



Research Paper

Patterns and Processes of Morphological Transformations: Reflections on Previous Sites of Cairo's Water Ponds

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ABSTRACT: Cairo is a city with long periods of stagnation and change. Its historic core represents a stratification of urban layers each reflecting different social, economic, cultural and political aspects. Historically, the city had a strict system of ponds that represented a main feature shaping its morphology. With Egypt's modernization project, ponds were filled-in and their sites became parts of the larger urbanization of Cairo. The present study aims at revealing patterns and processes of morphological transformations of infilled water ponds through comparative cartographic and archival analysis of four selected sites. A typomorphological approach is adopted. The study unravels different morphological patterns and processes of densification in the examined sites with various degrees of stability and change in their urban form elements. The present study adds to the understanding of the urban transformation of Cairo, one of the fast-changing cities, and sheds lights on urban conservation issues for the selected sites.

KEYWORDS: Urban morphology; morphological transformation; typomorphology; urbanization; historic ponds and canals; Cairo, Egypt.

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I. INTRODUCTION

Since ancient times, the location of Cairo was chosen for habitation due to its strategic location at the apex of the Nile River. A river that played a major role in the morphology of the city. Historically the urban fabric of Cairo included an intricate flood management system of significant number of plentiful ponds and canals. This system absorbed the overflow of the Nile's annual flood and worked as reservoirs in case of low levels of inundation. Being a depression, ponds became filled with water when the annual flood recedes and turn into low-lying flowering gardens when their water shrank. This meticulous system not only helped the city to control the needed water for daily use and agricultural needs, but also gave the city a unique, dynamic and seasonal character. Besides, Cairo ponds had a major role in the social, cultural and urban character of the city. They were highly present as entertainment feature of the city, and nodes for religious festivities [1].

During early 19th century a project to infill these ponds as part of the modernization of the city took place. A project that deprived the city forever from its significant water features but provided new sites for urban development. These sites became part of the larger urbanization of Cairo and were transformed into theatres for modern urban experimentation. Each site was developed with different perspectives according to the givens of the time of development and the characteristics of available space. Furthermore, each maintained different patterns of urban transformation throughout the following decades.

Despite the enormous literature on the city of Cairo, there is a wide gap when it comes to the morphological transformation of its historic water bodies and of the comparative analysis of their development. The present paper aims at investigating the patterns and processes of morphological transformations of pre-19th century ponds sites which is important for a better understanding of the morphological transformation of the city of Cairo as a whole. This gives special reflection on the way of the city's transition from a traditional to a modern city as well as on the chronological patterns and processes of urban transformations of the selected sites. The present study is also important as it could inform decision making processes in what concerns related interventions and urban conservation practices.

Towards the research aim, this study adopts the typomorphological approach for the investigation. Typomorphology is an analytical tool used in urban planning and design thinking to study urban forms through allowing a systematic classification of the constituent elements of the built environment. It combines the aspects of urban form of street networks, plots and block patterns, together with building typologies. Hence, it links between the building scale and the urban scale [2]–[4].

The study relies on comparative cartographic analysis for the examination of four selected sites of pre-19th century ponds, namely, al-fil, al-Azbakeya, al-Fawaleh, and al-Farayn. For each site, maps between 1820 and 2020 are gathered, reduced to same scale and when necessary, retraced to facilitate the comparison and omit any unnecessary information. Consulted maps are shown in Table 1. The presented morphological analysis focuses on the transformation on the level of street networks, plot patterns and building blocks, as well as on change on the level of main building types' volumetric characteristics in each period. Archival material and site visits were also conducted in April-February 2021 to support cartographic analysis and better understand current conditions of the selected sites.

Besides the introduction and conclusion, the present paper is organized in four main sections. The first presents the typomorphological analysis as a tool to understanding morphology of urban landscapes, illustrating its applications to urban interventions, conservation practices and urban landscapes management. The second provides a historic background of pre-19th century Cairo ponds and canals. Then, the third illustrates a detailed chronological tracing of the morphological transformation of the four selected focus areas. Finally, the fourth section presents the results and a discussion based on the findings of the illustrated morphological analysis. The paper concludes with reflections on patterns, processes of morphological change and a classification and mapping of stability and resilience to change of the elements of built form in the investigated sites over different historic periods. It also highlights how morphological studies could be used to inform urban interventions and urban conservation practices.

Table 1: Consulted maps.

Date	Title	Scale
1810-1820	Environs of Cairo: General Map of Bulaq, Cairo, Roda Island, Old Cairo, & Giza.	1:20000
1874	General plan of the City of Cairo.	1:4000
1897	General map of the city of Cairo and its environs.	1:10000
1911	Cairo.	
1920	General map of Cairo.	1:15,000
1948	Islamic monuments of Cairo	1:5000
1980	General map of Cairo.	1:20000
2020	Satellite image of Cairo (Google Earth Pro).	1:5000

II. UNDERSTANDING URBAN LANDSCAPES THROUGH TYPOMORPHOLOGY

Urban morphology is the study of urban forms, their formation and transformation over time. It is concerned with the reasons behind the urban spatial patterns at different urban levels and scales. Urban morphology studies had been applied with different aims to investigate different urban contexts across the globe. The stream of knowledge of urban morphology encompasses several approaches following different schools of thoughts, this includes the spatial analytical approach, the configurational approach, the historico-geographical approach and the process typological approach among others [4]–[6].

Typomorphology is an analytical tool used in urban planning and design thinking to study urban forms through allowing a systematic classification of the constituent elements of the built environment. Typomorphological analysis works on categorizations based on similarities and differences. It also works on finding relations between the different types and their overall contexts while observing historical processes of evolution [2], [4].

The term typomorphology was coined by Carlo Aymonino and was later adopted by other scholars including Castex and Panerai, Moudon, Chen and Thwaites among others [3], [7]–[10]. Typomorphology draws from both the typological and the morphological approaches to urban form, stressing the relationship between types and forms [11]. In other words, the typomorphological approach provides a combination of the volumetric characteristics of the built aspects and their related open spaces, defining built landscape types (Muratori, et al 1963). In this regard, typomorphological investigation combines “the infrastructures of urban form” represented in the street networks, plots and blocks patterns with “the superstructures of built form” represented in the shape and position of a building within a plot, its volumetric characteristics, internal layout,... [9], [10], [13], [14]. This approach, thus, detects links between the building scale and the urban scale [5].

