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DIGITIZING URBAN CODES TO SUSTAIN URBAN CHARACTER OF HISTORIC DISTRICTS: A CASE STUDY OF ROSETTA CITY, EGYPT

Mokhtar Hosni Akl*, Sherif A. Sheta, Lamis El Gizawi

Mansoura University, Elgomhouria St., Mansoura City, Egypt

*Corresponding author's email: mokhtarakl@mans.edu.eg

Abstract

Introduction: Effective urban planning relies on comprehensive knowledge of both physical and non-physical urban elements, which is vital for developing GIS models that support sustainable urban development by providing realistic representations of urban contexts. Accurate 3D models are critical for analyzing urban systems and processes. **Aim:** This study aimed to evaluate the impact of 3D GIS urban digitizing techniques and visualization methods on the feasibility of urban codes in preserving urban identity and character, with a focus on Rosetta City, Egypt. **Methods:** The research employed descriptive, analytical, and empirical approaches. Field visits, surveys, GIS simulations, and digital tools like ESRI CityEngine were used to create 3D GIS models. These models help digitize and analyze urban code parameters by using the form-based code approach. **Results:** The study demonstrates that 3D GIS models can enhance urban planning by improving the understanding of urban codes and their implications for preserving urban identity. The models provide insights into maintaining historical character while supporting development. **Discussion:** The findings highlight the potential of 3D urban models to improve decision-making in urban planning and underscore the value of such models in preserving the unique identity of historic districts like Rosetta City, offering a framework for similar regions.

Keywords: urban character; urban codes; historic districts; 3D GIS modeling.

Introduction

Urban knowledge, which includes data on both tangible and intangible elements, is crucial for the development of Geographic Information System (GIS) models that facilitate sustainable urban development. These models provide realistic description of urban environments, which are critical for analyzing urban systems and processes. Accurate 3D urban models have become essential tools for supporting urban knowledge and evaluating the performance of urban systems in the context of sustainable development (Billen et al., 2014). As highlighted by Batty (2013), understanding urban systems is a key requirement for achieving sustainable development goals in cities.

Spatial analytics, which involves understanding and managing space, is another crucial component of urban planning. The increasing availability of data from the web and sensors has significantly transformed the way we perceive and manage cities, particularly when dealing with urban transformations. Geography is crucial for understanding how the cities adapt and enhancing their resilience to developmental challenges (Kitchin, 2014). In the era of smart cities, 3D GIS models are indispensable tools for urban planners. These models enable enhanced visualization and analysis of urban systems, facilitating better decision-making processes that contribute to sustainable development. Additionally, these models improve the management of resources and infrastructure, fostering resilience and adaptability in cities (Townsend, 2013; Voghera and La Riccia, 2019).

Urban planning initiatives in Egypt, however, face several challenges. Current development strategies follow conventional planning processes that often overlook key factors such as location dynamics, target beneficiaries, and the economic foundations of new towns, as well as effective market incentives (Sims, 2015). Moreover, there is a notable gap in the understanding of the environmental and physical characteristics of selected development sites, compounded by the lack of sufficient studies and clarity (Kipper and Fischer, 2009). According to the Housing and Building Research Center, Egypt has around 50 building codes and design guides. Among these, the most relevant to urban form, identity, and building regulations (height, setbacks, cantilevers, etc.) are Unified Building Law No. 119 and the National Organization for Urban Harmony guides and periodicals (MHUC, 2008), (NOUH, 2008). While authorities have made efforts to introduce new codes for different regions, these codes still fall short of reflecting sustainable design approaches and preserving urban identity.

The research question is to what extent can 3D GIS urban digitization techniques and visualization

methods, aligned with a form-based code approach, assess the feasibility of urban codes in sustaining a neighborhood's identity and character? The hypothesis is that 3D urban models can effectively visualize the current physical urban context of a selected neighborhood and its relevant urban parameters, thereby supporting the digitization of urban codes to enhance smart urban management. The aim of this research is to analyze urban codes for a selected case study in Egypt using GIS analysis, digitize its urban parameters into 3D urban models, and visualize the impact of these urban codes on the city's character and identity. The structure of this research is divided into five sections. The first section offers a comprehensive literature review on urban character and the application of form-based codes, setting the theoretical foundation for the study. The second section outlines the research methodology, detailing the analysis of urban code parameters and the tools employed, including 3D GIS modeling techniques. The third section focuses on the case study of Rosetta City, Egypt, where the urban code parameters are critically analyzed to understand the local urban context. The fourth section explains the process of creating 3D GIS models, involving four key steps: upgrading GIS data, defining building use, developing building shape grammar, and visualizing urban code parameters. The final section presents the results of the study, discussing the findings and their implications for both urban planning and the preservation of historic districts.

Literature Review

Urban Character

The redefinition of urban land use classifications and zoning, along with the design of essential urban components such as nodes, special districts, and paths, plays a key role in enabling compatible mixed-use growth and promoting sustainable development. Kevin Lynch emphasized that identifying and reinforcing existing urban "nodes, paths, and districts" is crucial for sustainable urban development (Lynch, 1960). He defined special districts as areas of significant size associated with notable activities or characteristics (McGeough et al., 2014).

The growing loss of urban character in modern cities has led stakeholders and residents to place greater emphasis on areas where urban identity is linked to economic benefits. The preservation and development of urban character are vital for a city's vibrancy, as it reflects local culture. Urban character extends beyond visual appeal, fulfilling an emotional need for belonging. Identifying with the character of one's surroundings is essential for emotional well-being, and the loss of urban character can threaten cultural diversity as well as economic progress (Tiesdell et al., 1996; Yu, 2013).

This study is based on the regulations and standards established by the National Organization for Urban Harmony (NOUH), created by Decree No. 37 of 2001. NOUH's goal is to protect the aesthetic and cultural values of buildings, urban spaces, archaeological sites, and the architectural and urban character of Egypt while preserving the natural environment (NOUH, 2008). Relevant regulations, including urban design standards, heritage conservation, and architectural character preservation, are codified in Unified Building Law No. 119 and its procedural appendix No. 144 (MHUC, 2008).

Form-Based Codes

Form-based codes, a New Urbanism tool, aim to restore the form- and utility-based cityscapes of American cities' pre-zoning era. Form-based codes are used to maximize land use, benefit the general public, focus on producing a particular physical form, and design the development process and public spaces in alignment with the community's vision (MAP 2007), (Parolek et al., 2008). Form-based coding regulation of the built environment differs from traditional methods. This is because the use-based approach to zoning has proven ineffective in managing diverse, urban, mixed-use areas (Talen, 2012), (Zhang, Y. and Schnabel, M. A., 2017).

Form-based codes prioritize physical form over the separation of uses, fostering predictable built environments and a high-quality public realm. These codes are adopted into city law as regulations rather than guidelines. As regulatory tools, form-based codes provide an effective alternative to conventional zoning. They are specifically drafted to implement a community plan, resulting in neighborhoods that promote walkability, social interaction, and increased local investments (FBCI, 2023). Fig. 1 illustrates the main differences between conventional zoning and form-based codes.

Form-based codes are essential tools, particularly for historic districts, as they help maintain the identity of the district by considering all related urban elements. These standards include criteria for streetscapes, such as on-street parking, sidewalk width, and street trees, since the building form and streetscape are interconnected (Parolek et al., 2008). Many other rules found in traditional zoning ordinances, such as definitions, administrative processes, zoning board of appeals, nonconforming uses, and more, are also incorporated into form-based codes (Sitkowski and Ohm, 2006).

