



Code-based revealing of heterogeneity in urban form: Duhok City as a model

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Received: 11 December 2024 / Accepted: 13 February 2025 / Published online: 13 March 2025
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Abstract

This study explores the concept of urban heterogeneity in modern cities. Traditional planning and design methods tend to treat all areas of a city in a uniform way, applying the same urban codes throughout. However, in many cities, especially historical ones, different areas require diverse codes to maintain their heterogeneity, rather than enforcing homogeneity across the entire urban environment. In order to explore the heterogeneity in urban form, Duhok City in the Kurdistan region of Iraq is selected as a case study, which is characterized by a mix of traditional and modern architectural forms and implies the heterogeneity in urban form, although the municipal codes deal with it as a homogenous entity. Duhok presents a unique urban growth and transformation mechanism. It has its roots in a small town; over the period, the urban area gradually extended its geographic borders, integrating surrounding villages into its entity that have been transformed into parts of the city as urbanized villages. In order to reveal how the city's heterogeneous urban form resulted from old and newly developed parts and was influenced by the implicit and explicit urban codes. A mixed parametric approach is utilized, combining an objective spatial statistics analysis (Moran's I) and visual analysis. The main contribution of the current study is providing a framework for investigating the heterogeneity in urban form. As the findings indicated, the urban form of Duhok City is characterized by being heterogeneous. Consequently, to preserve this identity while regulating growth, at least two types of codes should be applied to the development area. That will offer valuable insights for urban planners, designers, and policymakers in Duhok, providing practical strategies for managing urban growth while preserving its unique identity.

Keywords Code-based urban form · Heterogeneity · Urban code · Urban form · Urban design parameters

1 Introduction

The concept of urban form heterogeneity emerged when the perception of the city and its form as a homogeneous entity encountered the reality that many cities, particularly those with historical roots, cannot be viewed as uniform in their urban form. Historically, cities up until the modern era exhibited a somewhat cohesive urban form. However,

as these historical cities expanded outward, their growth followed a pattern diverse from the original morphological formation. Later, in response to urban growth and the need to guide and regulate this expansion, master planning emerged as a tool to achieve these objectives. Traditional planning thus adopted the perspective of a city as a homogeneous entity, with modern expansions adhering to specific codes aimed at maximizing homogeneity in urban form. The establishment of distinct planning regulations for modern and historic areas implied the presence of at least two different urban forms within expanding cities [2].

The study of urban forms is a valuable and effective approach for urban planners and designers to understanding the existing city context, as the built environment exposes the disparity between discussing and addressing reality [3]. Urban form is shaped by economic, social, and historical factors, while policy proposals and regulations, including legislation, design codes, and planning policies, significantly influence urban development and environmental quality [4].

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The challenges of urban growth could be revealed through an analysis of urban form [5]. Urban form is typically referred to as a characteristic of a city and hence static at a particular time, whereas urban expansion is a dynamic development that affects urban form [5]. Decentralization, dispersed development, and several urban centers define the urban spatial structure and highlight the heterogeneity of city urban form [6].

It is essential to highlight the heterogeneity in the city, as the planning for diversity includes more than recognizing diversity but also exploiting it to create lively, inclusive, and resilient urban environments [7]. Furthermore, understanding urban diversity and effectively managing it in cities is one of the key aspects of planning for enhancing the sense of place and preserving the identity of the community and urban environments [8]. Additionally, it is important to identify areas that require significant policy intervention and to discover the diversity of urban developments from a planning policy perspective [5].

A review of the relevant urban literature gives the impression that the concept of urban heterogeneity is related to the overall urban fabric of modern cities with old historical centers. Many focused on land use, socio-economic factors, and others focus on the heterogeneity of cities worldwide, while the parameters of urban codes are not the explicit indicator of urban form heterogeneity. For that, this study intends to reveal the heterogeneity of urban form in historical cities based on the parameters of its codes to provide practical strategies for managing urban growth while preserving the diversity of local physical context. Duhok City, located in the Kurdistan Region of Iraq, is regarded as the city that encountered rapid urban growth issues. The urbanization trend of Duhok City is mainly categorized by organic expansion, resulting in an old and new development area and being treated as a homogeneous entity by municipal codes [2].

2 Urban form, planning, and coding

Urban form refers to the structure of a city, influenced by different factors and governed by different codes. Studying urban form codes provides precision in determining the new development proposals. Urban form is the physical structure, size, and population distribution of a city, influenced by factors like site, topography, economic development, and past planning efforts [5]. Urban form is significantly influenced by planning regulations, which govern public spaces and buildings. Historical evolution of urban form codes provides precision in determining the effectiveness of new development proposals, guiding planning and design practice [9]. Conversely, urban planning policies play a significant role in the change and control of urban form [4].

Historically, the urban form of the physical environment has been based on codes derived from culture, social, religious, and political practices throughout human history [10, 11]. Charney [12] stated that the early civilizations, including the Indus Valley, China, Japan, Greece, and Rome, had different standards initially reflected property protection, public health, and military goals. Furthermore, European city planning initially focused on fire and structural safety, well protection, and neighbor rights, but expanded to include design, placement, and uses [10]. The code is applied to new developments, such as additions to urban areas, and is used in conjunction with character evaluations, conservation area management plans, and design guidelines that control urban change in existing environments [9].

Urban Code is “a set of design and planning rules” that apply to an entire development and can dictate anything from widths of street to buildings high, as well as the finishing materials, architecture and design quality, and planning uses [13]. Schirmer and Axhausen [14] claimed that municipalities can be identified by their networks, housing area, and global or local centers, while the blocks, buildings and streets are the main physical urban elements [14]. Different parameters are a key to developing a specific code. For instance, Gao, Lu [4] defined building lines, heights, set-backs, and building-to-building distances as the main parameters related to the key elements of urban form, which were defined as building, street, and block.

3 Heterogeneity in urban form: an overview

The urban form reflects cultural diversity and contextual circumstances, resulting in spatial heterogeneity that promotes inclusivity and a sense of place, ensuring quality across various developments. Urban form heterogeneity emerged as many historically significant cities cannot be uniformly viewed as homogeneous in their urban form [2]. Different studies highlighted the heterogeneity in urban form from various view. Heterogeneity in a city refers to the diversity and variety of its population, places, and experiences [7].

The urban codes resulted in built forms, and architectural styles exhibit considerable diversity [15]. On one hand, Kuo [16] stated that, urban codes reflect cultural diversity and contextual circumstances, emphasizing the need for context-specific rules rather than uniform place-making. Consider cultural variances and the contextual specifications of a plan to determine what is suitable for construction and design, rather than adhering to an idealized average and societal homogeneity [16]. On the other hand, many stated that spatial heterogeneity in urban expansion, influenced by topography and policy factors, is evident in different urban regions, resulting in distinct land-use patterns and specific urban footprints [17, 18].