Within typological process, forms of cities and urban areas should be understood through their phases of continuity, transformation and replacement [6]. Normally, each phase has its distinctive basic forms and types including different types of streets, buildings and details. These types are used throughout development periods, and they are replaced with other types in following phases. In transitional phases, old

types are adjusted, adapted and modified, they thus become the nuclei for a new generation of types. Therefore, new types could contain some features of previous ones [15]. The typological process is thus concerned with the attention to the progressive transformation of types, with particular attention given to the dialectic of continuity and change between previous and new types within urban contexts [16].

The typomorphological approach can be used to generate clear context-based parameters that would inform local interventions and practices [17]. It could provide data bases to be used by entities charged for maintaining, upgrading and modifying built landscapes [3]. In addition, its application on urban contexts could be used as a useful tool to support planning strategies that aim to create new built environments that retain place characteristics [18]. Furthermore, typomorphological approach can be used to support design decisions and ensures that new infill designs are well incorporated into existing areas [18]–[20].

III. PRE-19TH CENTURY CAIRO PONDS AND CANALS – A HISTORIC BACKGROUND

The Nile and its flood cycles played a major role for the life in Egypt. Historically, every year, the annual inundation replenished the banks of the river with a rich thick layer of silt responsible for the fertility of the whole valley. Yet, the flood cycle was not always unequivocal; too much inundation brought massive destruction, while too little brought famine. In order to face this potential annual risk, Egyptians gradually refined an elaborate management system of irrigation canals and ponds. This system allowed to absorb the Nile's overflow and use them as reservoirs to be used for irrigation during the dry seasons. Canals and ponds were regularly maintained and re-dug in order to ready their storage for the following year [21].

The formation, transformation and urban development of the nucleus of Cairo's modern metropolis cannot be understood without an observation of its connection with the flood cycles and the human intervention to control it. Historically, this meticulous water system not only protected the city of Cairo from the annual unexpected intensity of inundation, but it shaped its morphology and gave it a unique urban character. During the four months following the flood, Cairo was compared to Venice, with its network of water bodies with different forms and sizes connecting all parts of the city [22]. Then, when the reserved water shrank, Cairo ponds were transformed into breathing gardens adorned with vegetations and wildflowers [1].

The first Islamic Capital, Fustat, was established in 641 by the eastern bank of the Nile in order to assure connection with the Arabian Peninsula by land and then by water through the reestablishment of the canal linking the Nile with the Red Sea [23]. Al-Askar was founded north of Fustat in 750, followed with al-Qata'I in 870, and finally, with the walled city of al-Qahira (Cairo) in 969. A series of political and natural disasters befell Fustat by the end of the Fatimid period and caused a massive immigration and preferences to inhabit al-Qahira which was previously exclusive for elites and upper social classes [24]. With the exodus towards al-Qahira, the area within the city walls became overcrowded. Therefore, members of the ruling class and high aristocracy started to show preferences to less crowded areas around ponds and canals outside the city core (Figure 1).

Several ponds were illustrated in the Description de l'Egypte map that documented Cairo's urbanism by the end of 18th century/ early 19th century (Figure 1). These ponds offered coolness in summer and great entertainment opportunities especially by night. Poems and eulogies about the ponds are found in Maqrizi and Gabarti chronicles [25], [26]. Other historians were impressed by the scenery and the leisure activities taking place in the ponds or on their shores such as musicians playing music; people swimming; night boat excursions among other activities [1].

The various ponds of Cairo were fed through two main canals (khaligs) (Figure 1). The main and most ancient of the two was khalig al-Masri. It formed the western boundary since the founding of al-Qahira. This canal originated in ancient Egyptian times, when the Canal, named after Sesostris, was dug to connect the Nile with the Red Sea. The canal went into periods of use and disuse. With the Arabs conquest, it was necessary to reestablish the Canal to link Fustat (the Muslim Capital) with the Red sea and the Arabian Peninsula, the homeland of the conquerors. Hence, Amr Ibn al-As restored the canal and called it Khalig Amir al-Mu'minin after the Khalif of that time, Umar Ibn al-Khatib. Then Khalig was restored and named al-khalig al-Hakimi during the reign of the Fatimid Caliph al-Hakim (996-1021) [1]. The other canal called Khalig al-Nasseri was established during the Reign of Sultan al-Nasir Muhamed Ibn Qalawun (1293-1341) to the west of Khalig al-Masri. The foundation of al-Nasseri Canal was to facilitate the transportation of Grains to the Delta. The then new canal began north of the mouth of the main canal and ran parallel to it until the two canals rejoined north of Bab al-Shairiya. Al-Nasseri Canal had a subsidiary function in comparison with the main Canal. Maqrizistates that when the former was established, the traffic of excursions and entertainment boats were diverted to it, leaving the main Canal to be utilized for goods transportation. An information that shows how necessary were pleasure boat activities [1].

The first half of the 19th century witnessed a significant change in Cairo's urban landscape. Mohamed Ali, who ruled in 1805, was very much influenced by European ideologies of his time [27]. His

policies were characterized with a break with traditions and great favoring of westernization of Egypt. This was translated into major public works towards the local reformation of the country. In Cairo of the 19th century, water ponds contradicted with the modern vision planned for the city. Still water ponds were perceived as pestilent and unhygienic nodes, especially when the water recedes, and they turn into marshlands. Therefore, several ponds were either fully or partially filled in [23]. By this filling, a main feature of pre 19th century Cairo urban landscape and cultural life had gone for good [28]. Previous sites of water ponds became part of the larger urbanization of the city, they developed with different urban patterns in the following decades, as will be illustrated in the next section.