Research Methodology

The research methodology relies mainly on the descriptive, analytical and empirical approaches to reach reliable results. Different methods are used to monitor and analyze the current situation of the case study through data analysis, study visits, questionnaire, surveys and GIS urban simulations as shown in Table 1. We used digital tools and programs like Google My Maps, Google Earth, and

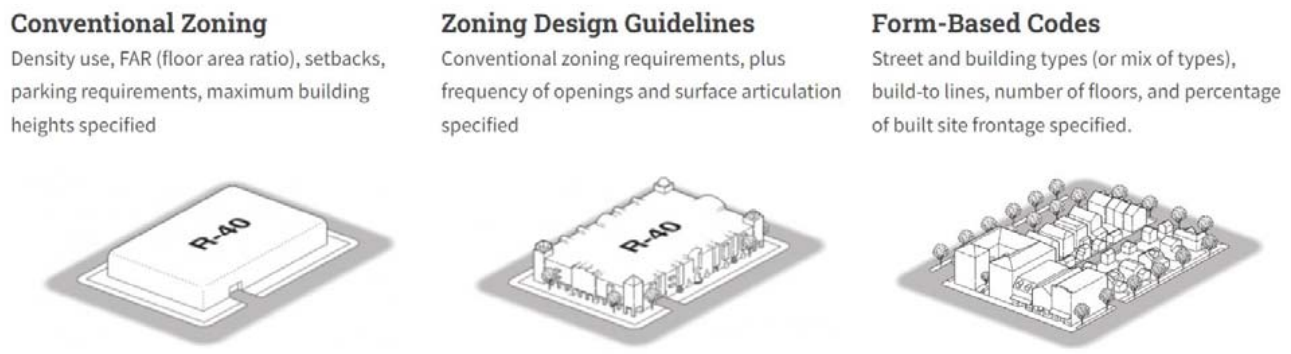


Fig. 1. Differences between conventional zoning and form-based codes, source: (FBCI, 2023; Zhang et al., 2018)

GIS platforms such as ArcMap, ArcScene, and Esri City Engine as a 3D city platform to aid in digital documentation and converting 2D spatial data into a 3D GIS model. Esri City Engine is widely used for rule-based modelling in the urban programming community (Souza, L. and Bueno, C., 2022).

Analyzed Urban Code Parameters

The application of digital tools using GIS will focus on specific urban parameters determined by the analysis of form-based codes and related Egyptian codes and guidelines, especially Urban Harmony guidelines and their executive regulations, as shown in Table 2. These urban parameters are analyzed using GIS analysis and processed with CityEngine into a 3D GIS model to create the identity of the selected neighborhood according to its regulations and design requirements.

Case Study Analysis

The city of Rosetta is located in the far north of Egypt on the west bank of the Rosetta branch of the Nile River and bordered to the north by the Mediterranean Sea, as shown in Fig. 2.

In terms of the number of its Islamic houses, Rosetta is the second-largest city after Cairo. The number of Ottoman-era heritage buildings has declined from 52 in 1963 to 37 at the present time (UNESCO, 2003; UN-HABITAT, 2006). The Rosetta stone, which enabled the discovery of hieroglyphs, is Rosetta City's most well-known historical monument. The Rosetta stone was found here during the French expedition in 1799, at the castle of Qaitbay at Burj Rasheed. Ancient ruins were discovered around the area, including those on Abu Mandur hill.

Table 1. **Assigned research methods and software, source: authors**

Methods/Tools	Software used
Field visits & survey	Google My Maps, printed maps
Case study analysis	ESRI ArcGIS Pro, Arc Scene
Experimental	ESRI ArcGIS Pro ESRI CityEngine

Digitizing the urban code using GIS is mainly based on the analysis of the Urban Harmony Guide for Rosetta historic district. There are two types of protection zones: (1) Zone A of max. protection that includes all historic buildings inside it, and (2) Zone B that surrounds Zone A and includes the waterfront of the historic district on Nile River (NOUH, 2022).

Urban Form Analysis

This section shows the analysis of legal requirements for building forms such as building ratio and heights. These parameters are defined in the "Specific to Transect Zones" section in the form-based code.

Building ratio

The urban fabric must be preserved in all areas. Land plots should not be subdivided. Buildings should be constructed right on the plot borders without setbacks or side spaces, creating solid and continuous blocks that result in a compact urban fabric similar to the historic urban layout in Rosetta (NOUH, 2022). Spaces left from building ratio regulations should be in the form of internal courtyards, skylights or back gardens, with the use of tree types similar to palm trees in the city. The reference for the boundaries of the buildings is the cadastral maps of 1936, as shown in the maps in Fig. 3, while Fig. 4 displays the regulated percentage of building ratio based on the land plot area.

Building heights

The height requirements mentioned in this guide should not contradict the Armed Forces Operations Authority or the Civil Aviation authorities, as well as Antiquities Protection Law No. 117 of 1983 and their executive regulations. Building heights are determined according to the street width in each zone. The study through survey and analysis of building heights in the historic district shows that approx. 30 % of the buildings do not comply with the requirements and regulations of building heights in the guide due to the weak control over construction from the concerned authorities, insufficient application of laws, administrative corruption and the landowners' demand for more profits (Fig. 5). These practices impact the urban form and character of

Table 2. **Urban parameters of Rosetta historic district for GIS analysis and CIM (city information modeling) development, source: authors**

Form-based codes	Related Egyptian codes and guidelines	Analyzed urban parameters
Specific to Transect Zones	Urban Harmony for Rosetta City Egyptian Classification of Urban Development Areas Guideline Egyptian Code for Housing and Residential Cluster Design	Building ratio Building heights
Specific to Building Types	Urban Harmony for Rosetta City	Architectural style Facade materials Balconies and cantilevers Openings Facade details
Specific to Frontage Types	Urban Harmony for Rosetta City	Storefronts
Supplemental to Transect Zones	Urban Harmony for Rosetta City Urban Harmony basics and criteria for heritage buildings and areas Urban Harmony basics and criteria for city centers Urban Harmony basics and criteria for advertisements and banners	Lighting Vegetation
Specific to Creating a Walkable Neighborhood	Egyptian Code for Housing and Residential Cluster Design	Building ratio
Specific to Thoroughfares	Road Elements Design Standards Guide Egyptian Code for Urban and Aerial Road Works — Part 3	Roads and Sidewalks

