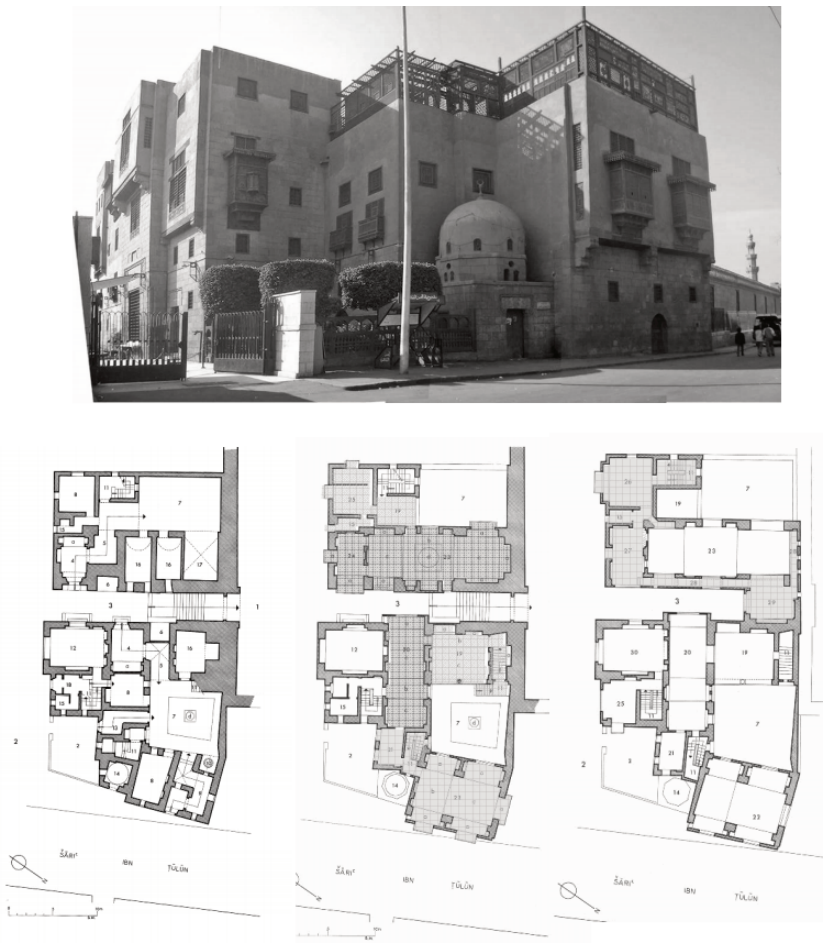

Fig. 2: Manzil Amna bint Salim (back) and manzil al-Kiridliya (front), located adjacent to Ibn Tulun Mosque on Ibn Tulun Street. Above, photo from the street by Nermine Abdel Gelil Mohamed; below, ground, first and second floors (Nermine Abdel Gelil Mohamed 2014)

3.2 European Cairo

The end of the Islamic architecture era in Cairo can be considered to be at the beginning of the 19th century (1805), after the expulsion of the last Ottoman governor by Mohamed Ali, who announced the virtual independence of Egypt from the Ottoman court. This was the beginning of „Modern Egypt“ with comprehensive efforts and mega infrastructure projects to modernise the city and the country in general. In 1863, the Cairene population had barely passed 300,000 (Raymond 2000). Khedive Ismail - who received European education in Paris - showed more effort for social and cultural modernisation of Egypt. A completely modern western city emerged from a small neighbourhood ‘Azbakia’ and the physical and urban patterns of Cairo changed. His famous saying was “My country is no longer in Africa; we are now part of Europe. It is therefore, natural for us to abandon our former ways and to adopt a new system adapted to our social conditions". (Haag 2003)

The first city plan presented by a French architect was inspired by Haussmann’s plans for Paris. It ignored the existing compact patterns of Islamic Cairo and produced new radial grids of large wide streets. English, Italian and Greek architects presented proposals and participated in the construction of a new part of the European city. Cairo was nominated as “Paris along the Nile” and this area – constructed by the Khedive- is now known “Downtown- Wust El Balad”. Utilities and services like water, electricity and trams were developing on a huge scale (Myntti 2000). The new elegant city centre offices, shops, restaurants and cafés gave a new identity to the city. Traditional Islamic architecture was abandoned, and in some cases the use of

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its elements like mashrabiyya was prohibited and replaced by glass window panes and wooden shutters. Styles ranged from Baroque, Neo-classical and Rococo to Bauhaus, Italian Renaissance and Arabesque until the 1950s (Elshahed 2007).