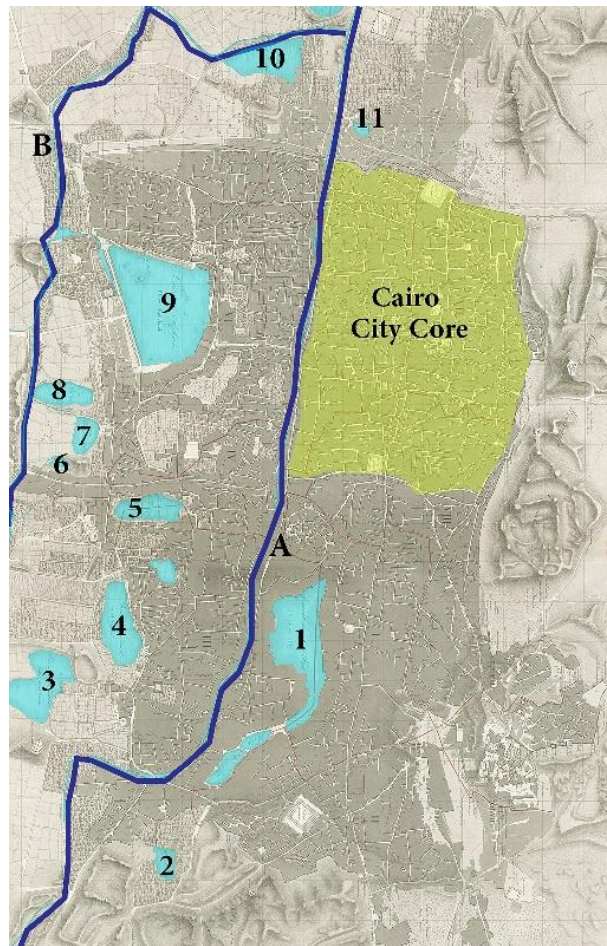


Figure 1: Cairo's historic ponds and canals with the city core highlighted, based on Description de l'Egypte map [29]. Ponds: (1) al-Fil; (2) al-Moulla; (3) Qarun, (4) Sitti-Nassra (also al-Saqqayin), (5) al-Farayn, (6) al-Dam, (7) al-Saber, (8) al-Fawaleh, (9) Batn al-Baqarra (later renamed as al-Azbakeyya), (10) al-Ratli, (11) Janaq - Canals: (A) Khalig al-Masri, (B) Khalig al-Nasseri.

IV. PATTERNS AND PROCESSES OF MORPHOLOGICAL TRANSFORMATION

Sites of previous water ponds maintained morphological transformations throughout the different historic phases. This section illustrates detailed chronological morphological transformation analysis of four sites of pre-19th century water ponds in Cairo, namely: al-fil (currently al-Helmiya al-Gadida), al-Azbakeyya (currently al-Azbakeyya garden and surrounding), al-Fawaleh (currently a part of Downtown Cairo), and al-Farayn (currently Abdin Square and surrounding). The selected sites for investigation are indicated in (Figure 2).

1.1. Site 1: previous site of al-Fil pond currently al-Helmiya al-Gadida

Al-Fil pond was located to the south of Cairo city core. Until early 13th century, the shores of al-Fil pond were free of population and were used for gardens and occasional pavilions [25]. With the shifting of the seat of governance to the citadel during the Ayyubids, interest shifted to the nearby Darb al-Ahmar district and the surroundings of al-Fil pond. Then, during the Mamluks period, the area flourished and became an area of choice for the aristocracy since it was near the citadel, away from the crowds and

overlooking the magnificent scene of the pond [25]. Gradually, the surroundings of al-Fil pond became a dense settlement of Mamluks Emirs palaces and prestigious foundations including mosques and sabils (water fountains). Raymond states that between 1650 and 1755 already a legacy of three-quarters of all Emirs residences were established in the southern part of Cairo and 40 percent of these were on the shores of al-Fil pond [24]. Many of these foundations are still extant including Taz palace (1352), Ulmas al-Hageb Mosque (1329), Shaykhun mosque (1349) and Sultan Hassan Mosque (1356-61) among others.

The lust and prestigious status of the area surrounding al-Fil pond however, started to wane by the end of the Mamluks when the city expanded westwards, between the two canals. Raymond states that during the 18th century, well established Emirs migrated from the area around al-Fil pond to the west part of the city, preferring to build their palaces on the shores of the less congested pond of al-Azbakeya, and hence the area around al-Fil pond declined [24].

Until late 18th century, the area around al-Fil pond maintained traditional urban fabric with organic street networks (Figure 3-A). This, however, changed with early decades of the 19th century that witnessed the modernization of the country and the filling of most of Cairo ponds. The map by Grand bey in 1874 (Figure 3-B), shows the filling of the majority of al-Fil pond and the construction of Abbas Hilmi I palace with its vast gardens. The palace was completed in 1851 and the area became known as al-Helmiya. The style and planning of the palace and its garden dictated the westernized architecture of all structures to be built in the area from this point onwards.

Another turning point took place during late 19th and early 20th century and proceeded in two phases (Figure 3-C and D). The first in 1890, when the garden of the palace was taken over by the Ministry of Public Works and declared a public land to be used for residential purposes. The second in 1903 when the palace was torn down declaring the second phase of residential development. The two phases of development produced different land parcellations options. The first included diagonal street patterns forming islands of triangular blocks, while the second produced a grid iron street network with more regular blocks. Parcels developed in both phases included villas and apartment buildings surrounded by gardens with varied sizes (Figure 4-B). [30]

Khalid Asfour raised detailed analysis of late 19th and early 20th century villas and apartment buildings established in al-Helmiya al-Gadida. He showed how they presented a pairing between local abstract ideas and values with foreign physical form [31]. The modern villa inspired from western ideals with a central hall flanked by rooms with no intermediate space was not fully accepted as it violated the family privacy. Thus, a separate reception room (called salamlek) was established to receive male guests without disrupting the family privacy. This created a totally new urban fabric dotted with villas and apartment buildings surrounded by gardens with detached rooms [31]–[33] (Figure 4-B).

A third turning point took place starting late 1970s. The area witnessed a gradual densification process. While street networks and plots shapes and sizes were maintained, several villas and low-rise apartment buildings surrounded with gardens were demolished to be replaced with attached apartment buildings (Figure 4-C). Currently, few remaining villas and palaces dating back to late 19th and early 20th century still extant amidst the modern apartment buildings with no setbacks.