Urban codes are frequently employed to guarantee quality across various developments and contexts, and they can offer diversity with coherence or variety with uniformity, potentially overcoming blandness in large-scale developments and chaos in unplanned ones [13]. Their heterogeneity reflects distinct community demands [7]. Fincher highlights how crucial it is for urban planners to acknowledge this heterogeneity to meet the demands of various groups and reduce ingrained distinctions to design urban spaces that encourage interactions between various groups, promoting inclusivity and a sense of place [7]. Studies have revealed that while certain parts of urban structure may be combining due to globalization and similar planning practices, there are still substantial distinctions between cities [19]. Furthermore, Kauko [20] emphasizes that recognizing the heterogeneity in urban housing patterns is vital for building successful housing initiatives and policies.

Nowadays, adopting a transect-based codes approach, which is globally gaining favor, is an efficient way to increase urban diversity while also addressing the concerns of modernization and homogeneity in urban forms. As these codes preserve cities' distinct character while encouraging sustainable development [2]. Saudi Arabia is one of the examples in the Middle East for adopting this approach. Transect-based codes, as part of Form-Based Codes, promote different urban forms across multiple strata of urban areas, including rural, suburban, and urban zones. This method ensures that Riyadh's urban environment reflects a variety of densities, uses, and architectural expressions that are appropriate to its unique socio-cultural context. The Wadi Hanifa project in Riyadh exhibits this, with several transect zones defined by specific code characteristics such as public space, block, building type, heights, setbacks, and architectural styles [11].

4 The relevance of studying the heterogeneity in urban form for Duhok city: the research problem, hypothesis, objectives and methodology

Revealing the heterogeneity in urban form for Duhok city is crucial for ensuring the quality of urban development and preserving its historical centers. Ghahremani, Hashemi [21] stated that, if urban development process occurs in an uncoordinated and rushed manner, it will result in inconsistencies across various aspects. Furthermore, the city urban form is crucial to achieving a high-quality urban environment [11].

Duhok City has its roots in a small town. Over its development, the entity progressively extended its geographic boundaries, integrating adjacent villages, which were also extended its boundaries. At the same time, the gap in between was filled, resulting in two distinguished parts: old and new development areas. In response to urban growth

and the need to guide and regulate this expansion, master planning emerged as a tool to achieve these objectives. Traditional planning thus adopted the perspective of a city as a homogeneous entity, with modern expansions adhering to specific codes aimed at maximizing homogeneity in urban form [2]. Furthermore, Duhok master plan is not tailored to the local context due to a lack of expertise and context-specific studies [22]. Duhok's building permits department primarily enforces urban codes based on street width, leading to environmental problems due to the lack of detailed site-specific regulations and implementing homogeneous urban codes across the old and new development contexts. For example, the setback value is 4 m for the one- and two-story residential building, while it is zero for the three-story residential building in the whole city [2].

4.1 Research problem, hypothesis, and objectives

A review of the relevant urban literature gives the impression that the concept of urban form heterogeneity is related to the overall urban form of modern cities with old historical centers. The research intends to support the hypothesis that urban heterogeneity is present in cities where the urban fabric is formed from the growth of old centers and expanded outside to integrate with neighboring villages and fill the gap in between, resulting in a city's overall urban form.

The city of Duhok presents an exceptional model of a modern city that resulted from the integration of the expanding urban fabric from an old center integrated with the tissues of surrounding villages at relatively close distances. On this basis, the current research aims to reveal the formal heterogeneity of the old parts of the city of Duhok from the overall urban form of the city. In addition to offering valuable insights for urban planners, designers, and policymakers in Duhok and providing them with practical strategies for managing urban growth while preserving the unique diversity of urban forms.

4.2 The significance of the research

Achieving this goal of the research is an important issue within the framework of the general goal of preserving the characteristic of urban heterogeneity within modern urban fabrics that make them formally rich urban fabrics. This is a significant step for two important considerations: the first is documenting the historical development of the urban growth of the city, and the second is that it is a fact that can be based on proposing specific formal codes to preserve the formal heterogeneity of the parts of the city in a way that provides the characteristic of richness resulting from the diversity in terms of the urban form.

4.3 Research materials and methods

This research included a mix of qualitative and quantitative methods. Four phases were followed to solve the study's problem and achieve its objectives. Firstly, in building the theoretical basis, the fundamentals and key concepts of the heterogeneity in urban form were reviewed in addition to its relevance to Duhok City, which was selected as a case study. Concluding with extracting the theoretical aspects for investigations (see Fig. 1 below). Second, an inclusive investigation of the Duhok City's urban form was done, resulting in the selection of two parts: the overall development layout and two neighborhoods (urbanized villages) as examples of the transition from rural to urban in the city. The objective was to identify the key features of urban form that shaped the heterogeneity of urban entities, focusing on the various parameters of explicit and implicit codes. Finally, synthesis of finding to formulate a general framework for revealing the heterogeneity in urban form'. In addition to come up with final conclusion and recommendation.

Regarding the research methods, the researcher used primary and secondary data to ensure comprehensive coverage. Primary data were acquired through field observations and interviews with residents, architects, and urban planning relevant stakeholders in Duhok City. Semi-structured interview, open-ended questions were asked, focusing on topics related to urban planning, regulations,

and municipal codes. The interviews were conducted with architects and relevant stakeholders in urban planning and design. Over the course of 5 days, interviews were held separately with 20 architects, engineers, surveyors, and planners from the Urban Design Department and Project Management Committee, in the General Municipality of Duhok. Furthermore, interviews were conducted with residents using open-ended questions about the history of the area's development. The interviewees were original villagers who still reside there. Whereas secondary data were sourced from web pages, articles, and local authorities such as the General Municipality and Urban Planning Directorate of Duhok City.

To analyze the data, a mixed approach incorporating both spatial and visual analysis was employed. First, the spatial statistics tool (Moran's I) was utilized to assess the city's development pattern. The global Moran I, a measure of spatial autocorrelation, was developed in 1948 to assess the association between variables in neighboring locations [23]. It evaluates the global degree of autocorrelation in the selected urban area. It is a spatial autocorrelation tool that gives five values: Moran's index, expected index, p-value, and z-score. These values are given as "a set of features and associated attributes" which are evaluating whether the pattern expressed as random, dispersed, or clustered (see Figs. 2 and 3 and Table 1) [1].

The global Moran's I expressed in the below formula:

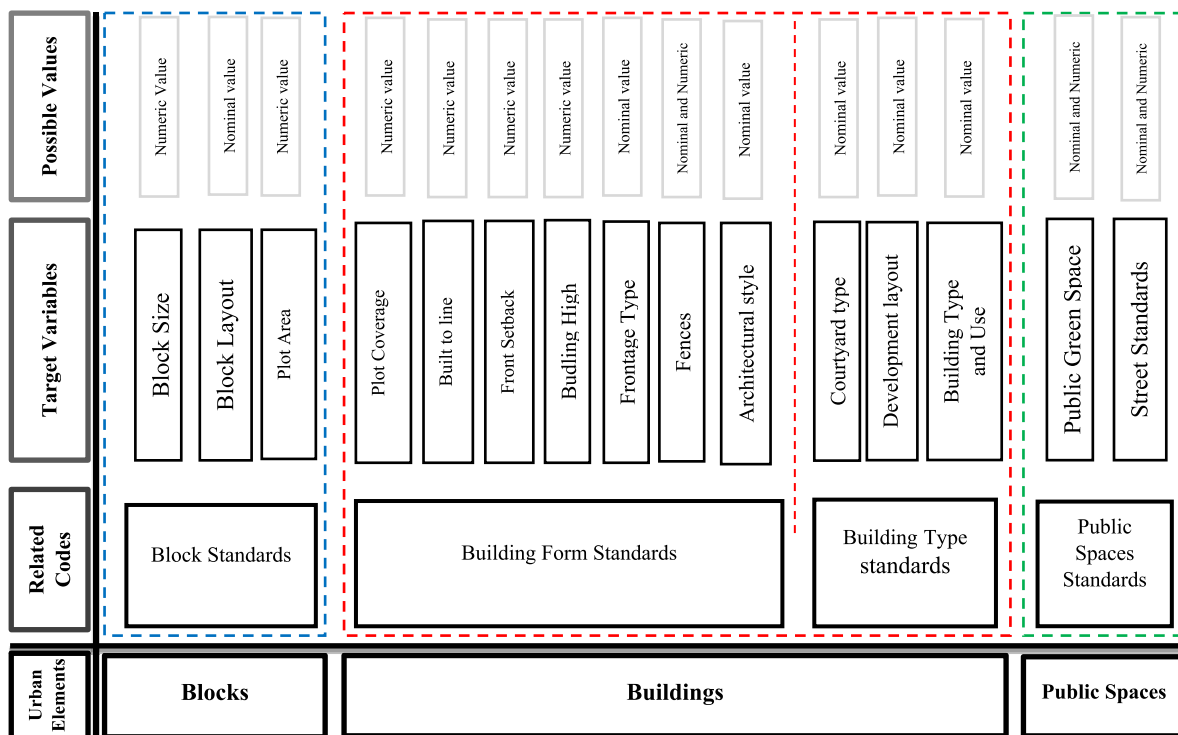


Fig. 1 Extracted aspects for investigations; Source: The researcher

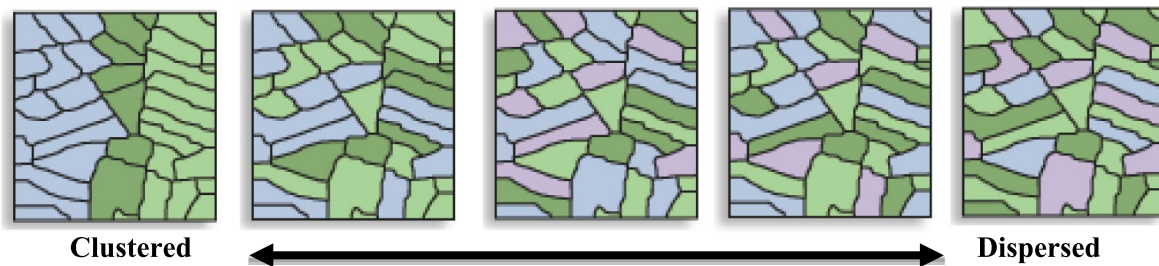


Fig. 2 Moran's I illustrations; Source: Esri [1]

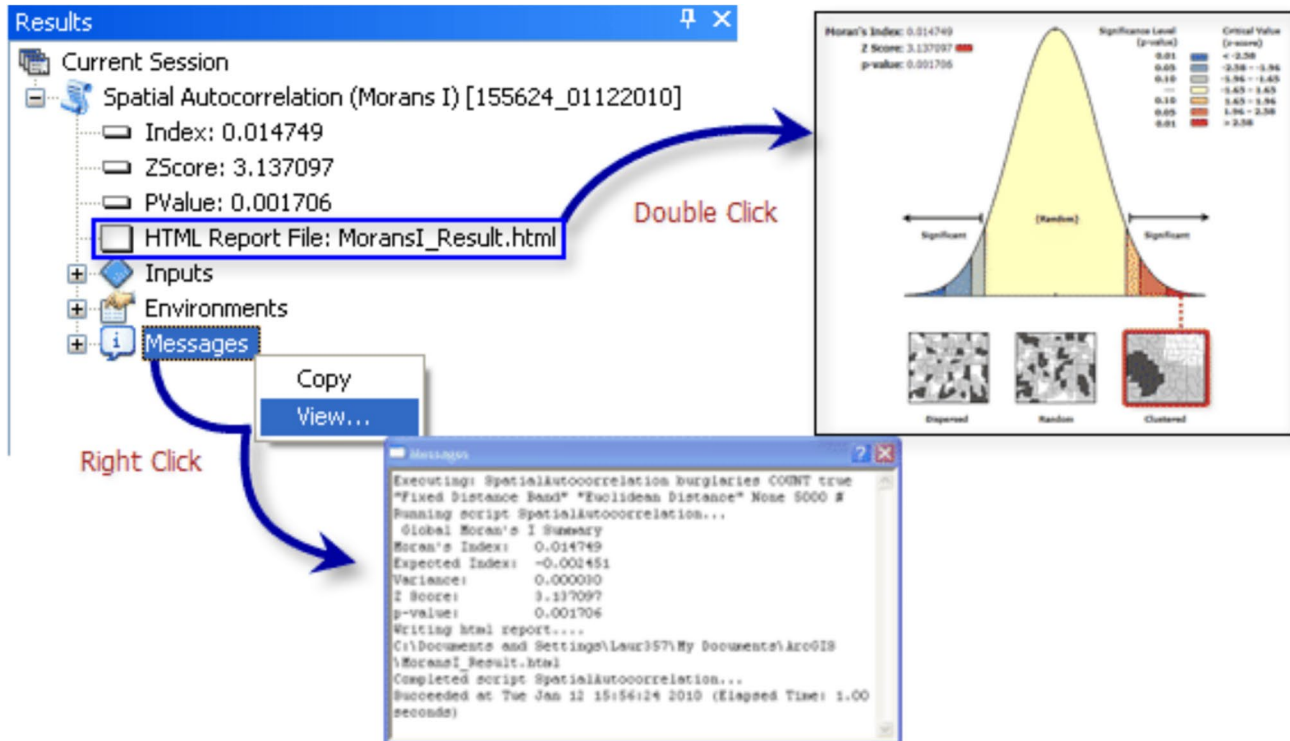


Fig. 3 Moran's I result; Source: Esri [1]

Table 1 Moran's, I result;
Source: The researcher

Label	Value	Explanation
Index	Moran Index value (−1 to 1)	A Positive Moran index denotes a tendency to clustering A value close to zero denotes random scattering A negative Moran index denotes a tendency to dispersion
Z score	The Z-score	Both values evaluate the statistical significance of the index to decide whether accept or reject the null hypothesis
P-value	The P-value	Null hypothesis “states that the values connected with the features are randomly distributed and the features are uncorrelated”
Report file	HTML file of a graphical conclusion of results	