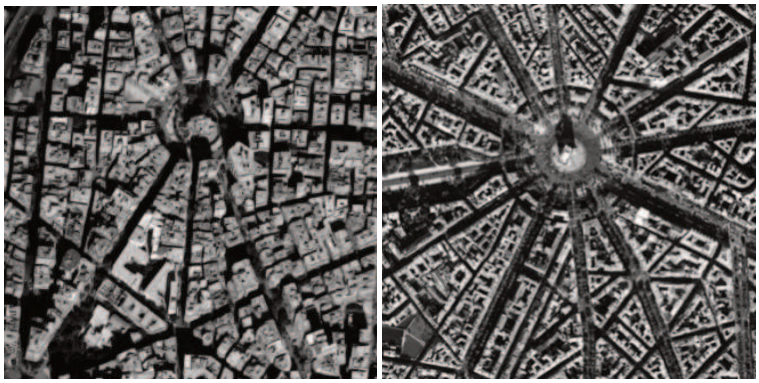

Fig. 3: European Cairo urban fabric (left) vs Paris urban fabric (right)

By the beginning of the 20th century, new lavish neighbourhoods (e.g. Garden city and Zamalek) were already developed. Urban expansion later took place along the north (towards Shubra), then the first satellite cities – like Heliopolis- were designed to host up to 100,000 inhabitants. In the 1940's roads, bridges and water system projects started to take place to provide a solid base for further urban expansions. Cairo became an attractive pole for all Egyptians that came from rural and surrounding areas. The first industrial slums were developing in nearby Boulak, where spot densities reached world records (4000 person/hectare). From 1937 to 1947 the population of Cairo doubled from 1,300,000 to 2,800,000 inhabitants and moving out of the slowly degrading old city centre became a trend by the higher income groups which could afford to buy property in more modern neighbourhoods (Cresti 1987).

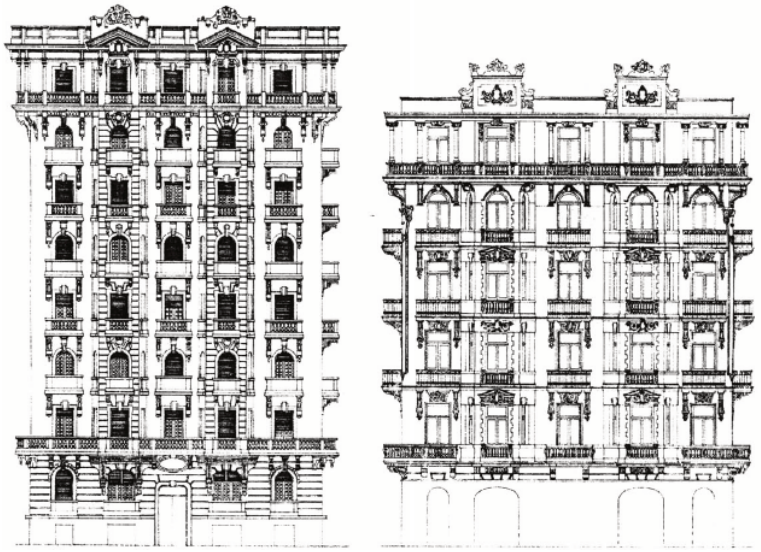

Fig. 4: Change in architectural elements - Downtown Facade from European Cairo 1927 (Elshahed 2007)

Fig. 5: Buildings from European Cairo (photographs by Alain Bonnamy) (Galila El Kadi 2006)

Until today, published work that analyses the architecture of European Cairo from an environmental and passive design perspective is not evident. It is obvious that not until building with reinforced concrete started to take place during the first decades of the 20th century, thick load-bearing stone and masonry walls with high thermal mass was the main building and structural technology used for residential buildings. In addition to the function of articulating the space, load bearing walls ensure the stability of the building to enable it to withstand vertical loads and horizontal thrusts.