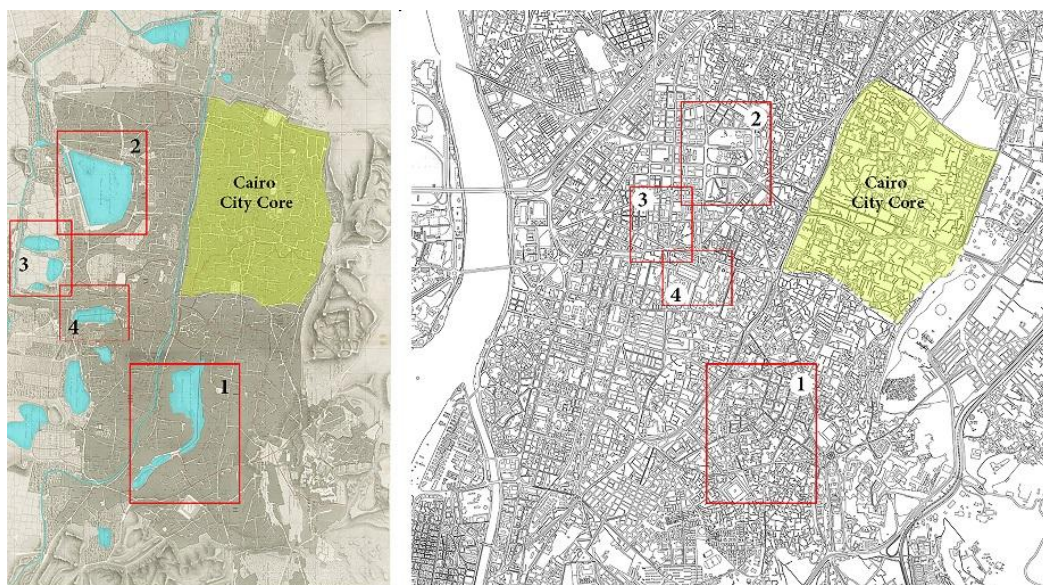


Figure 2: Cairo between 1820 (left) and 1980 (right) with areas of study indicated. Site (1) al-fil (currently al-Helmiya al-Gadida), site (2) al-Azbakeya (currently al-Azbakeya garden and surrounding), site (3) al-Fawaleh (currently a part of Downtown Cairo), and site (4) al-Farayn (currently Abdin Square and its surrounding).

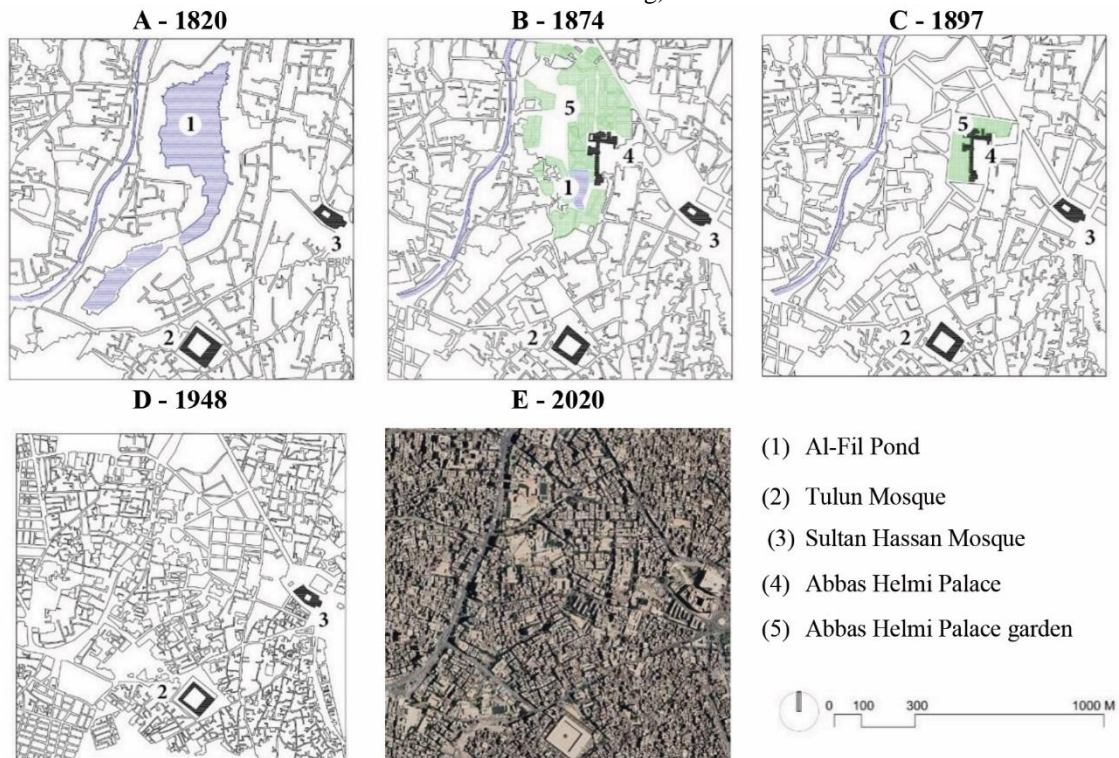


Figure 3: Morphological transformation of al-Fil pond site – the general level.

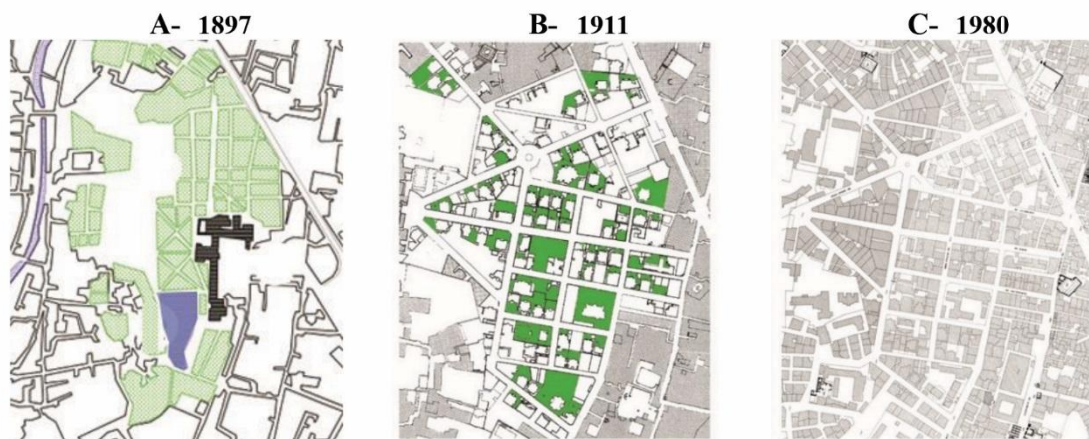


Figure 4: Morphological transformation of al-Fil pond site – plots and buildings level.