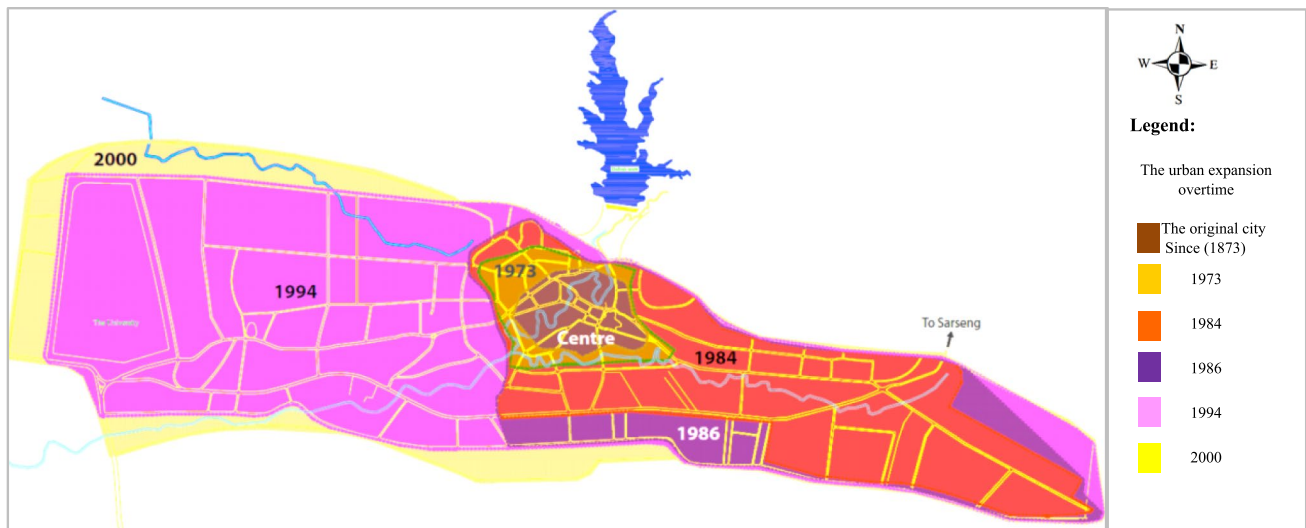


Fig. 4 Urban development of Duhok city since 1973; *Source:* Vössing [25]

Static of Spatial autocorrelation is assumed as the following:

$$I = \frac{n \sum_{i=1}^n \sum_{j=1}^n W_{ij} Z_i Z_j}{S_0 \sum_{i=1}^n Z_i^2} \quad (1)$$

where Z_i = The deviation of an attribute for feature I from its mean ($x_i - \bar{x}$),

W_{ij} = Spatial weight between n and j

n = Total number of features

S_0 = Aggregate of all the spatial weight

$$S_0 = \sum_{i=1}^n \sum_{j=1}^n W_{ij} \quad (2)$$

Secondly, visual analysis was an additional tool used to conduct both quantitative and qualitative analysis. It allowed for a comparison of various urban form aspects, including urban block layout, public spaces, and building footprints in selected areas. For this purpose, two oldest urbanized villages in Duhok City were selected for detailed investigation of urban codes (Malta and Shindokha). Three parts were selected in each case study, each with an area of 40,000 m². The first part is the oldest, representing the original village area. The second is the transitional part, visually selected as situated between the newest and oldest parts of the area. Thirdly, the newly developed part. Finally, the quantitative analysis of each part is conducted, and the results are statistically measured and presented in charts using, Arch GIS, AutoCAD, and Microsoft Excel.

5 Duhok City as the research model

5.1 Overall development layout

Duhok City is located in the middle area of Duhok Province in Iraq's Kurdistan Region. Its establishment took place in 1887, during the era of the Ottoman caliphate [24]. It spans 36 square miles and is situated between the Bekhair and Zawa mountains, while Duhok River forms the main natural green corridor, as shown in Figs. 4 and 5. Duhok, originating from a small town, has expanded its boundaries over time, integrating neighboring villages into its urban area. These villages, including Zirka, Masike, Malta Nasara, Malta Islam, Gavarke, Nizarki, Eatiti, Shindokha, Shakhke, Baroshke, and Qasara have been transformed into quarters of the city, as illustrated in the Fig. 6 below. According to the city planning authorities, another two surrounding villages, Besre and Eminky, were planned to be added to the city masterplan. border (General Municipality of Duhok, 2024). Generally, Duhok City includes of two recognized parts, which are the old parts, as the urban core and original villages areas, and the new developed area that surrounded the old parts.

Although the linear shape of growth recognizes the urban area of Duhok City [25], the main villages that have been urbanized are irregularly distributed around the city center. As Fig. 7 below illustrates, Moran's I report approves an irregular distribution of the village's centers.

5.2 Urban blocks

The plots are the primary elements of urban blocks, determining their overall shape and area based on their forms and

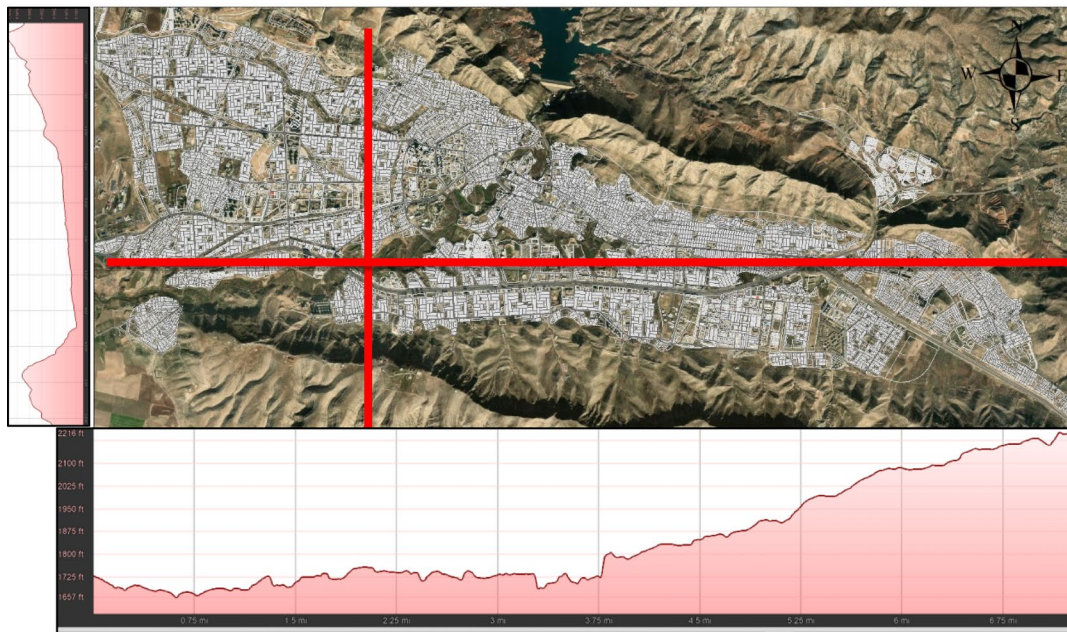


Fig. 5 The main figure: The linear development pattern of Duhok City, the Left: topographic section between north and south mountains, and the lower: topographic section from east to west side of the city. *Source:* <https://earth.google.com/web/search/Duhok>, 2023



Fig. 6 Main Parts of Duhok City; *Source:* The researcher according to General Municipality of Duhok

sizes. Plot size is a one of the main parameter used to identify the different city districts [26]. In order to examine the homogeneity in the city's parts, the research used Moran's I to show the level of spatial autocorrelation of the plot sizes distributed in the city.