Fig. 2. Case study location, source: authors, processed by Google Earth Pro

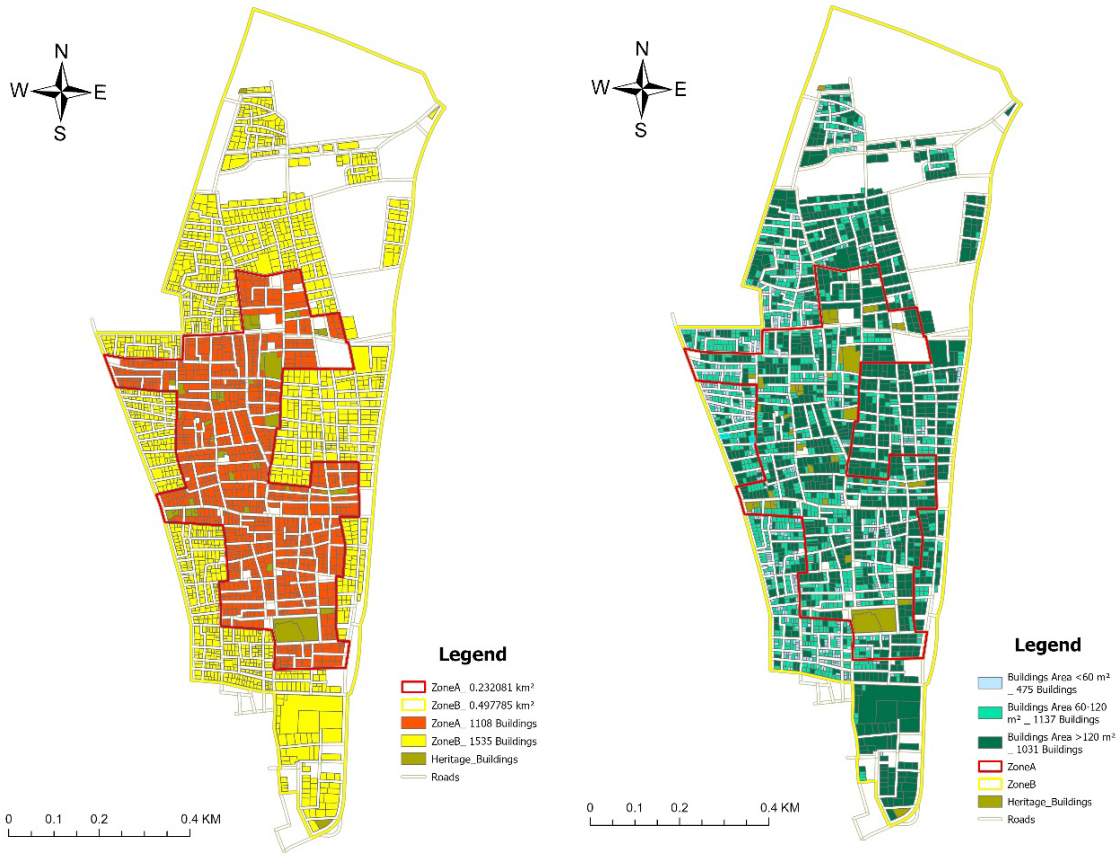


Fig. 3. Protection zones of Rosetta historic district, source: authors

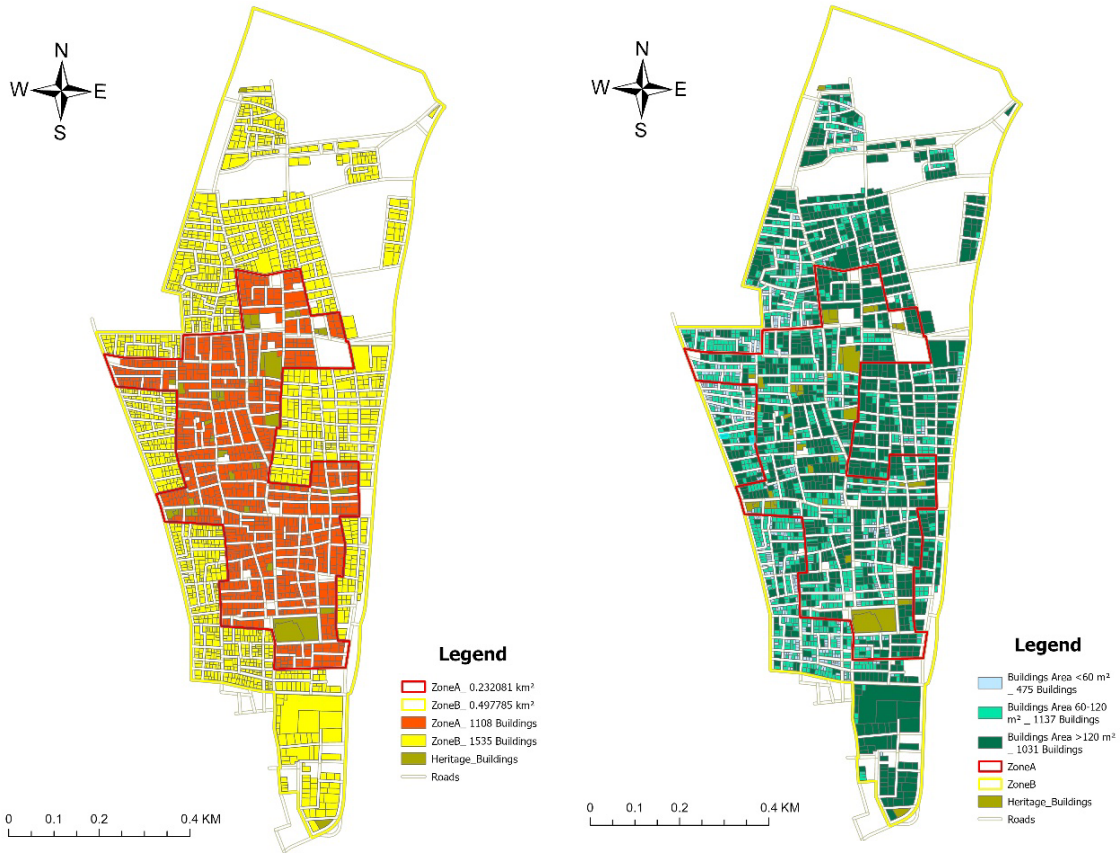
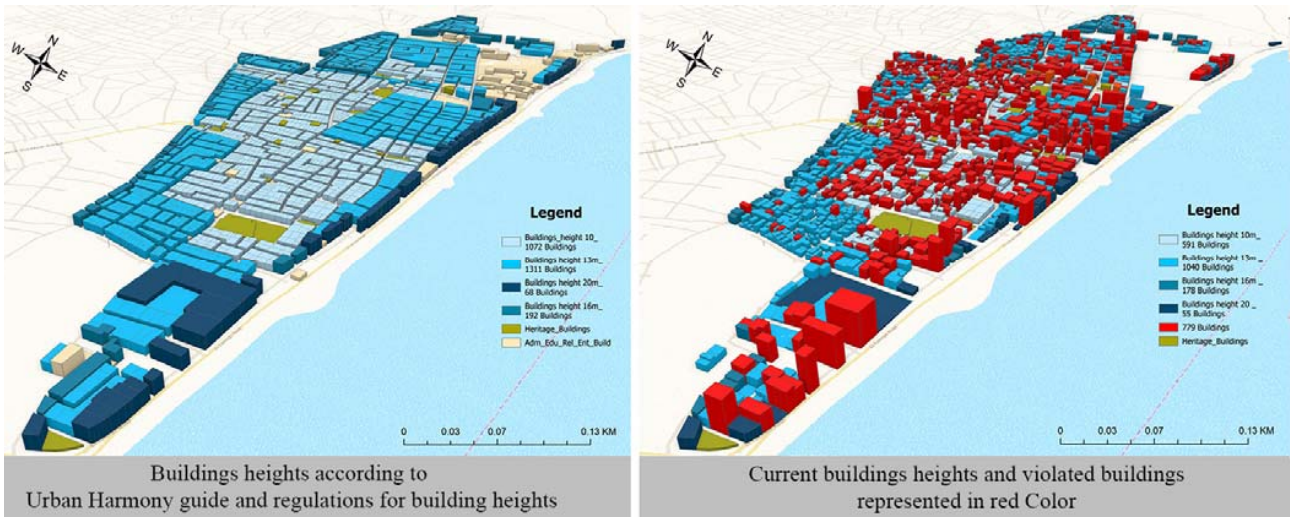


Fig. 4. Protection zones of Rosetta historic district, source: authors



Buildings heights according to Urban Harmony guide and regulations for building heights

Current buildings heights and violated buildings represented in red Color

Fig. 5. Building heights compliance with the Urban Harmony Guide and regulations for Rosetta urban district, source: authors

the historic district, influencing its preservation and development to enhance tourism appeal and boost social and economic vitality.