This structural function is associated with thermal and acoustic insulation. Therefore, construction materials of poor thermal conductivity were chosen for the construction of thick heavy walls; they provided thermal flywheel effect resulting in a cool environment in summer and a warm environment in winter. This guaranteed higher comfort levels in comparison to slim envelopes of reinforced concrete beam-column structures that started to spread later for residential blocks. Typically, apartment block heights started to be 4, 5, 6 floors. Average floor-to-ceiling height was 4m; this is higher than average floor-to-ceiling height of residential buildings built today – and in the last 40 years- which is typically 3m. This allowed better air movement and higher comfort levels. Through the phenomenon of convection, fluids have a natural movement in which hot air tends to rise allowing the lower part of the room to have lower temperatures that could reach up to 1°C less in warm days. Therefore, in hot climates, a higher floor-to-ceiling distance means a greater distance of the hot air layers from the users, guaranteeing higher comfort levels. (R. P. Guimarães 2013)

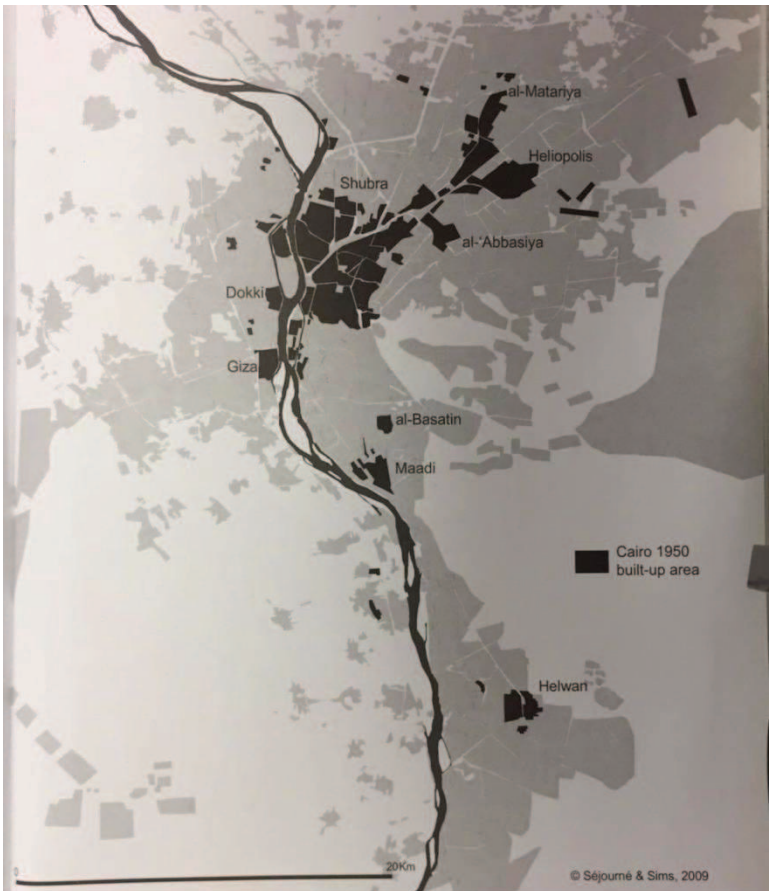

Fig. 6: Cairo built-up area before and after 1950 (Sims, 2012)

Thick wood was used for window frames and shutters on the outside, which worked as a good insulator of solar radiation as wood has low thermal conductivity. Metal was used sparingly for façade ornaments and balcony fences, but it was not a dominant material. Facades included elaborate decorative ornaments, balconies and overhangs which had a shading function that varied in relation to the orientation of the façade. However, the void-to-solid ratio in residential facades of European Cairo was higher than that of the hosues of Islamic Cairo; allowing major solar access through openings and reducing comfort levels during the hot season. Light hues of colours were used to reflect solar radiation, decrease heat absorption and conduction, which guaranteed lower radiant and operative temperature of internal spaces. Many residential blocks included inner courtyards, which permitted higher air cross ventilation between outer façade openings and

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the ones overlooking the interior courtyard. In addition, weather conditions in Cairo were moderate compared to extreme temperatures reached in the last couple of decades due to global warming, urban heat island effect, and climate change.