1.2. Site 2: previous site of al-Azbakeya pond, currently al-Azbakeya garden and surrounding context

Development around al-Azbakeya pond started with late 13th / early 14th century, when the area between the two canals witnessed great urban development. As mentioned, when the previously fancy area around al-Fil pond became overcrowded, the Emirs emigrated to the shores of al-Azbakeya. The first Emir whose palace in al-Azbakeya paved the way for the development around the pond, was Emir Azbak, and hence the area became known as al-Azbakeya[1]. Raymond stated that Emirs could find quieter and safer place for their residences and could build agreeable houses with gardens and outbuildings for servants [24]. The examination of Description de l’Egypte map reveals a concentration of 24 palaces of Elite Mamluks in the organic fabric around the pond (Figure 5-A). Many of these palaces were seized by Napoleon and his generals for residence and as headquarters during the French occupation to Egypt. This explains why Cairo revolts of March-April 1800 against the French had devastating effects on al-Azbakeya area [24].

In 1835 the pond was drained and transformed into a park. Then, by late 19th century, the face of al-Azbakeya had completely changed when chosen as a main node for al-Ismailia district which was established following Haussmann's model of Paris. The previous garden was replaced with an octagonal garden, and in contrast to the previous traditional fabric, the surrounding area was divided into wide streets and spacious squares surrounded with geometric and regular plots (Figure 5-B). Four main squares were developed around al-Azbakeya garden, namely: Azbak, Attaba al-Zarqa, al-Opera and al-Khazindar Squares. These squares provided points of contacts with the new cut-through thoroughfares linking al-Azbakeya to almost every part of the city (Figure 5-B). The new streets included Clot Bey Street which connects Khazindar Square with the central station in the north; Mohamed Ali Street which connects Attaba Square with the foot of the citadel and AbdelAziz Street connecting Attaba Square with Abdin Square in front of the Khedivee palace; the new seat of throne.

Not only was the planning of the area different than traditional Cairo planning principles, but several new building types were introduced reshaping the cultural, social and economic life of Cairo. The area became premises of the most famous hotels of the city including Shepherd (1841), the Continental (1860) and Hotel de l'Orient (1848). In addition, the first Opera House was established in 1869 along with other three theaters. Consulates, cafes, market building and fancy department stores were established including Attaba Market, Halawa stores, Omar Effendi, Stein, Tiring, among others [34]. With early decades of the 20th century, this area became a major transportation hub to the whole city thanks to the tramways network connecting it from Attaba Square to almost every other part in the city.

The area continued to be a strategic hinge between traditional and modern Cairo. With early to mid-20th century, the centrality of Azbakeya was further ameliorated with the added cut through streets of Prince Farouk Street (now al-Guish Street) and al-Azhar Street linking Attaba Square with Bab al-Shaereya and al-Azhar district respectively (Figure 5-C).

In 1971, the Opera House was destructed by fire, and with its demolition the area lost a corner stone in its cultural life. Further, with late decades of the 20th century, tramways tracks were dismantled from many parts of Cairo, including Attaba Square and its surrounding. Al-Azhar flyover was then established passing above the square to absorb the growing traffic of private cars in the following years (Figure 5-D).

Al-Azbakeya garden suffered from long years of neglect and gradually lost its spark. Even the continuous shrinking green surface of al-Azbakeya garden can be detected through comparison of historic map with the current satellite image of the area (Figure 5-E). This was due to several establishments on the garden site including the Telecommunication building, the underground metro station among others.

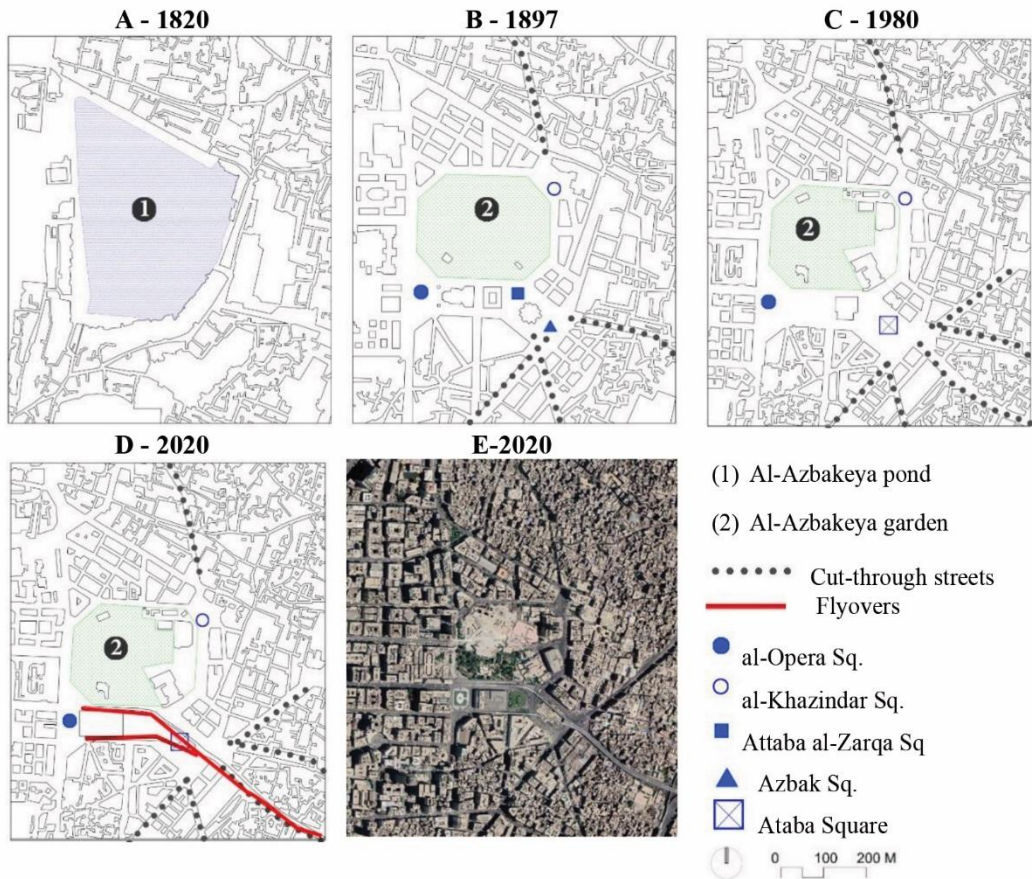


Figure 5:Morphological transformation of al-Azbakeya pond site – the general level.