Architectural Style of Building Types

This section outlines the building standards and architectural styles within the Rosetta historic district, analyzing them in accordance with the Urban Harmony Guide for building design standards, which aligns with the "Specific to Building Types" section in form-based codes. New architectural styles for buildings should be compatible with the existing character of the historic district, avoiding any distinctly different or unusual details. Figs. 6 and 7 highlight the original architectural character of the city, which reflects the Islamic style from the Mamluk and Ottoman periods. A blend of European and local architectural styles also emerged at the end of the 18th and early 19th centuries during the Khedivial period, though few buildings from this era remain in the historic district, as shown in Fig. 8.

Building facades should feature earth tones, such as shades of beige and gray. Brick cladding is required for ground floors, with a minimum height of 60 cm from the sidewalk, not exceeding the height of the first-floor slab, particularly in Zone A. In Zone B, bricks, stones, and natural materials are permitted. Wrought iron, in black, is used for vertical and horizontal grilles to protect the ground and mezzanine floors (NOUH, 2022).

In Zone A, openings are based on historic building features, with rectangular vertical shapes, brown-toned wooden doors and windows, transparent non-reflective glass, and the optional use of sunshades or mashrabiya as coverings. Balconies are only allowed in inner courtyards in Zone A. In Zone B, balconies are permitted on buildings facing streets wider than 10 meters, with restrictions on their width (not exceeding 10 % of the street width and a maximum of 120 cm). Cantilevered projections are allowed to a certain extent, with a maximum of 50 % of the facade surface. Limits on extrusion depend on the street width: up to 60 cm for streets under 12 meters wide and 100 cm for wider streets. In the historic district, only 10 % of buildings are allowed to have balconies, while 89 % may have cantilevers with a maximum protrusion of 60 cm (NOUH, 2022).

Storefronts

This section outlines the standards for the design of private frontages in the form-based code. The Urban Harmony Guide focuses only on storefront facade in terms of the original design of the building facade. Fig. 9 shows samples of storefronts inside the historic district, the photos show violations of some and their encroachment on the street. The Urban Harmony Guide for Rosetta City shows samples of the preferred architectural style from old storefronts and a sample for a new shop which adhered to this style as shown in the following Fig. 10.

GIS Analysis for Building Types Distribution

The development of each building type in Rosetta historic district is analyzed using GIS mapping to study their distribution according to the building standards and regulations discussed earlier, as shown in Tables 3 and 4. The GIS analysis focuses on three main parameters: building location (Zone A or Zone B), plot area, and street width. These parameters help determine the form of each building in terms of building ratio, heights, balcony and cantilever regulations. Based on data from GOPP GIS, street widths in the Rosetta historic district fall into two ranges: 5–10 meters and 12–20 meters.

The findings are categorized into 12 cases of varying urban regulations, which will be digitized using CityEngine to allow for easy control and visualization by different users. Each case is defined with specific details; for instance, Case 01 consists of 131 buildings and includes such information as area, building ratio, height, and

Fig. 6. Samples of historic residential buildings in Rosetta (Arab kulli, Al-Amasyali and Asfour houses), source: authors

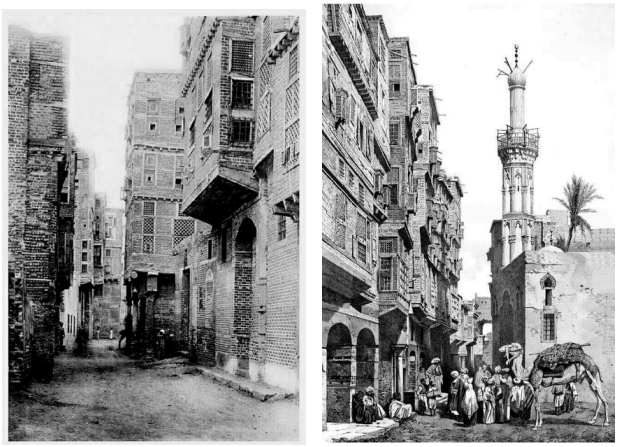


Fig. 7. Historic architectural style in Rosetta City, source: Rosetta online archive

Fig. 8. Mixed architectural style in Rosetta City, source: Rosetta online archive

Fig. 9. Samples of storefronts inside Rosetta historic district, source: authors

Fig. 10. Example of a new shop which adhered to the guide regulations, source: NOUH (2022)

the dimensions of balconies and cantilevers. This digitized approach enables local residents, urban planners, architects, local government authorities, developers, investors, and other stakeholders to identify and apply the relevant regulations for each building, ensuring compliance with design features

Table 3. **GIS analysis of Building Types Distribution for streets 5–10 m wide, source: authors**

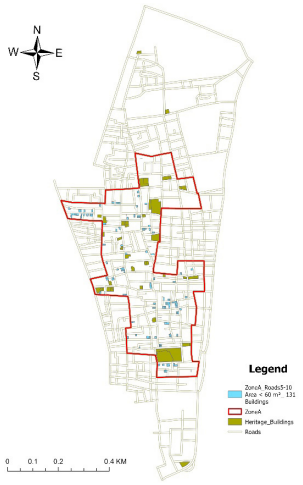
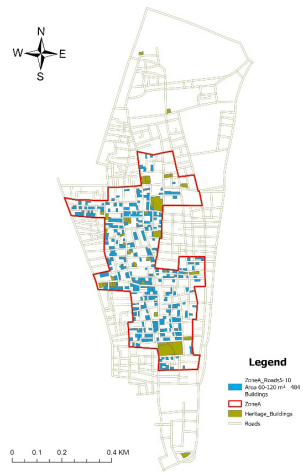
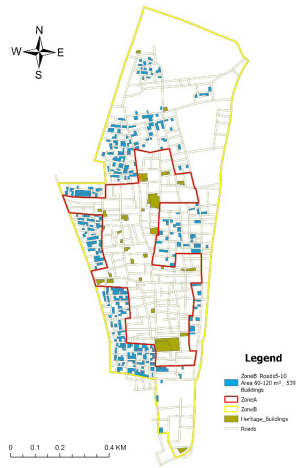
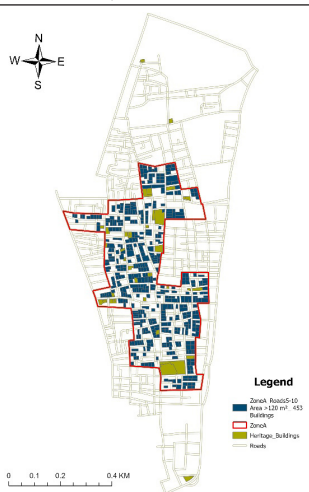
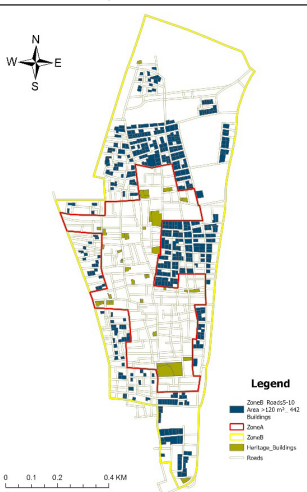
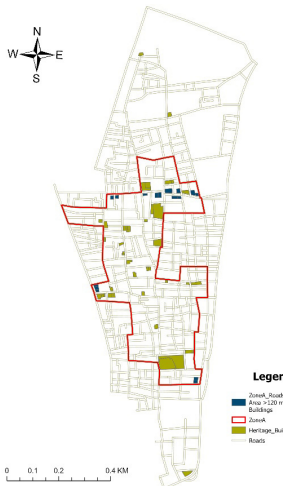
Plot area	Zone A	Zone B
	Street width 5–10 m	
< 60 m²		
	Case 01: 131 buildings < 60 m², building ratio 100 %, heights 10 m No balconies, 25–50 cm cantilevers	Case 02: 287 buildings < 60 m², building ratio 100 %, heights 13 m No balconies, 25–50 cm cantilevers
60–120 m²		
	Case 03: 483 buildings 60–120 m², building ratio 80 %, heights 10 m No balconies, 25–50 cm cantilevers	Case 04: 539 buildings 60–120 m², building ratio 80 %, heights 13 m No balconies, 25–50 cm cantilevers
> 120 m²		
	Case 05: 453 buildings > 120 m², building ratio 70 %, heights 10 m No balconies, 25–50 cm cantilevers	Case 06: 442 buildings > 120 m², building ratio 70 %, heights 13 m No balconies, 25–50 cm cantilevers