4 MODERN CAIRO

4.1 New phase with new policies

In 1949 the Municipality of Cairo was created as the official local administration responsible for managing the city resources and development. The Ministry of Housing, Utilities and Urban Development (MHUUD) issued its first housing and building statutes and laws regarding conciliation, and law amendments. In 1953, the King was deposed by a revolutionary command council and a republic was declared. This was an announcement of a new phase in Egyptian history and led to Cairo's total change. The building sector and the urbanism were directly influenced by those political changes. The new government followed new policies:

- Subsidised public housing
- Applying social housing programmes
- Condominium investments were encouraged to provide the possibility of growth in new areas of Cairo (e.g. Mohandessin neighbourhood)
- New laws were issued regarding improving fees on the real-estate that was upgraded due to the improvement of public utilities and others to reduce rents on housing units
- European Cairo neighboorhoods were Egyptianised (mixed land use and commercial zones were created; elegant villas were replaced by high apartment blocks).

Until 1940, Cairo represented 6-8% of the national population. Between 1950 to 1960, Cairo's percentage of the national population inflated from 11.2% to 18.4%. Rural settlements - of migrants to Cairo - were expanding around the actual city with no planning, architecture or construction reference at all (Yousry 1997); with reinforced concrete as a fast and convenient solution, the city started to grow at a fast pace.

Year	**Cairo**		**Egypt**		**Cairo as % of national population**
	Population ('000)	% growth rate	Population ('000)	% growth rate	
1800	200	2.0	3,000	1.2	6.7
1900	600	2.3	10,000	1.3	6.0
1920	875	3.1	13,000	1.4	6.7
1930	1,150	2.2	15,000	2.3	7.7
1940	1,525	4.1	19,000	1.0	8.0
1950	2,350	4.1	21,000	2.2	11.2
1960	4,784	2.2	26,000	2.4	18.4
1976	6,776	3.5	38,200	2.8	17.7
1986	9,514		50.500		18.8

Table 1 Population growth of Cairo and Egypt, 1800-1986 (Yousry 1997)

4.2 Master plans (1950s -1960s)

In 1956 a master plan that included east and west desert flank expansions was prepared and in the 1960s new industrial zones were identified - Helwan, Shubra, Imbaba and Giza- enhancing the appearance of Cairo as a future mega metropolis. The government financed the design of new settlements like Nasr city (designed to cover 6,300 acres of vacant desert and later extended incorporating additional 14,000 acres) allowing the growth of areas like Abbasiya and Heliopolis. MHUUD issued a new law in 1964 (Law No.6) defining design criteria and rules for structural and building works. It issued ministerial decrees to regulate building execution because of informality; this was followed by other laws and decrees that regulate the restoration, maintenance and elevation of existing buildings (Ministry of Housing 2015). Cairo's population was 6,113,000 inhabitants in 1966 and new master plans had to be created again to include the extension of the industrial area of Helwan and new towns like the 6th of October, Al Badr, El Obour and a West Bank project

that was not realised. Later additions included distant extensions towards the north and east: unsuccessful town examples namely Sadat City and 10th of Ramadan new town. These plans had the objective of sccommodating future population growth until 1990 (Sutton 2001).