Two dominate sizes of plots detected in the city were selected as input feature: $\leq 150 \text{ m}^2$ and between 151 and 300 m^2 . The results demonstrate the significant clustering

of small plots in the city center and the urbanized villages center, while the larger plot sizes meaningfully clustered in different parts of the city, including the city center (urban core) and the urbanized villages centers (see Figs. 8, 9, and Table 2). As a result, there is a notable homogeneity between the urban core and the original village blocks, which exhibits a heterogeneity with the newly developed area.



Fig. 7 The layout of urban area and the distribution of urbanized villages around the old core of the city; *Source:* The researcher

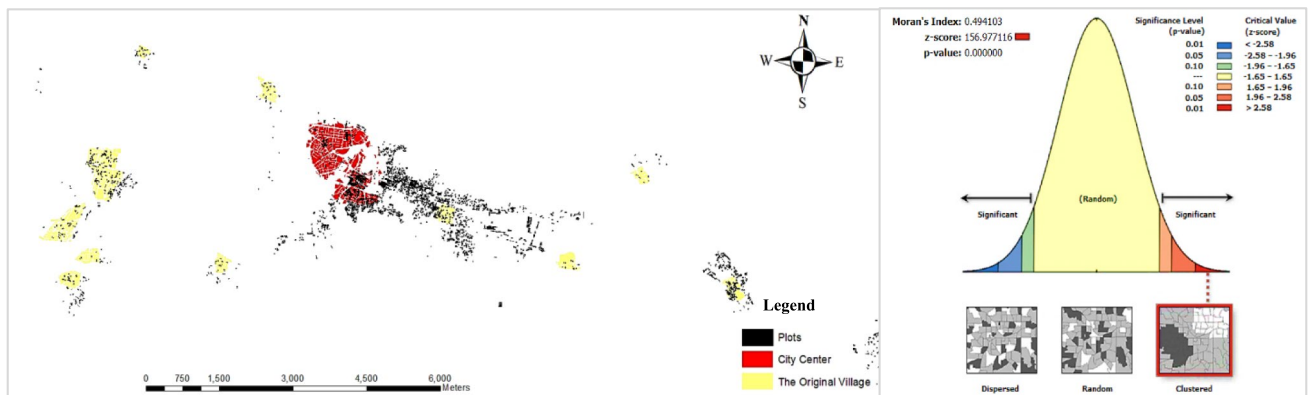


Fig. 8 The distribution of the small plots size clustered in the original villages area and the city center; *Source:* The researcher



Fig. 9 Road network of Duhok City; *Source:* The researcher according to General Municipality of Duhok, 2023

Table 2 The result of analyzing pattern of different plot size distribution in the city; *Source:* The researcher

Global Moran's I summary	Small plots ($\leq 150 \text{ m}^2$)	Large plots ($151\text{--}300 \text{ m}^2$)
Moran's Index	0.494103	0.132434
Expected Index	−0.000205	−0.000495
Variance	0.000010	0.000048
z-score	156.977116	19.217290
p-value	0.000000	0.000000

Table 3 Urban codes of the main corridors of Duhok City; *Source:* The researcher

Street name	Street width (m)	Setback (m)	Set-front (m)	No. of floors	Pedestrian path (m)
Mangesh	12	0	0	4	0
Gali	30	0	0	5	2
Barzan	100	5	2.5	Up to 10	0

5.3 The public spaces

Different type of roads illustrated in the Fig. 9 below highway, arterial and collector, and local streets. Each type has

its different width, sidewalks and building codes requirements. The majority of arterial and collector streets are developed as planned and nonplanned urban corridors (commercial streets). According to the Municipality of Duhok as mentioned by Shingali and Malaika [27], Building height, setback, set-front, and pedestrian path width are the main urban codes, with different parameters value tailored to different street width, established for the urban codes to guide the development of urban form in these areas as shown in Table 3.

Regarding the green space, different types of green open places are present in Duhok city as the Fig. 10 show. Natural green spaces as the main green corridor situated on the Duhok River in addition to the farmland that is placed in the original villages' area. Green parks are the second form of the green spaces that developed in the city, exhibited on two distinct levels: city level and the neighborhoods level scattered largely in the newest development areas of the city.

In conclusion, Duhok city was developed organically, and different urban blocks and public spaces were revealed in various parts of the city that showed the similarity in the historical parts and diversity from the newest parts. This indicates that Duhok City's heterogeneous urban form is the result of the organic growth of the old city and neighboring villages and then filling the spaces in between to form the overall city urban form.

**Fig. 10** Types of green spaces in Duhok city; *Source:* The researcher

6 Malta and Shindokha as a research sample

In order to reveal the explicit and implicit urban codes parameters, next parts of the research the focus will be on studying two selected neighborhoods: Malta and Shindokha. Which were chosen due to their proximate geographical location and parallel development mechanisms and periods.

6.1 Malta

Malta is one of the eldest villages sited in the west part of the city, close to Malta Historical Hill. It was agricultural land with a few village houses and some shopfronts. The villagers used the shops in front of their house to sell their agricultural and animal products. Because of the population growth and the increasing demand for housings, after 1970, the agricultural land gradually changed to residential use in an illegal way. In 1995, Malta village was officially urbanized and added to the Duhok city master plan boarder (Municipality of Duhok, 2023). In the end of 2002, its boarder expanded, and the newly developed area was added to meet the requirements of the whole city growth (see Fig. 11).

6.2 Shindokha

Shindokha is one of the known villages in Duhok city by its geographical location on the Duhok River from one side and the city's main street on the other, and Zawa Mountain on the third side. It is located on the south-west part, and the street divided it into two parts called north and south Shindoh. For

the purpose of this research, the study will focus on the south part, which is the oldest part located in. It is developed in the same mechanism and similar time of Malta village. The oldest map of Shindokha in 1949 shows the small village surrounded by agricultural land, and the existing map shows a fully urbanized area in 2023 (see Fig. 12).

A comparison visual analysis has been done between different parts of the selected areas in order to provide details about the urban fabric. The analysis demonstrates the variability of the urban fabric between the historical parts and the newly developed area, especially regarding block pattern irregularity and street network type. The most recent development shows a highly regular grid design, while the older parts are defined by an irregular layout. The transitional parts in between them exhibit a combination of both patterns (see Tables 4,5, and 6).