Table 4. **GIS analysis of Buildings Types Distribution for streets 12–20 m wide, source: authors**

Building ratio	Zone A	Zone B
	Street width 12–20 m	
< 60 m²		
	Case 07: 4 buildings < 60 m², building ratio 100 %, heights 13 m No balconies, 60–100 cm cantilevers	Case 08: 54 buildings < 60 m², building ratio 100 %, heights 16 m 120 cm balconies, 60–100 cm cantilevers
60–120 m²		
	Case 09: 20 buildings 60–120 m², building ratio 80 %, heights 13 m No balconies, 60–100 cm cantilevers	Case 10: 96 buildings 60–120 m², building ratio 80 %, heights 16 m 120 cm balconies, 60–100 cm cantilevers
> 120 m²		
	Case 11: 16 buildings > 120 m², building ratio 70 %, heights 13 m No balconies, 60–100 cm cantilevers	Case 12: 117 buildings > 120 m², building ratio 70 %, heights 16 m 120 cm balconies, 60–100 cm cantilevers

and facilitating the implementation of form-based codes. As a result, users will better understand and manage the urban landscape of the Rosetta historic district, enhancing both preservation and development efforts.

Roads and Sidewalks

The Thoroughfares section in form-based codes provides thoroughfare guidelines and components. The thoroughfares guidelines in the Urban Harmony Guide are classified into two types according to the location in Zones A and B. Based on the field survey, most streets need restoration and development, as many of them are deteriorated, with different finishing types, specifications and measurements. They do not comply with the requirements and regulations of the Urban Harmony Guide as shown in Fig. 11. Even the main waterfront street of Rosetta city has problems related to infrastructure and maintenance with no accessibility or crossing places for pedestrians and people with special needs as shown in Fig. 12.

Lighting

Lighting poles need to be installed every 30 meters on streets 12 meters wide or more. In the streets of less width, the lighting should be in the form of cables fixed to the building walls at a height of no less than 4 meters. Based on the field survey, lighting elements inside the historic district should be replaced and modified, as shown in Fig. 13. Lighting poles were found inside the historic district in the streets less than 12 m wide, while cables were seen hanging in the air between buildings, which distorts the visual image of the historic district. Fig. 14 shows lighting poles which located on the main waterfront street of Rosetta City.

Vegetation

It is allowed to plant plazas, squares and main streets more than 6 meters wide using appropriate techniques to protect the heritage buildings from the impact of irrigation water. These trees should not cover the facades of heritage buildings. Palm trees of the types found in the Rashid area should be used whenever possible as shown in Fig. 15.

Fig. 11. Example of narrow streets inside Rosetta historic district, source: authors

Fig. 12. Waterfront street of Rosetta City, source: authors

Fig. 13. Lighting elements in Rosetta historic district, source: authors

Fig. 14. Lighting elements on the waterfront street of Rosetta City, source: authors

Fig. 15. Palm trees as vegetation elements in Rosetta City, source: authors

Generating 3D GIS Models

Step 01: Upgrading the existing GIS data

The GIS database of Rosetta City from the General Organization for Physical Planning in Egypt is inaccurate, outdated, and different from the reality of the current situation. Field surveys were performed to update its GIS data for the current buildings' features of the historic district in June 2022. 3D GIS modeling for the historic district was developed using ArcGIS Pro to visualize the current urban context as shown in Fig. 16. The main aim was to check and update the GIS dataset for the historic urban district of Rosetta City and develop a 3D GIS urban model that could provide a clear visualization for the current urban data and form.

Step 02: Defining building use

Most buildings in Rosetta historic district are mixed-use residences as the ground floor is mainly used for commercial purposes while the rest of the floors are residential. A color coding for each building is scripted using Python as a CGA rule to define the use of each floor in CityEngine as shown in Fig. 17. The CGA rule file was mainly created by ESRI R&D Center and Devin Lavigne, Houseal Lavigne Associates, but it was edited by the researchers to be suitable for the urban context of the Rosetta case.

Step 03: Building shape grammar

Building regulations and forms were developed using Python-based CGA rule. The code defines the urban parameters that could be adapted according to the 12 previous cases for a better visualization of the whole urban district. The CGA rule was applied depending on the previously analyzed urban parameters such as building ratio, setbacks, heights, cantilevers, facade order and opening proportions as shown in Fig. 18. Facade design and order could be

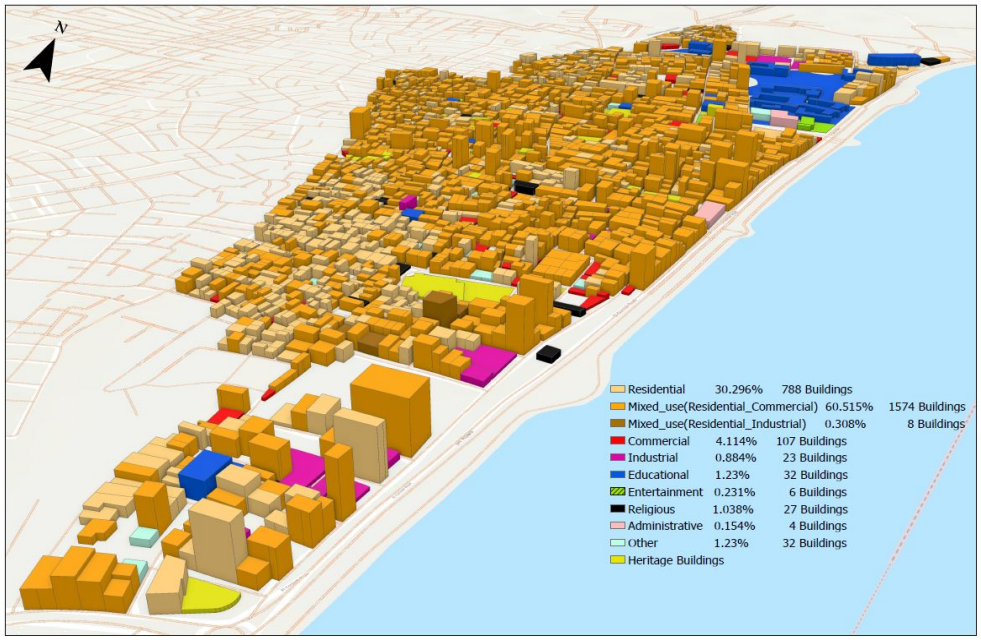


Fig. 16. 3D GIS land use map for Rosetta historic district, processed by ArcGIS Pro, source: authors