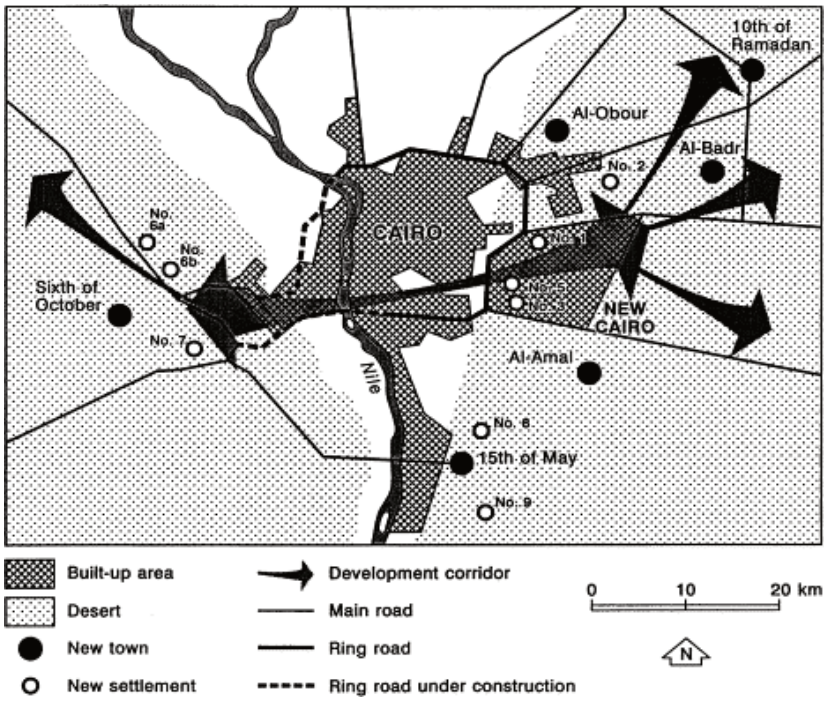

Fig. 7: 1970 and 1983 master plans for Cairo: new towns, new settlements, ring road, and east–west axes of development (Sutton 2001)

4.3 New laws and informal housing (1970s)

In the 1970s the MHUUD issued a new series of laws aiming to regulate the growing building sector and control rising illegality:

1. Law No. 62 of 1974: Provisions for reconstruction, 1974
2. Law No. 66 for in 1974: Establishment of Engineers' Syndicate, 1974
3. Law No. 49 of 1977: Sale and lease regulations between owners and leasers.
4. Law No. 59 of 1979: Indications concerning new urban communities and settlements.

However, the war of 1967 had a negative influence on the national economy and the city's urban development. The government was unable to fulfil the new urban aspiration, shelved the planned projects and turned a blind eye on the illegal growth of the informal sector caused by fast demographic growth. In Greater Cairo, more than 80% of new units built during the 1970s were considered illegal (Sharaf 1999). The official public constructions that started in the 1970s aimed to reach different economic groups and they accelerated the city's expansion towards the east through new settlements and towns like Nasr City and the 10th of Ramadan. Spontaneous urbanisation was promoted west of the Nile towards existing neighbourhoods like Giza, Dokki and Mohandessin. A process of "demolition-reconstruction-densification" was the reason for the transformation of elegant neighbourhoods in the city centre „e.g: Mohandessin". Between 1980 and 1992 a third of the villas and smaller blocks have been demolished and were replaced by tower blocks (Galila El Kadi 2006). Today in neighbourhoods like „Mohandessin", it is hard to find a trace of the old villas or planned low-rise residential blocks built according to regulations. Instead, they have been replaced by tall blocks built by private –mostly the illegal – sector and contractors with a main target: increasing financial profit margins (Sutton 2001). The spread of reinforced concrete as a fast and efficient construction material had a direct influence on the pace of urban growth; new settlements and towns were planned to reach different social groups. High residential blocks of reinforced concrete - column and beam structure and bricks for walls and interior partitions - were built, increasing the average height of residential and commercial blocks. 10-12 story buildings with elevators were starting to become more common and were often built for social housing in the new satellite towns and settlements.