7 Results and discussion

The overall layout development of Duhok City analysis presented that the organic development of the city and the inclusion of the old villages within the border of the urban area and filling the gap in between resulted in a heterogeneous urban form that reveals a mix of historical and modern elements. On the other hand, in order to explore the main changes in the physical urban form of the area, visual analysis has been conducted in this study to intensely focus on the parameters of urban codes for the three selected parts: the oldest, transitional, and newest developed parts of the development that was selected in the case studies (see Tables 4,

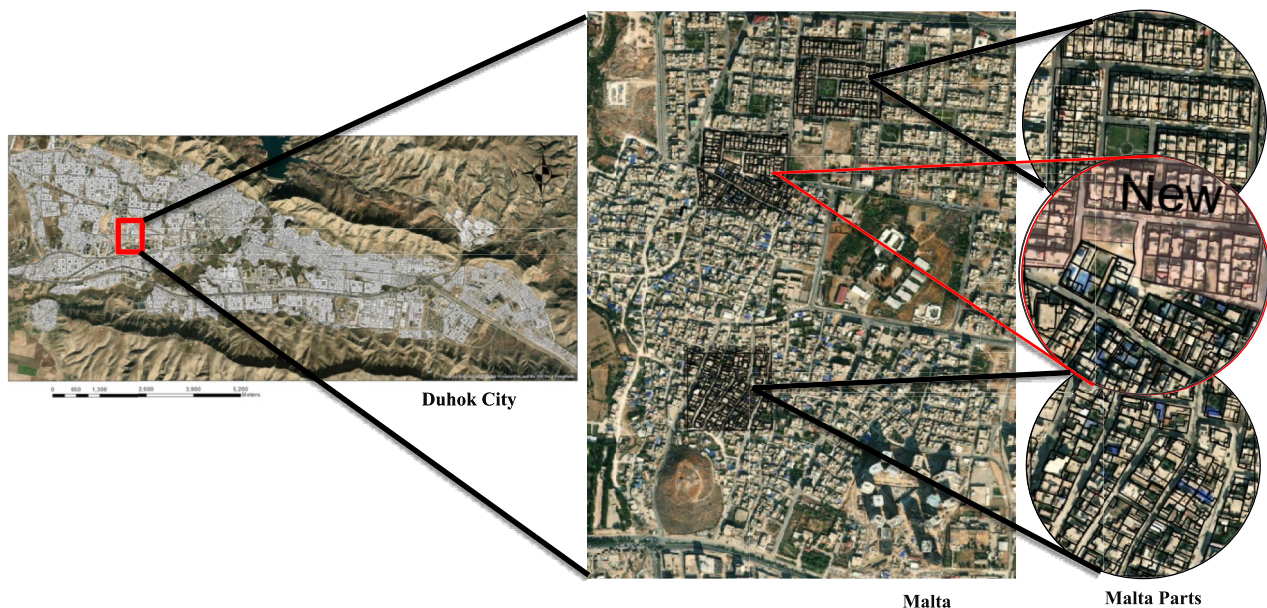


Fig. 11 Malta, 2023; Source: <https://earth.google.com/web/search/Duhok>, 2023

Fig. 12 Shindokha, 2023;
Source: <https://earth.google.com/web/search/Duhok, 2023>



Table 4 Visual analysis of urban blocks layout; Source: The researcher

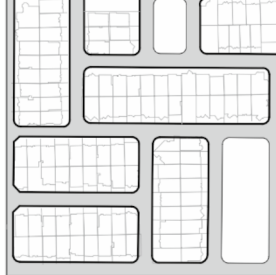
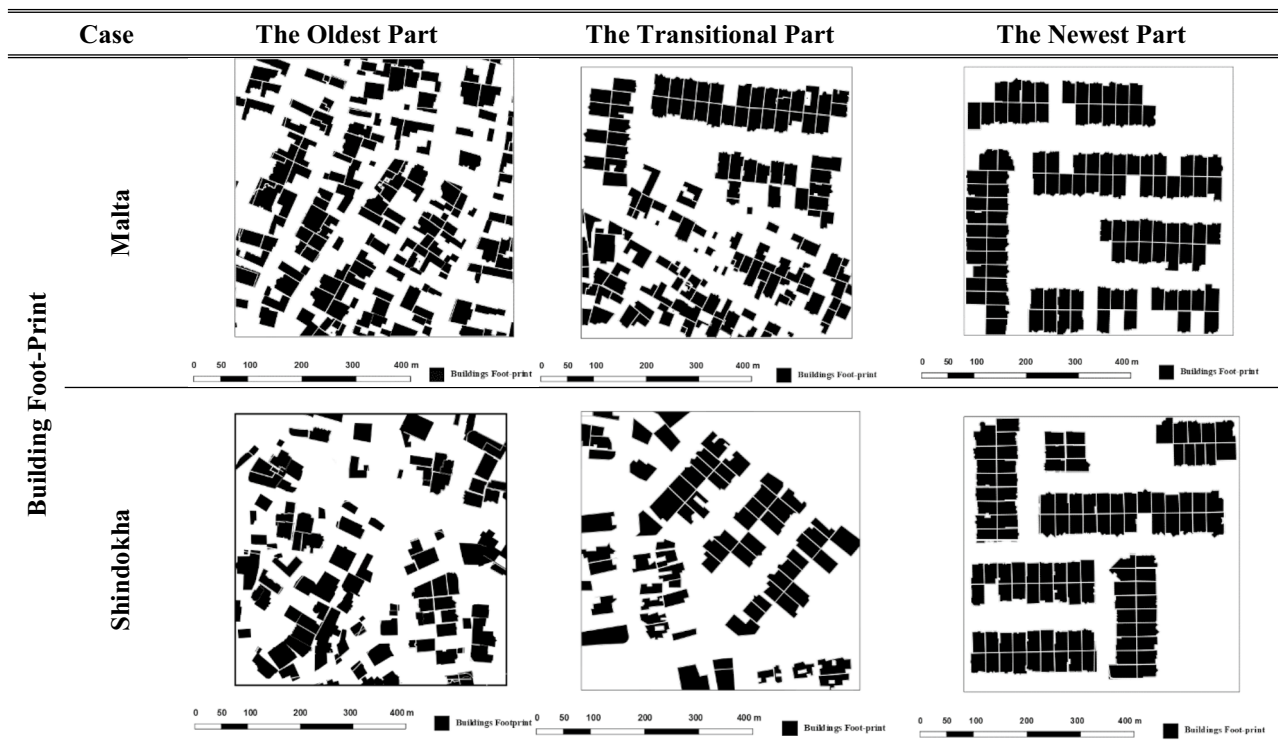
		Case	The Oldest Part	The Transitional Part	The Newest Part
Urban Block Layout	Malta				
	Shindokha				

Table 5 Visual analysis of building foot-print; *Source:* The researcher**Table 6** Visual analysis of public spaces; *Source:* The researcher

5, and 6). Additionally, a statistical analysis has been conducted on the urban block size and the average areas of public and private spaces, as shown in the diagrams below.

Regarding Malta, the analysis of the urban block areas revealed more homogeneity (uniformity) in the newest part compared to the other parts. Conversely, In the transitional parts, the urban block areas show significant heterogeneity due to the presence of two types of blocks: old and new. Furthermore, it is exhibiting the highest percentage of private space and the lowest percentage of public space among the three parts, at 74% and 23%, respectively. Whereas, the percentage of public spaces in the newest part shows a significant increase to reach 33%. Additionally, the public space in the newest part defined as public green space and road network instead of vacant land and road networks in the oldest part (see Diagram 1).

Regarding Shindokha, a statistical analysis has been performed on the urban block size and the average areas of public and private spaces in order to examine the primary variations in the physical urban form of the area. The diagrams below illustrate the findings. Upon analyzing the urban block size, it was found that the newest part had a greater degree of homogeneity in comparison to the other sections. On the other hand, in the transitional part, the urban block areas exhibit noticeable diversity as a result of the existence of two

distinct types of blocks: old and new. However, is important to note that the transitional part shows a slight decrease in the proportion of private space by 2% and then decreased by 4% in the newest part to exhibit only 53%. Meanwhile, the public space increased to reach 47% in the newly developed part (refer to Diagram 2).