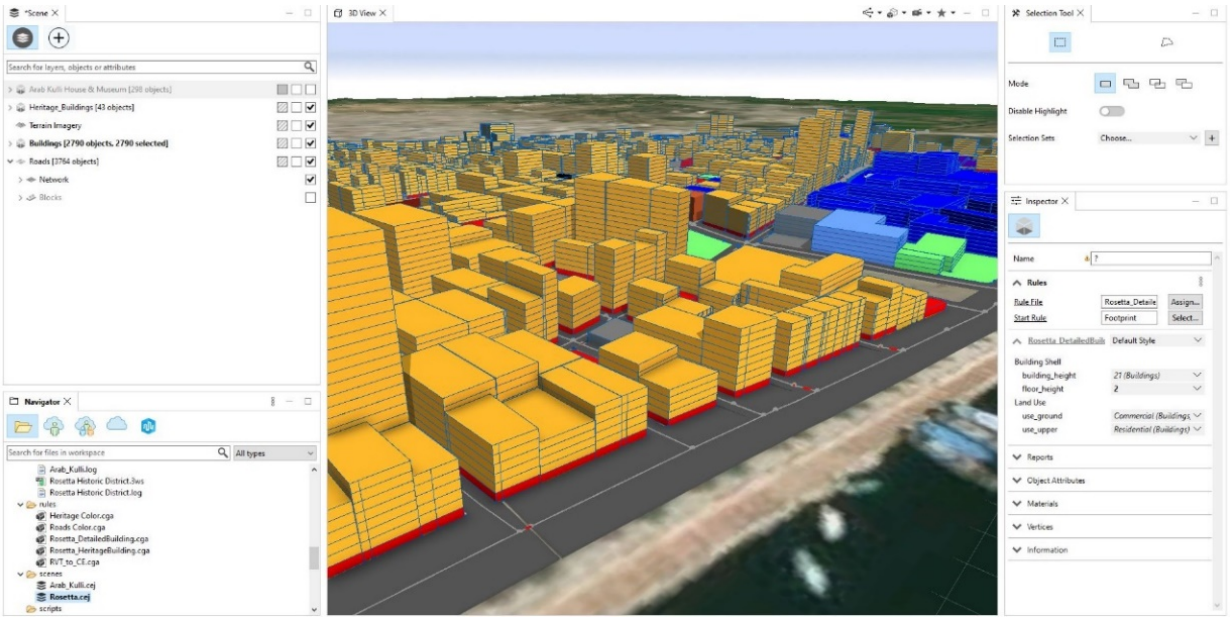


Fig. 17. Building floor uses in CityEngine viewport, source: authors

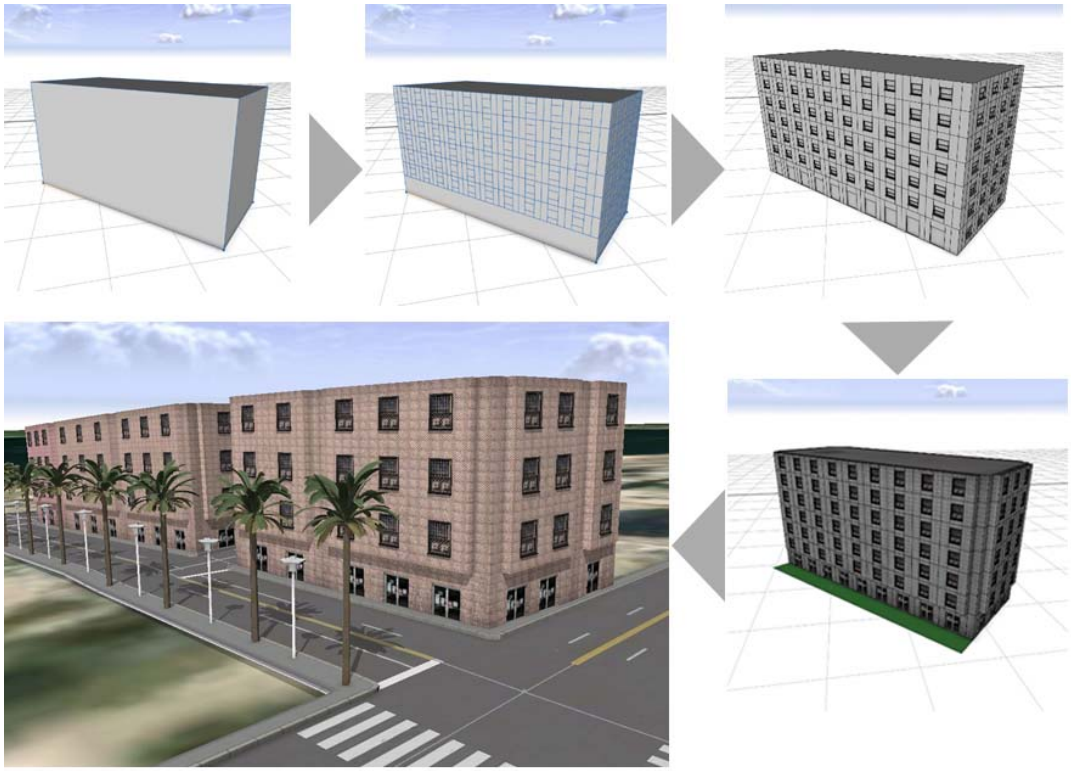


Fig. 18. CGA rule development for the controlled urban parameters, source: authors

Table 5. **Urban code procedural modeling: controlling different urban parameters affecting urban character, source: authors**

Urban parameters	Control parameters
Building parameters	Building ratio, setbacks, heights, cantilevers, facade order and openings proportions, storefronts, and texture mapping.
Street parameters	Street, lanes, right sidewalk and left sidewalk width, pedestrian crossing lines, street lines and texture mapping.
Tree parameters	Tree types, height, radius and visualization options.
Lights parameters	Lights height — depends on 3D model in .obj format.

developed by CGA rules to define the architectural style and order of buildings. All these parameters could be changed and modified easily through Python scripting and “inspector” tab in CityEngine which contains all the defined urban parameters.

Step 04: Urban code control parameters and visualization

Table 5 shows the application of different urban elements in CityEngine platform and the ability to control their parameters.

The 12 cases of different urban regulations in Tables 4 and 5 for Rosetta historic district were digitized using CityEngine to be controlled and visualized by different users as show in Fig. 19. Figs. 20 and 21 show the ESRI CityEngine web-based model. which could be shared with all users and stakeholders to check the regulations and building forms for each plot.