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4.4 New city and local divisions (1980s)

In 1982 Greater Cairo was defined by the General organisation of physical planning, located within the jurisdiction of the 3 Governorates: Cairo on the east, Giza on the west and Qalyubia on the north. The total built-up area of GCR was 32,600 hectares with 21,690 hectares for residential use representing 67% of all land use. So, it was necessary to prepare new plans again and one year later a new master plan was made to house 2-3 million people (Luloff 2001). Egyptian authorities confirmed infrastructure development plans and the city was divided into 16 homogeneous sectors for the first time. The division aimed to decrease the suffocating high densities, transfer the population to outer areas of the centre and decrease the pressure on central areas. The census of 1986 had a major impact; the city's ring road plan was changed, and this allowed a better connection with new settlements like 6 October and New Cairo and gave the way for later development outside the centre on both the east and west flanks of the desert.

4.5 Master plans and their impact (1990s)

In the early 1990s, the urban form, size, and fabric of GCR had already developed in a random and spontaneous manner, instead of following a planned strategy. Sutton and Fahmi listed a series of factors behind, what they considered the failure of the previously mentioned master plans and strategies (Wael Fahmy 2008). They observed the following main factors:

- The dominance of the unplanned "spontaneous urbanisation" over three decades (probably referring to the 1960s, 1970s and 1980s).
- Failure of new towns/settlements to attract residents and alleviate overcrowded conditions in central Cairo.
- Financial constraints on government expenditure and growth of the private sector involvement.
- The strengthening of Cairo's polycentricity
- Negative impact of the 1992 Earthquake
- Vacant city dwellings in a situation of housing crisis
- The role of the new ring road and its influence on land use and population.

The impact of the failure of the master plans (made in 1956, 1970, 1982 and 1983) was evident in the 1990s. Since the 1970s till the end of the 1990s, because of a spontaneous rather than a planned land use transformation, central Cairo witnessed a contradictory movement, namely the consolidation of its central place tertiary functions and the fragmentation of these functions over multi centres. Due to the financial constraints on the government expenditure, the government was incapable of providing suitable or economically convenient housing solutions that responded to the fast demographic growth and migration to the capital. Most of the planned new towns failed completely to attract residents and provide them with suitable housing solutions (e.g. 10th Ramadan, Al badr, El Obour, Mobarak housing). It is estimated that in 2006, 25-30% of units were presumably vacant, especially in the new towns ((USAID) 2006). This opened a wide door to the private investment and illegal sector to gain momentum with a market economy approach. Studies propose that up to 84% of constructions over the 1970s and 1980s have been illegal. By illegal, for the most part, studies do not refer to slums or shanty town dwellings. Instead, it is referred to modern formal housing built illegally or without any formal planning permission, possibly with violations of floor plans, land use and construction materials (Sutton 2001).

This led to two main results:

- The spread of informal housing with no design or planning, built by local contractors under no strict administrate control or building regulations of any type.
- The spread of a standard poor construction procedure served to meet people's housing needs. This procedure ignored sustainable or environmental design and produced repetitive minimalistic rectilinear (linear and tower) apartment blocks with no consideration of passive design strategies like quality material selection, shading, natural lighting and ventilation. (Wael Fahmy 2008)

Fig. 8: Residential buildings from Modern Cairo "Mohandessin" and a construction site with traditional technologies (Author)

Due to material availability, common knowledge, easy application, time efficiency, and economic convenience: reinforced concrete column and beam structural system and bricks (slit, clay, cement) for walls and interior partitions is the dominant method used for residential construction since the 1950s and almost exclusively used with the flat slab structural system for residential sector and apartment blocks. Double and triple glazing technologies for windows are not common and single glazed windows with wooden shutters are widely used for openings.

Informal settlements (either semi-legal or illegal residences built on private and public land) are where 70% of the inhabitants of GCR live. Apartment blocks is the dominant housing system in GCR and most of it is owned by the private sector which represents more than 97% in housing construction, with no energy efficiency or renewable energy awareness (Hanna, Sustainable Energy Potential in the Egyptian Residential 2013) (Ahmed Abdin 2006). According to HSE in Greater Cairo, building median height is 5 floors with an average total surface area of the building (building footprint) 157m2. Some structures could reach a height of more than 12 stories, but it is uncommon to find low rise buildings and villas (David Sims 2008). In Egypt, 99% of the households receive electricity and the national demand is on a continuous rise (Singerman 2011).