In conclusion, the analysis of case studies presented that the selected transitional part of urban areas in the oldest and newly developed areas did not show any transition. The newly developed parts shifted from irregular forms to regular patterns, with streets in between as separators. This demonstrates the heterogeneity in urban form in both areas, as shown in Table 7. Additionally, three distinct types of residential buildings were identified: village houses in the oldest part of the area and two types of townhouses one- and two-story houses and three-story houses with shopfronts, as shown in Table 8.

Finally, the study revealed that while there is a limitation in the number of explicit municipal urban code's parameters (only setback, buildings height, and plot coverage), there are large number of codes implicitly involved and naturally in urban form. The description of the existing state of the urban codes (both implicit and explicit) implied in the existing urban form is detailed in the Tables 9 and 10 below. These codes could serve as a basic for designing urban codes for

Diagram 1 Urban blocks, public and private space area in Malta parts; *Source:* The researcher

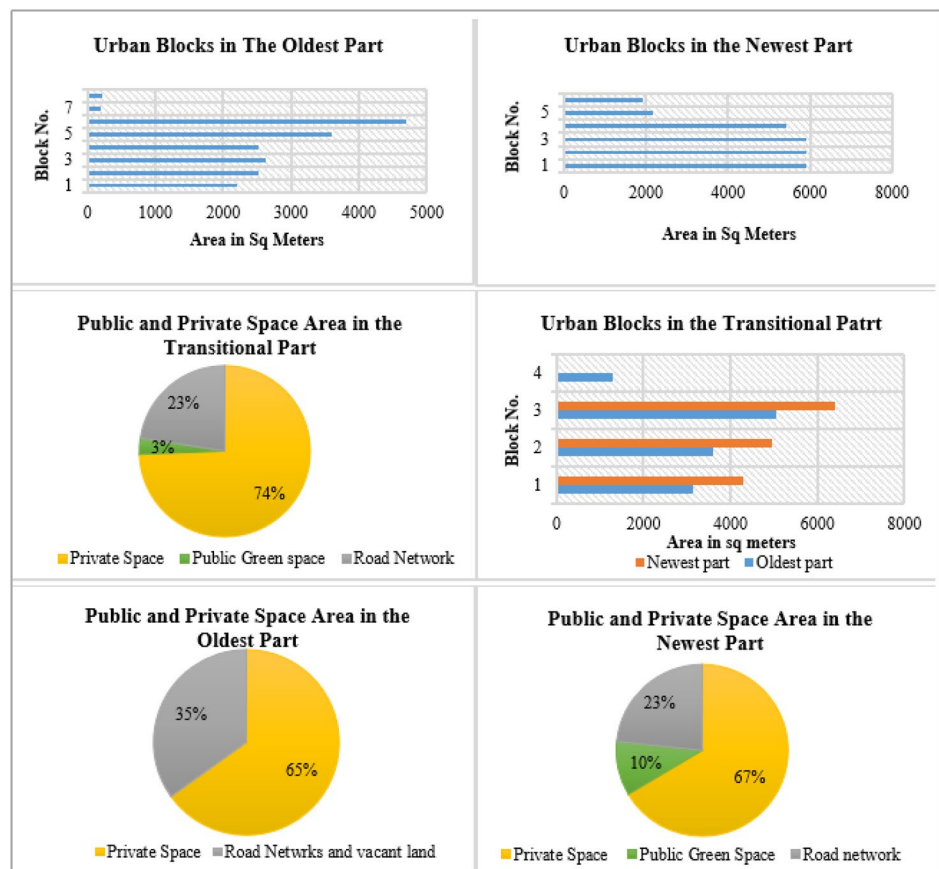
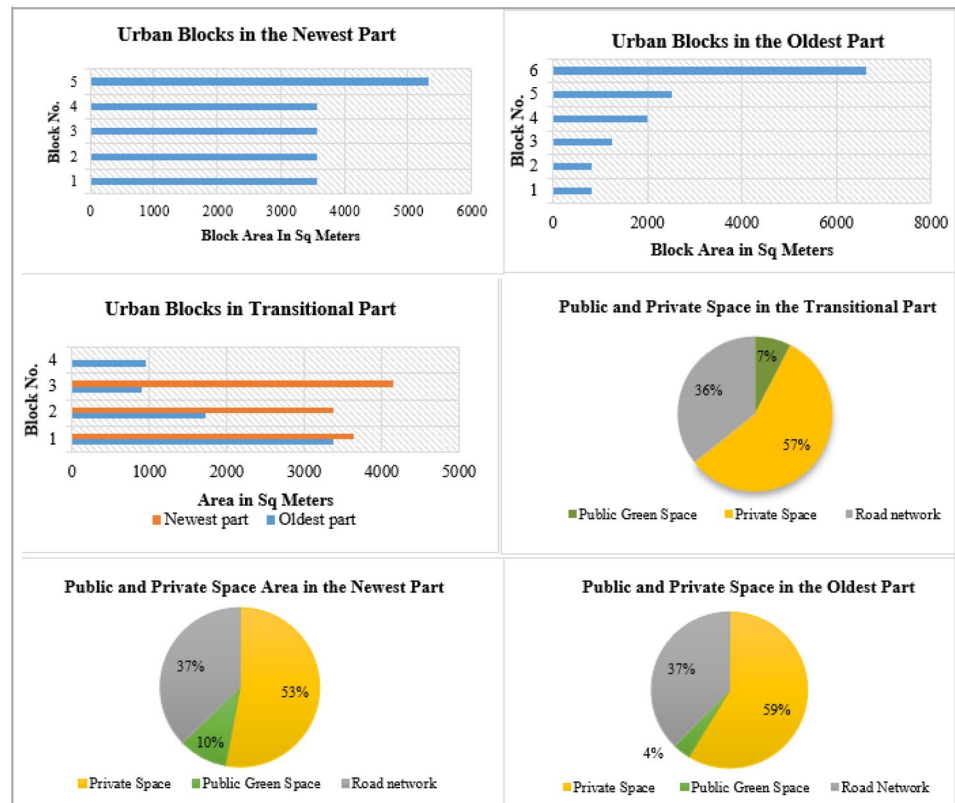


Diagram 2 The urban blocks, Public and private space in Shindokha parts; *Source:* The researcher



both old and new development areas in order to maintain the heterogeneity of the urban form and preserve its identity.

8 Conclusion

Revealing the nature of urban form is central for managing urban growth. While revealing the heterogeneity of urban form is essential to setting the planning policy and municipal codes that enhance high-quality urban development and preserve the identity. The current research revealed that Duhok City's heterogeneous urban form is the result of the organic growth of the old city, neighboring villages, and filling the spaces in between to form the overall city urban form. The overall urban form is influenced by explicit urban codes developed through planning policies as well as implicit codes naturally implemented by property owners and developers. Even though the irregular shape of the urban blocks in the original village area still dominates, the types

of buildings and other code parameters are losing diversity and becoming homogenized with the new development area due to municipal codes that treat the entire city as a homogeneous entity.