Results and Discussion

City information modeling platforms could support the decision makers to develop a comprehensive, integrated, upgrading methodology using a GIS-based spatial data management framework. This framework could efficiently assist the policies

Fig. 19. Twelve cases of different urban regulations, source: authors, processed by CityEngine

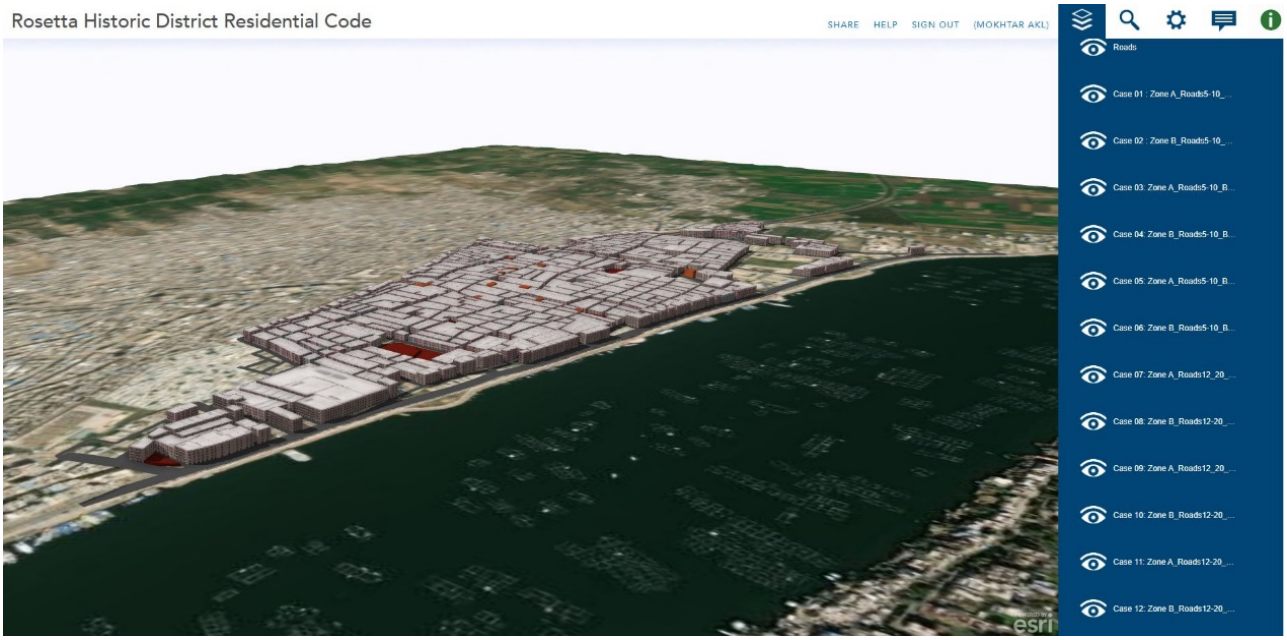


Fig. 20. Twelve cases of different urban regulations in the ESRI CityEngine web-based model, source: authors

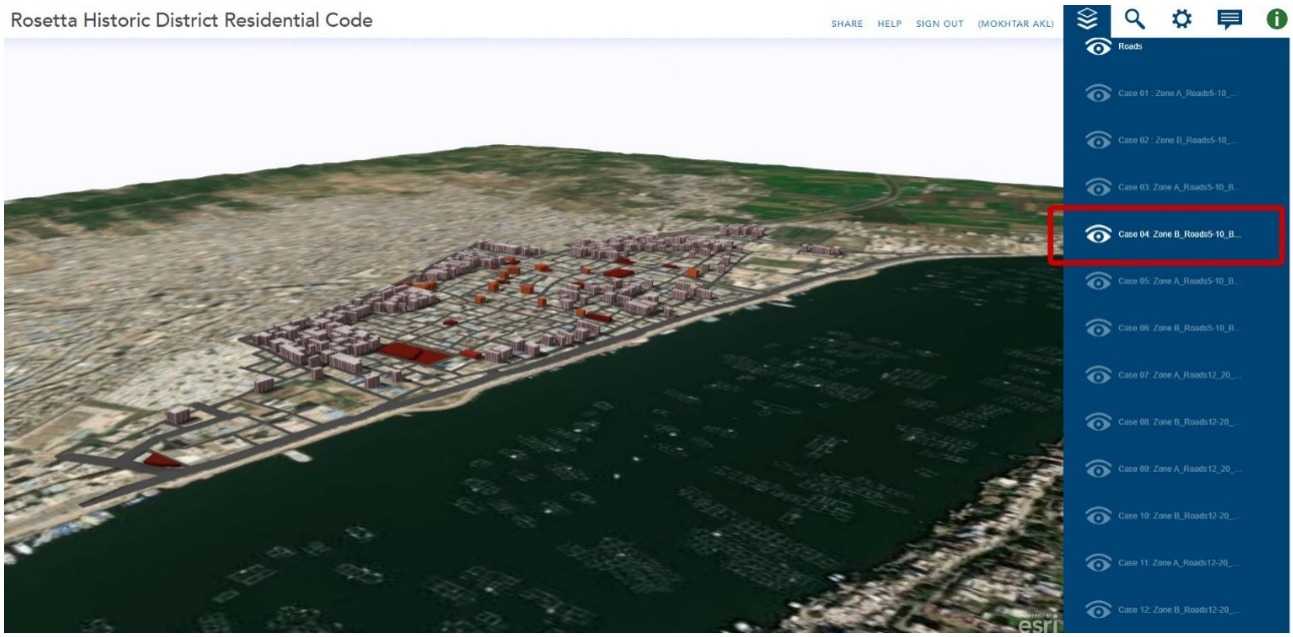


Fig. 21. Case 4 selected from different urban regulations in the ESRI CityEngine web-based model, source: authors

of urban development, urban regeneration, conservation, protection, and rehabilitation of urban neighborhoods. The development of urban codes using digital urban tools could preserve the urban elements manifesting urban identity.

The research results could be summarized as shown in Fig. 22.

We developed and updated the GIS dataset for the historic urban district of Rosetta city and a 3D GIS urban model that could provide a clear visualization for the current urban data and form.

We digitized urban code parameters representing the regulations of Rosetta historic district as a CGA rule (scripted using Python language) in CityEngine. The digitized urban code enables visualization of the district's urban character using 3D GIS models.

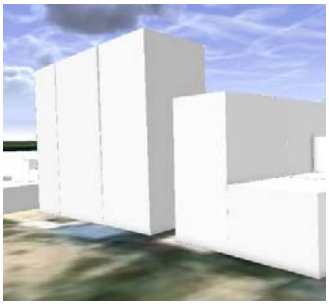
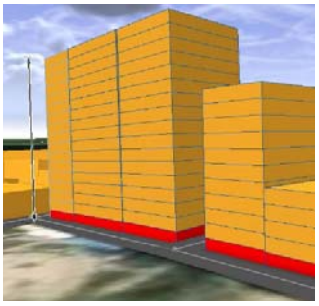
The developed 3D GIS model represents form-based code approach as it visualizes the criteria of urban form in which building form and streetscape are interconnected.

The study develops three 3D urban models with different level of detailing and visualization methods. The three developed models were compared to determine their extent in visualizing a realistic description of current physical urban context and all urban parameters that support the digitizing of urban code. The comparison criteria show the level of details achieved, ease of modeling and modifications, application of procedural modeling and the ability of online dissemination. In addition, we analyzed how much urban and building details could be visualized in each model.