The 2006 national census showed that the Egyptian building stock comprised about 16.5 million buildings and 11.5 million were used residential purposes in 2006, representing more than 60% of the Egyptian building stock. The Organisation for Energy Planning (OEP) conducted energy surveys between 1998 and 2002 in major cities like Cairo, Alexandria, Port Said and Asyut to represent 2634 apartments in GCR. The research revealed that the average annual end-use energy consumption was 2866kWh/m2 per apartment with 17% as the degree of saturation of air conditioners (Hanna, Sustainable Energy Potential in the Egyptian Residential 2013). The residential sector represented 36% of electricity consumption and about 21% of the total energy consumption nationally in the period 1990-2000 (International Energy Agency 2015). The residential consumption continues to rise 5-10% annually and it is necessary to adopt new efficient policies (Mohamed Edeisy, Energy Efficiency for Egyptian Housing: Code Compliance and Enforcement 2018).

Fig. 9: Satellite images of (from left to right) Islamic (in by informality), European and Modern Cairo

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Fig. 10: Buildings (from left to right) Islamic, European and Modern Cairo (Nermine Abdel Gelil Mohamed 2014) (Galila El Kadi 2006)

5 DISCUSSION

The Islamic residential stock represented compact morphological characteristics. On a building scale, this provided minimum heat gain and minimum heat loss through the building envelope and implied higher thermal comfort conditions. On an urban scale, this provided higher shading and lower temperatures. Islamic Cairo is characterised by using local materials. Stone was widely used – especially limestone - (12-16th century) for the construction of thick walls. Wood was used for building roofs, furniture and window shades (mashrabeya). In terms of environmental sustainability, the compactness of the Islamic urban fabric provided more shading and a low surface area to volume ratio – on an urban and architectural scale, which guaranteed higher indoor and outdoor thermal comfort levels.

European Cairo residential morphology is dominated by apartment blocks inspired by European - Baroque, Neo-classical and Rococo to Bauhaus, Italian Renaissance and Arabesque – architecture. On an urban scale, European Cairo witnessed a significant infrastructure development. It is characterised by wide streets for cars, lighting and open space. European Cairo residences were mostly built with thick load-bearing stone and masonry walls and then with the development of the concrete technologies, it started to become widely used. European Cairo residential blocks' thick heavy walls had low thermal conductivity and high thermal mass. Internal courtyards allowed good cross ventilation on hot summer days. On an urban scale, the city's infrastructure was developed significantly.

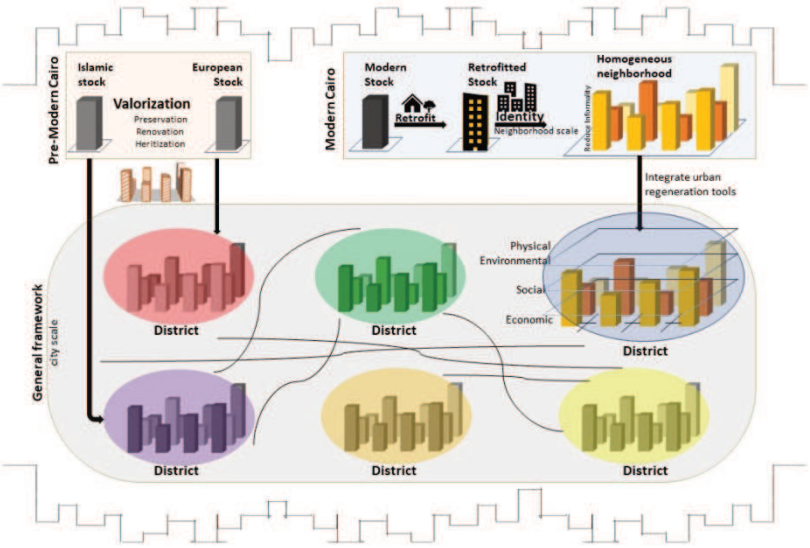

Fig. 11: General framework for future strategies prioritizing the problems of the existing built environment (Author)