The findings Support the argument that the urban form of Duhok City is heterogeneous. Consequently, this study indicated that to preserve the city's heterogeneous identity while regulating growth, at least two types of codes should be applied to the development area: one for the old areas and another for the new development sections.

The study recommends implementing the code parameters revealed in this research as a basis for establishing new urban codes in order to preserve the identity of the studied sample area (Shindokha and Malta) while managing the growth. Finally, the strategy that followed in this research could be used as a framework to reveal the heterogeneity of urban form in different urban areas. Also, further research is recommended in order to expand the study to include a comparison with similar contexts.

Table 7 Buildings footprints and development layout in the oldest and newest parts; *Source:* The researcher

Table 8 Different house types and architectural styles; *Source:* The researcher

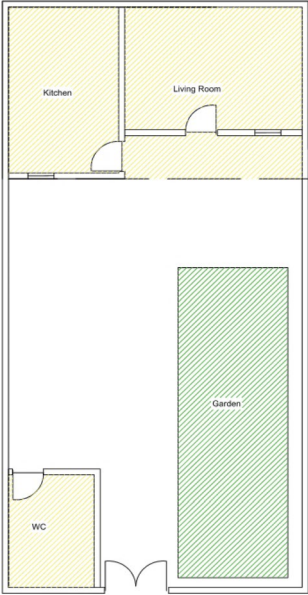
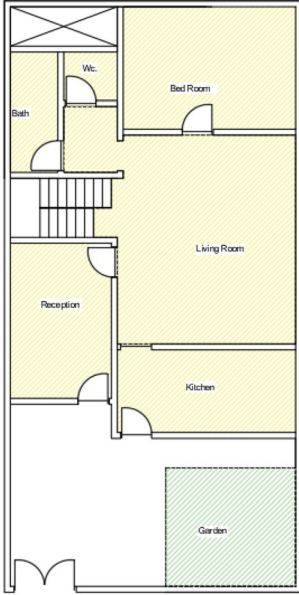
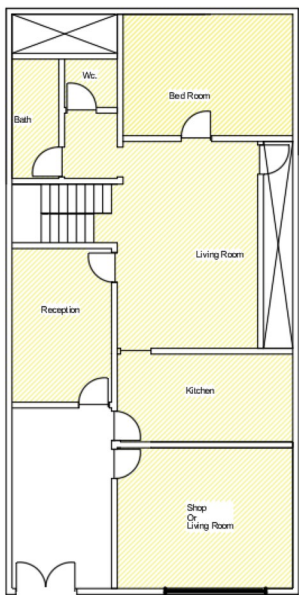
	Typical village house	Typical 1 and 2 floors town house	Typical shop front and 3 floors town house
Examples of Ground floor plan			
The Architectural Style			

Table 9 The current urban codes of residential and mix use development in Malta; *Source:* The researcher

Urban elements	Related codes	Parameters	Measurements	
			Oldest part	Newest part
Blocks	Block standards	Block area (m ²)	Undefined (Diagram 1) min 881; max 4100	Repeated (Diagram 1) min 5400; max 5910
		Shape	79% Irregular 21% Regular	100% Regular
		Plot size (m ²)	Undefined:(57–380 m ²) 10% less than 100 m ² 54% 100–199m ² 33% 200–299 m ² 3% 300 m ² and more	Defined 1% Less than 200*** 70% 200 m ² 29% 201–300 ** &***
Buildings	Buildings type standards	House type	64% Village house 36% Town house	6% Village house 94% Town house
		Development layout	80% Attached 20% Non-attached	100% Attached
		Courtyard location	51% Middle 30% Front 19% N/A	80% Front 20% N/A**
	Buildings form standards	Front setback	64% Undefined 0–12 m 36% 4 m*	18% 0 m. 3 floors 82% 4 m. 1–2 floors
		Built to line	Undefined	Not to exceed setback
		Building high	64% 1 floor 30% 2 floors 6% 3 floors*	12% 1 floor 70% 2 floors 18% 3 floor
		Plot coverage	38% covered 40–60% 36% covered 65–70%* 6% covered 90%	76% covered 65–70% 24% covered 85–90% **
		Frontage type	Fence Stoop Shopfront	Fence Stoop Shopfront**
		Architectural style	64% Village house style 36% Undefined new style*	100% Undefined New Style
Public spaces	Landscape standards	Public green spaces	Non planned	In Front (middle) of a grouped housing block
		Streets	Irregular pattern 95% car oriented 5% pedestrian oriented	Regular pattern 100% Car oriented

*The newest developed houses in the old part of the neighborhood

**The houses with commercial use (shops) in the ground floor or 3 floors town house

*** The houses located in the block corner

Table 10 The current urban codes of residential and mix use development in Shindokha; *Source:* The researcher

Urban elements	Related codes	Parameters	Measurements	
			Oldest part	Newest part
Blocks	Block standards	Block area (m ²)	Undefined min 810; max 6600	Repeated: min 3500; max 5500
		Shape	73% Irregular 27% Regular	100% Regular
		Plot area (m ²)	Undefined:(57–380 m ²) 3% less than 100 m ² 67% 100–199 m ² 15% 200–299 m ² 15% 300 m ² and more	Defined 2% Less than 200*** 68% 200 m ² 29% 201–300 ** &***
Buildings	Building type standards	House type	47% Village house 53% Town house	100% Town house
		Development layout	86% Attached 14% Non-attached	100% Attached
		Courtyard location	32% Middle 60% Front 8% N/A	82% Front 18% N/A**&***
		Front setback	Undefined 47% 0–7 m 50% 4 m. 1–2 floors* 3% 0 m. 3 floors & above*	20% 0 m. 3 floors & above 80% 4 m. 1–2 floors
	Building form standards	Built to line	-Undefined -Not to exceed setback*	Not to exceed setback
		Building high	47% 1 floor 48% 2 floors 5% 3 floors*	12% 1 floor 68% 2 floors 20% 3 floors**
		Plot coverage	Undefined 47% covered 40–60% 50% covered 65–70% * 3% covered 87–90%	80% covered 65–70% 20% covered 85–90% **
		Frontage type	Fence Stoop (topography) Shopfront	Fence Shopfront**
		Architectural style	47% Village house style* 53% Undefined New Style	100% Undefined New Style
Public spaces	Landscape standards	Public green space	Non-planned	In front of a grouped housing blocks
		Streets	Irregular pattern 96% Car oriented 4% Pedestrian oriented	Regular pattern Car oriented

*The newest developed houses in the old part of the neighborhood

**The houses with shops in the ground floor or 3 floors town house

***The houses located in the block corner

Acknowledgements The researchers thank the Municipality of Duhok engineers and survivors for their contributions and support in providing secondary data.

Author contributions Hanan is the corresponding author has collected the data, designed the research, analyzed the data, and wrote the manuscript. Ali is the contributing author who has supervised the work and provided critical feedbacks.

Funding No external funding received for the purpose of this research.

Availability of data and materials The primary data is not available publicly due to institutional restrictions, however, they can be available from the corresponding author based on reasonable request.

Declarations

Conflict of interest This is original research as a part of PhD research. The researcher declares that there is no conflict of interest regarding this research.

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