A zooming in on the southern part of al-Azbakeya garden (Figure 6), shows that the geometry of the space had dramatically changed through time. Attaba al-Zarqa and Azbak squares were combined into one spacious square, called Attaba Square when the mixed-Tribunal Court building was demolished. In addition, when the Opera house building was burnt down, it was never rebuilt, instead, it was replaced with a multi-story car parking building. Furthermore, al-Azhar flyover was established passing over the space of Ataba square. Over and above, due to its very high connectivity to several parts of the city, and its vicinity to the main train station, the area is currently a main commercial hub for the city of Cairo and nearby governorates. All sorts of retail, with specialized markets, street vendors, formal and informal markets can be found in the area.

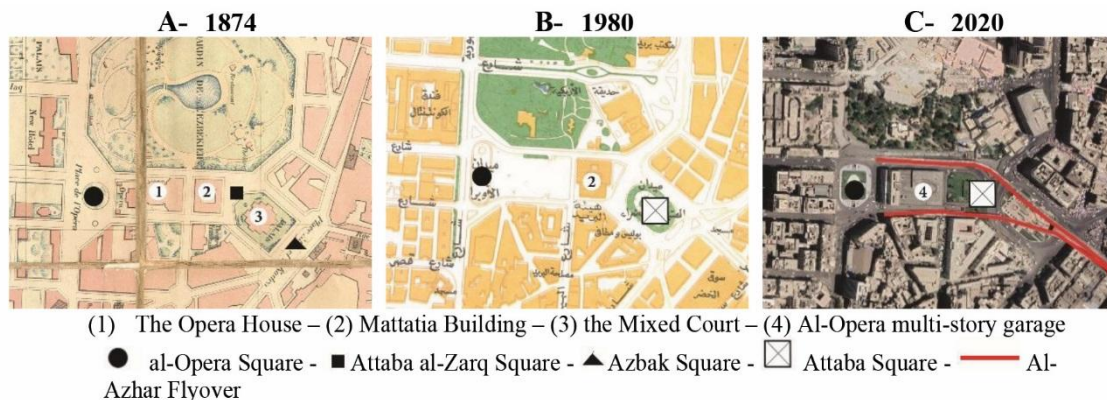


Figure 6:Morphological transformation of al-Azbakeya site – plots and buildings level.

1.3. Site 3: previous site of al-Fawaleh, al-Saber and al-Dam ponds, currently within Downtown Cairo

This area was formed of a grouping of three ponds: al-Fawaleh, al-Saber and al-Dam, located at the western fringe of the traditional city. This grouping of ponds was bordered by Khalig al-Nasseri from the west and by the urbanism of the traditional city from the eastern and southern parts (Figure 7-A).

Since this area was quite at the fringe of the traditional city, it became at the very heart of the plan of al-Ismailia district (the 19th century city core – currently Downtown Cairo). After filling-in Khalig al-Nasseri and the three ponds, the whole area was redesigned and planned into diagonal streets, intersected into spacious squares. Plots subdivisions show large plots sizes that included palaces and villas surrounded by vast gardens (Figure 7-B). At this stage, average plot sizes were much bigger that their rival in al-Helmiya al-Gadida.

Tracing morphological change in this area shows a continuous process of densification. The once wide land parcels were divided and subdivided through the following years. Palaces and villas were replaced with apartment buildings and a sub grid of streets had to be added to serve the new subdivided plots (Figure 7-C and D).

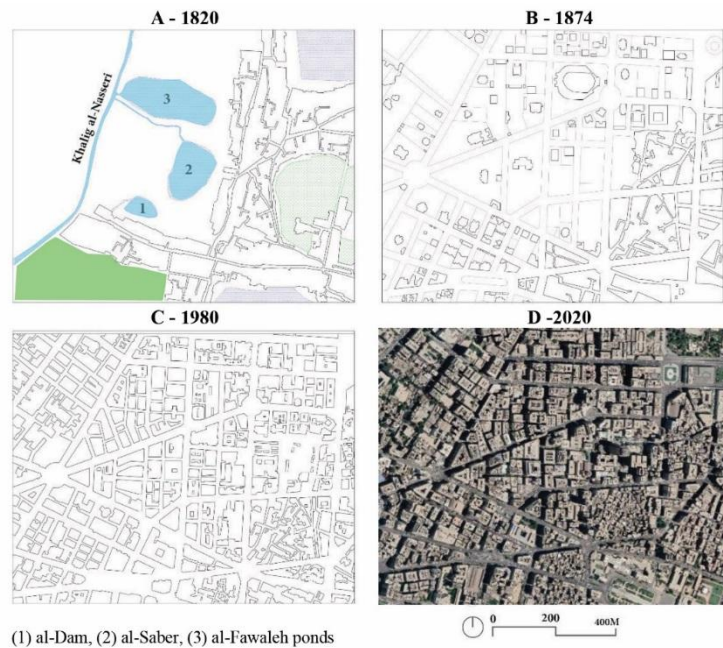


Figure 7:Morphological transformation of al-Fawaleh pond site – the general level.

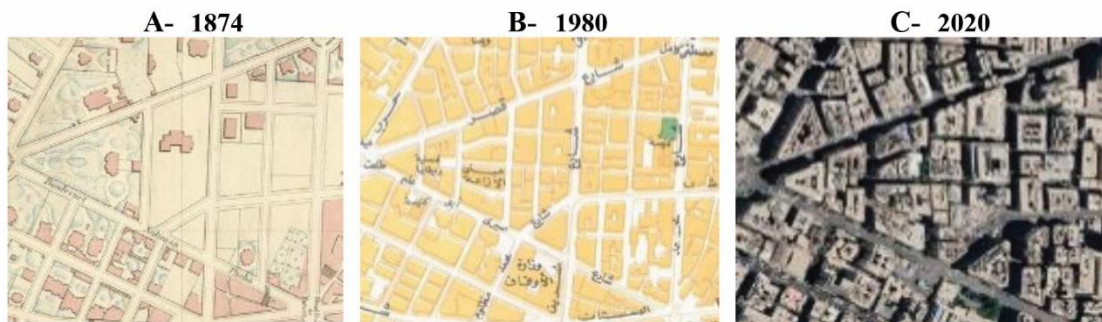


Figure 8:Morphological transformation of al-Fawaleh site – Plots and buildings level.