After 1953, modern minimalistic apartment blocks - linear and tower – started to become more common gradually and it became the dominating building morphology. The impact of the failure of the master plans was evident and lead to a spontaneous transformation rather than planned land use. The informal settlements (either semi-legal or illegal residences built on private and public land) are where 70% of the inhabitants of GCR live (Hanna, Sustainable Energy Potential in the Egyptian Residential 2013). Modern Cairo blocks were built in a reinforced concrete column and beam structural system and bricks (slit, clay, cement) for walls. Modern Cairo (after the 1950s), is dominated by informality and illegality. Building skeletons of reinforced concrete and red brick filling have high thermal conductivity and thermal bridges are present. In

addition, in the last decades, reliance on artificial acclimatisation is rising accompanied by high consumption levels and greenhouse gas emissions.

6 CONCLUSION

New public policies should take into consideration the factors that led to the failure of previous masterplans. The continuous rapid growth and load on GCR made it extremely complex to manage the numerous actors of physical change of the built environment. The public sector should consider strengthening the attractivity of other Egyptian poles/cities to attract the population there, take advantage of the resources available in unused land – 99% of Egyptians live in 5.5% of land area (Erin H. Foubery 2009)- and decrease the pressure on the capital region.

Future strategies should give priority to solving the problems of the existing built environment through urban regeneration and requalification strategies on urban, neighbourhood and building scale. It is important to valorise the existing building stock of Islamic and European Cairo through urban preservation movements, heritage conservation, and renovation.

Moreover, it is necessary to foresee applicable tools that -while upgrading and maintaining the identity and services of the existing stock- work on upgrading the current state of the informal and illegal existing building stock of Modern Cairo. Passive retrofits have a high environmental potential in GCR; envelope retrofit in Cairo can lead up to lower energy consumption, increase in indoor comfort levels and lower greenhouse gas emissions (Mohamed Edeisy, Envelope retrofit in hot arid climates 2017) (Mohamed Eledeisy 2016); it provides an added aesthetic value through renovating the façade and helps cover gaps or cracks. When applied on a neighbourhood scale, it can be an instrument that contributes to decreasing informality and disorder between buildings in each district. It can be used as a tool to give harmony in the buildings' external aspect (similar colours, materials, etc.) and kick start an urban regeneration movement that begins with the household and expands to reach the neighbourhood within a general framework that integrates the actors of change on a city scale.

The article identified three significant styles of Cairene architecture. It evaluated the development of the housing stock on an urban and building scale before and after 1953. It is obvious that the built-up area of Cairo increased sharply after the 1950s (figure 6). GCR reached an uncontrollable size; the instability of governmental policies and regular change of decisions led to unsuccessful results on the urban and the building scale. The residential sector is mostly informal with a low effort in upgrading. This work presented a descriptive analysis of 3 typologies of a residential building; two of them are from the period before 1953 and the third is after. It analysed the development of housing stock after 1953 with common construction methods and their impact on the current built environment. In terms of technological, environmental and morphological quality of the housing sector -building and urban scale-, it is necessary to apply realistic solutions that reduce informal sprawl of the capital and encourage the private sector to adopt higher construction qualities in design, material selection and energy demand. The work provides an evaluation base and offers guidance in relation to the presented typologies within a general work frame on a wider scale. The indications given can support public policies for future scenarios of GCR and for Cairo vision 2050 strategies.

7 LIMITATIONS AND FUTURE WORK

This work understands that the Cairene housing stock is complex and it cannot be limited to three residential typologies and/or styles. However, the article aims to provide an inclusive overview of the main and most common architectural styles with a focus on their morphological and technological quality before and after 1950. Future work can further analyse the building stock in the period (2000-2020) and propose guiding indications for the vision of Cairo 2050 within the national vision of Egypt.

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ISBN 978-3-9504173-8-8 (CD), 978-3-9504173-9-5 (print)
Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI, Clemens BEYER, Judith RYSER, Christa REICHER, Canan ÇELIK

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