The results indicate a progressive enhancement in the models' capacity to visualize urban contexts and support urban code digitization as shown in Table 6:

Fig. 22. Key results of the study, source: authors

Table 6. **The three developed 3D urban models with different level of details, source: authors**

	GIS System extruded by Arc Scene	Developing GIS System using City Engine	
	Model 01	**Model 02**	**Model 03**
	Updated GIS Data	Scripting Building Use	Scripting Building Details from Urban Codes
			
Level of Details	LoD01	LoD02 - supports LoD04	LoD03 - supports LoD04
Ease of Modeling	*	*	*
Ease of modifications		*	*
Procedural Modeling		*	*
Online Dissemination	*	*	*
Open Source Software	*		
Urban Details			
Land Use	*	*	*
Building Footprint	*	*	*
Total Floor Areas		*	*
Roads and Side walks			*
Lightings			*
Vegetation			*
Building Details			
Building Use		*	*
Buildings Heights	*	*	*
Buildings Ratio		*	*
Architectural style			*
Balconies and Cantilevers			*
Openings			*
Façade details			*
Facades Materials			*
Storefronts design			*
Indoor Spaces			
	6/21 – 28 %	11/21 – 52 %	20/21 – 95 %

Model 01 achieves 28 % of the criteria. This model, using basic GIS data, offers minimal detail and lacks advanced urban information, making it more suitable for basic visualizations without complex urban forms or architectural styles.

Model 02 fulfills 52 % of the criteria. It enhances the basic model by adding key urban data like total floor areas, building use, and ratios. The inclusion of procedural modeling makes modifications easier and supports further urban data integration.

Model 03 performs the best, meeting 95 % of the criteria. This model integrates detailed urban information, including roads, sidewalks, lighting, vegetation, and specific architectural elements such as facade materials and storefront designs. It also supports online dissemination and procedural modeling, making it the most robust for visualizing and managing urban environments.

The progression from Model 01 to Model 03 reflects the increasing level of detail and complexity required to digitize urban codes and enhance urban planning. Model 01 provides a basic foundation, but it is insufficient for detailed urban analysis. Models 02 and 03, particularly with the application of CGA

rules and procedural modeling, offer significant improvements in the visualization of urban and building details, making them valuable for decision-making in urban management.

Model 03, with its higher level of detail, supports a more accurate and realistic portrayal of urban neighborhoods, crucial for implementing form-based codes and maintaining the architectural integrity of historic districts. This model's ability to display specific architectural elements is particularly useful for stakeholders aiming to preserve or replicate the character of historic cities like Rosetta. The importance of online dissemination in Model 03 also satisfies the need for real-time updates and collaboration between different government sectors and urban planners.

Building on the initial comparison and discussion, it is essential to emphasize the increasing significance of each model's level of detail (LoD) and its broader implications for urban planning, especially in historic districts such as Rosetta. The progressive enhancement of the models is not merely a technical achievement but a reflection of the need for advanced urban analysis tools that can bridge the gap between traditional urban fabric and modern urban management strategies.

Conclusion

Neglecting the built environment and urban sprawl, along with not enforcing regulation codes, heightens the vulnerability of urban structures to disaster risks. At the same time, a well-conserved natural and historic environment supported by urban regulations and design codes can play a significant role in the physical, social, and economic resilience of communities. The integration of digital urban tools and new technologies at different stages of planning and implementation should be improved to provide more options to sustain our cities. The collection of data on existing buildings or a certain urban area is quite challenging due to the lack of connections between databases of different governmental institutions as they create their own data for specific purposes independently. The research results could be discussed in four main aspects: the importance of GIS platforms in decision making, GIS data accuracy in Egypt, the importance of urban code simulations for city identity, and the suitability of form-based codes application and integration into local urban codes.

GIS Platforms and Decision-Making

Digital urban platforms could support the decision makers to develop a comprehensive, integrated, upgrading methodology using GIS-based spatial data management framework. This framework could efficiently assist the policies of urban development, urban regeneration, conservation, protection, and rehabilitation of urban neighborhoods. The development of urban codes using digital urban tools could preserve the urban elements that reflect urban identity.

GIS Data Accuracy

The accuracy of GIS data mapping for urban districts needs to be updated and expanded. The issues in Egypt stem from the GIS data at the General Organization for Physical Planning being inaccurate and lacking. The GIS databases for each organization are not the same and there is no unified governmental source to support spatial data for all organizations. Many of the Egyptian cities have missing data on the online GIS platforms such as "open street maps" compared to other developed cities. Also, the compacted urban fabric and narrow streets of old cities in Egypt complicate the digitizing of these cities and require mixed methods to collect, survey and digitize the current urban data.

Urban Code Modeling for City Identity

Inability to envision or picture the visual image of neighborhoods after implementing building requirements might result in an unsuitable view, visual boredom, or distortion. Thus, it is important to model building requirements and regulations to examine the visual identity of cities before implementing them in real life. The software offers a chance to change several urban parameters which could develop many alternatives of building regulations and analyze their effect on the visual identity of neighborhoods.

Form-Based Code Integration

The form-based code could be integrated after undergoing certain adaptations. There are different legislative, social, economic, environmental constraints which could affect the upgrading of current Egyptian codes. There is a need to develop and initiate special legislative system for urban neighborhoods, especially the historic and valued ones. In addition to introducing a set of planning regulations and guidelines which help in implementing the ideas of the form-based code, the study considers utilizing already-existing legislation that is not mandatory or currently in use.

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ЦИФРОВИЗАЦИЯ ГРАДОСТРОИТЕЛЬНЫХ КОДЕКСОВ ДЛЯ СОХРАНЕНИЯ ГОРОДСКОГО ХАРАКТЕРА ИСТОРИЧЕСКИХ РАЙОНОВ: НА ПРИМЕРЕ ГОРОДА РОЗЕТТА, ЕГИПЕТ

Мохтар Хосни Акль*, Шериф А. Шета, Ламис Эль Гизави

Университет Мансура, улица Эльгомхурия, город Мансура, Египет

*E-mail: mokhtarakl@mans.edu.eg

Аннотация

Введение: эффективное городское планирование опирается на всестороннее знание как физических, так и нефизических городских элементов. Они имеют решающее значение для разработки моделей ГИС, которые поддерживают устойчивое городское развитие, обеспечивая реалистичные представления об урбанистическом контексте. Точные 3D-модели играют главную роль в анализе городских систем и процессов. **Цель:** оценка влияния методов городской оцифровки и визуализации 3D ГИС на целесообразность градостроительных кодексов для сохранения городской идентичности и характера на примере города Розетта (Рашид), Египет. **Методы:** мы использовали описательный, аналитический и эмпирический подходы. Полевые исследования, опросы, моделирование ГИС и цифровые инструменты, такие как ESRI CityEngine, использовались для создания 3D-моделей ГИС. Эти модели помогают оцифровывать и анализировать параметры градостроительных кодексов на основе объемно-пространственного регламента. **Результаты:** исследование показало, что 3D-модели ГИС могут улучшить городское планирование благодаря лучшему пониманию градостроительных кодексов и их последствий для сохранения городской идентичности. Модели дают представление о сохранении исторического характера при поддержке развития. **Обсуждение:** результаты подчеркивают потенциал городских 3D-моделей для улучшения принятия решений в городском планировании и ценность таких моделей для сохранения уникальной идентичности исторических районов, таких как город Розетта, предлагая основу для подобных регионов.

Ключевые слова: городской характер; градостроительные кодексы; исторические районы; 3D-моделирование ГИС.