1.4. Site 4: previous site of al-Farayn pond, currently Abdin Square and its surrounding

Al-Farayn pond was also located on the western edge of Cairo and was surrounded with traditional urban fabric from all sides except the southern part which was occupied with planted fields (Figure 9-A). During late 19th century, this area was chosen as site for the new palace of Ismail Pasha who wanted to govern from the new-modern district, al-Ismailia, instead of the traditional seat of governance at the Citadel. Following the 19th century modern planning principles, it was necessary to have a main square in front of the monumental palace to stress its grandeur. The map pf 1874 shows that a large part of the pond turned into the square that was designed to be bordered by two main Royal palaces. However, this plan had never seen the

light and only the palace on the eastern side was established. Otherwise, parcels around the square were divided as squarish blocks to include fancy apartment buildings (Figure 9-B and C).

Abdin palace and square came to be another hinge between traditional and modern Cairo city cores. Since the square with linked with the Royal Palace (currently a presidential palace), it maintained a prestigious status with little change in terms of its physical form. However, this area was embedded with several symbolic meanings especially during political unrests and revolutions including Orabi Revolution in 1882, the events of 1942, 1952 revolution, 2011 uprisings among other major influential events in the history of the city.

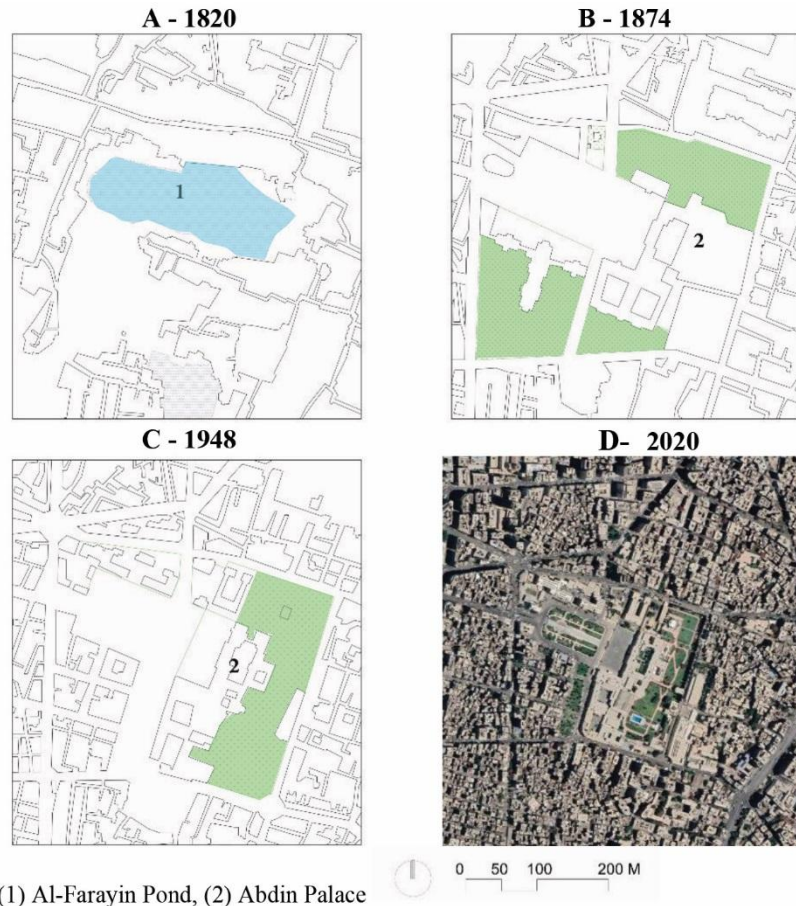


Figure 9: Morphological transformation of al-Farayin pond site – (1) Abdin Palace, (2) Abdin Square.

V. RESULTS AND DISCUSSION

The previous section presented a detailed chronological analysis for the development of the four selected sites. The analysis showed a transition from traditional to modern spaces configurations. Traditional and modern space configurations are based on totally different morphological structures. Carmona et al, differentiated morphological structures between traditional and modernist spaces in terms of buildings placement in the urban fabric [35]. Whereas it is buildings continuity that constitutes the urban block and that defines spaces in traditional settings; buildings in modernist settings are free standing discontinued entities. The presented analysis showed that the shift from traditional to modern urban systems in the selected settings was a shift from the small scale mostly organic street meshed local street networks, into wider scale road networks, and from continuous buildings entities to free standing pavilions. This, however, is more than an aesthetic preference, as each of the two systems produces completely different social characteristics [35]. Therefore, it must be noted that although this study focused on the physical aspects in the investigated sites, the said transition from traditional to modern urban forms was a transformation in both the social and the spatial aspects of the investigated contexts.

By comparing the development of the selected sites, it is noticed that original spatial characteristics and abstract shapes of previous ponds could be traced in current spatial configurations with various degrees of clarity (Figure 10). Initial traces of the ponds are mostly visible in the case of al-Azbakiya garden and its surrounding as well as in Abdin Square, since in these two settings, the previous ponds were converted into major urban spaces, a garden in the former and a Royal Square in the latter. In contrast, in the sites of al-Fil pond and al-Fawaleh traces of infilled ponds are harder to be defined since they were absorbed into the urban

fabric of the city by being subdivided into land parcellations with different patterns. Having identifiable traces of previous spatial configurations in historic contexts helps and supports place memory consolidation and communication which in turn could have positive impacts on place attachment, community and urban conservation[36].

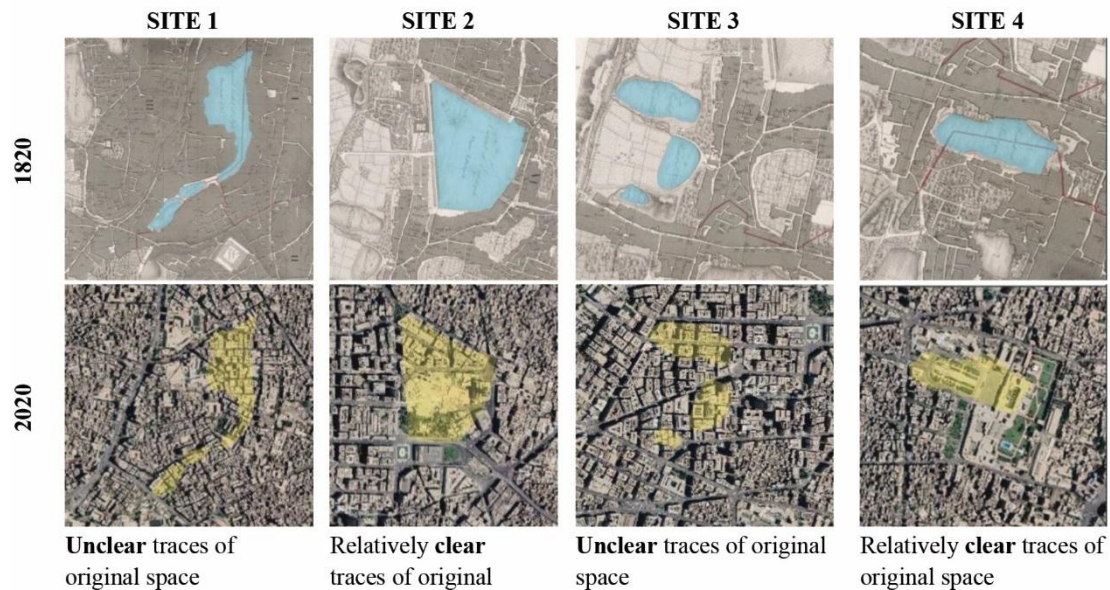


Figure 10:Spatial characteristics and abstract shapes of previous ponds in current settings.

Several studies discussed stability and resilience to change of urban form elements represented in buildings, plots, blocks, and street patterns. Scholars confirmed that, in general, buildings are the most prone to demolition and reconstruction; plot patterns are more enduring but also subject to subdivision and amalgamation through time; and street patterns represent the most enduring of urban form elements. Unless being subject to transformation due to drastic change like that caused by major urban development projects, street networks are expected to last for centuries with little modifications[37]–[39].

By investigating historic and recent maps of Cairo between 1820 and 2020, it is possible to classify and map stability and resilience to change of urban form elements in the investigated sites over different historic periods. Findings of this analysis are presented in (Table 2). The two-century period which constitutes the timeframe of this study was divided into four sub-periods, and a simple scale of: a) stable, b) slightly stable and c) unstable, was used to map the detailed change in street, blocks, plots and building patterns through time.

Table 2:Mapping stability and resilience to change urban form elements in the investigated sites.

		Site 1: Al-Fil pond – Helmiya al-Gadida	Site 2: Al-Azbakeya pond – al-Azbakeya garden and surrounding	Site 3: Al-Fawaleh pond – part of Downtown Cairo	Site 4: Farayn pond – Abdin Square and surrounding
Buildin g pattern	1820-1849				
	1850-1899				
	1900-1949				
	1950-2020				
Plots pattern s	1820-1849				
	1850-1899				
	1900-1949				
	1950-2020				
Blocks pattern s	1820-1849				
	1850-1899				
	1900-1949				
	1950-2020				
Streets pattern s	1820-1849				
	1850-1899				
	1900-1949				
	1950-2020				

Stable
 Slightly stable
 unstable

The present study shows that investigated sites maintained different patterns of urban densification. In the case of al-Helmiya al-Gadida, densification was mainly on the level of building patterns. In this case, many villas or low-rise apartment buildings surrounded with garden were gradually demolished and replaced with attached multi-stories apartment buildings built on original plot subdivisions. In general street patterns, building blocks and plot sizes, were stable in al-Helmiya al-Gadida throughout this transformation.

In the case of al-Fawaleh previous pond site, the densification appeared on the level of buildings, plots, blocks and street patterns. Huge plots originally designed to house low-rise palaces surrounded with enormously vast gardens, ended up being subdivided into smaller land parcels for multi-story buildings with no setbacks. The new plots subdivision necessitated the introduction of a sub-network of streets to serve them.

The Case of Abdin Square and its surrounding was the most stable of the investigated sites. After being designed as a Royal Square, little change occurred on the level of buildings, plots, blocks and streets patterns. Transformation in this square and its surrounding was however, on the non-physical level, and the different meanings the space acquired with the shift in political and ideological shifts in the history of Egypt.

The case of al-Azbakeya garden and its surrounding showed a different type of densification. It showed a continuous densification of public spaces. This appeared in the continuously shrinking area of al-Azbakeya garden, as well as in the engulfing of Attaba square and surrounding streets with street vendors and flyovers.

The present investigation could be used to development control regulations and guide context-based urban interventions in the selected areas, which are all listed as urban areas of value according to Section 2 in the Egyptian Building Law (119/2008) [40]. Development control regulations in historic contexts of value should put into consideration not only current urban form but should also consider the process of urban transformation through time [20]. That is why development control regulations in areas of value should be informed by deep morphological understanding of the context [41], [42].

This is currently not the case for the selected sites. For instance, one of the current building regulations applicable to al-Helmiya al-Gadida, “all new buildings should be built directly on the peripheries of the land parcel with no front or side setbacks in order to maintain the traditional urban fabric of the area of value.” [43] This, however, would lead to the erasure of all remaining traces of unlisted villas, palaces and apartment buildings with gardens in the area. In case of any listed or unlisted historic villa was to be demolished, it would be replaced – according to this regulation – with a new building that has no relation with the original urban form.

By adopting the typomorphological approach, this study confirms that deep morphological understanding of patterns and processes of change in urban areas of value is essential for maintaining urban character, for guiding infill design projects and for ensuring context-based control regulations.

VI. CONCLUSION

In cities with long history and fast paces of urbanization, urban contexts represent a stratification of historic layers. By tracing their morphological metamorphosis and disentangling their various urban layers, patterns and processes of cities urban transformations are revealed.

The present study traced the transformation of pre-19th century water ponds into sites for modern urban development. The study illustrated detailed chronological investigation of four selected sites of pre-19th century water ponds in Cairo. The cartographic and archival analysis revealed that not only did the selected sites show a clear transition from traditional to modern space configurations, but also that the modern spatial configurations maintained different patterns and processes of transformation through history.

The study mapped different degrees of stability and resilience to change in the elements of urban form over a period of two-century period from 1820 to 2020 and detected different patterns and processes of urban densification in the investigated settings.

The present paper supports the argument that understanding patterns and processes of urban transformation is essential for a better understanding of contexts of value and for informing better context-based decisions concerning urban interventions and urban conservation practices. It is also crucial in order to inform development control regulations in urban areas of value with periods of drastic and gradual change and transformation patterns. Decision makers concerned with drafting development control regulations need to put into consideration not only current built forms but also patterns and processes of their urban transformation through time.

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