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## Impact of contemporary rebuilding process on changing architectural genotype

### أثر عملية إعادة البناء المعاصر في تغيير النمط الجيني المعماري

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#### Abstract

The rapid economical, socio-cultural changes in Sulaymaniyah city, Iraq in the last three decades promoted radical changes on both urban and architectural level. Several traditional houses in the historical center of the city have been demolished and replaced with rebuilt modern houses leaving negative impacts on the old fabric at both formal and spatial level. This paper aims to investigate the role of the contemporary rebuilding process achieved by landowners within the traditional neighborhoods of the city on changing the underlying genotype constants of housing spatial configuration through examining the morphological characteristics of the architectural layouts of both original and rebuilt type. To achieve this aim five traditional houses' plans built from (1900-1960) were selected to compare with five modern rebuilt houses (1990-2022) within the same neighborhoods, their spatial arrangements have been compared following analytical quantitative methodology using (A-graph software) as one of space syntax techniques also known as (Gamma analysis) to determine the characteristics of houses layouts in terms of (Symmetry/Assymetry) and (Distributness/Non Distributness) of the whole system. Results suggest existence of different structuring modes based on genotype distinction despite similarities in some organizational principles.

**Keywords:** Architectural Genotype, Justified graph map, Space syntax, Sulaymaniyah city, Traditional Houses Layouts.

#### المستخلص:

عززت التغيرات الاقتصادية والاجتماعية والثقافية السريعة في مدينة السليمانية، العراق في العقود الثلاثة الماضية تغييرات جذرية على المستويين الحضري والمعماري حيث تم هدم العديد من المنازل التراثية في المركز التاريخي للمدينة بالكامل واستبدالها ببيوت حديثة أعيد بناؤها من الصفر مما ترك آثاراً سلبية على النسيج التراثي المتوارث على المستويين الشكلي والتنظيم الفضائي. تهدف هذه الورقة إلى التحقق من دور عملية إعادة البناء المعاصر المنجزة من قبل مالكي الأراضي داخل الأحياء التراثية السبعة في المدينة في تغيير ثوابت النمط الجيني المتوارث و الاصلية للتنظيم الفضائي لهذه البيوت من خلال دراسة الخصائص المورفولوجية للمخططات المعمارية لكلا النوعين الأصل والمعاد بناؤه. ولتحقيق هذا الهدف تم اختيار خمس مخططات لمنزل تراثية و التي تم بناؤها بين الاعوام (1960-1990) لغرض المقارنة مع خمسة منازل حديثة أعيد بناؤها خلال (1990-2022) ضمن نفس السياق، وقد تمت مقارنة التنظيم الفضائي والبنية المجالية للنمطين باتباع منهجية تحليلية كمية باستخدام برنامج (A-Graph) كأحد تقنيات نظرية التركيب الفضائي والمعروف بأسم (تحليل جاما) لتحديد خصائص مخططات المنازل من حيث (التناظر / اللاتناظر) و (التوزيع / الانتشار) للنظام بالكامل. تشير النتائج إلى وجود أنماط تشكل مختلفة اعتماداً على مفهوم النمط الجيني في العمارة على الرغم من وجود بعض أوجه التشابه في بعض المبادئ التنظيمية.

**الكلمات المفتاحية:** النمط الجيني المعماري، خارطة الرسم البياني المبرر، قواعد تركيب الفضاء، مدينة السليمانية، مخططات البيوت التراثية.

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## Introduction

“When a house is demolished, more than the home is lost” (Murphy, 2015). Every house has a story to tell, it is evidence of how earlier generations thought about and designed spaces to reflect their daily beliefs and needs. Architecture as a practice of the non-verbal system of symbols mirrors the cultural values, images, and beliefs that can be transmitted and shared through society, it can express and embody the collective cultural codes like no other artefact (Abdullah & Shari, 2019). Houses are believed to be the most complex buildings considering their functions and meanings, their spatial configurations describe the cultural ideological aspects of the inhabitants (Hanson, 2003).

According to the researchers the abstract rules behind houses organization in a specific culture are translations of socio-cultural codes of that society for this reason they show consistency in their spatial patterning, this consistency is called “Housing genotype”, a quality that can be conceived of as an archaeology of the space (Hillier & Hanson, 1989) (Hanson, 2003, p. 32). It is an intermediary of form and function in architecture, as well as an illustration of how that space received the information from society in its pristine form (Elizondo, 2021).

Traditional historical houses in Sulaymaniyah city compromise an important part of local architecture heritage, these houses were built by vernacular builders based on physical and non-physical needs of their inhabitants using construction methods inherited and passed from generation to the next. Despite showing several architectural typologies, their spatial arrangements shared common characteristics starting from the city’s establishment until 1960 when local socio-cultural impacts shaped houses layouts, however the contemporary rebuilding practices achieved by land owners generated drastic changes due to imitating modern westernized styles and produced distorted architectural styles (Abdullah & Shari, 2019).

As a result, the spatial arrangements of traditional houses layouts have been replaced with new setting that shows different morphological attributes. From this perspective this study investigates an issue related to the change and loss of inherited spatial patterns (genotypes) of these houses through answering the following questions:

1. What are the interior spatial genotypical constants behind housing arrangement in traditional districts of Sulaymaniyah city?
2. Do the spatial configurations of contemporary rebuilt houses within the historical districts differ from the spatial settings of traditional ones? if yes in which ways?
3. How the concept of genotype transition could be invested in future design and rebuilding processes within the historical context of the city for more sustainable rebuilding practices?

To achieve this aim, this study investigates the morphological attributes of traditional houses particularly in seven neighborhoods first, then explores the nature of change in these patterns throughout the time, therefore the architectural layouts of both traditional (courtyard) houses and modern rebuilt ones are compared in terms of syntactical characters using A-Graph software also known as (gamma analysis) to convert these plans into graphs and numerical data then to reveal their spatial genotypical constants.

The basic hypothesis in the present study is that given the importance of preserving the original architectural genotypes of traditional houses, modern rebuilding process doesn’t take in consideration the inherited spatial genotypes that may influence modern spatial arrangements and domestic setting, to answer the research questions the researcher suggests space syntax for being socio-spatial applicable methodology.

After comparing similarities and differences between the selected spatial patterns in terms of (Symmetry/Asymmetry) and (Distributness/non Distributness), the spatial system of each type could be determined and compared through obtaining the syntactical indicators of each house including mean depth (MD), integration (RRA), Base difference factor ( $H^*$ ), space link ratio (SLR), types of spaces (spaceness).

The study doesn’t include the concept of phenotype or observable physical attributes of these houses (shape, length, envelope) or (social, behavioral, phycological) aspects of the inhabitants, it also excludes the period of (1960-1990) for being transitional period with transformational effects in housing industry in the city. Study results may influence future design and rebuilding processes in the way that original underlying codes behind spatial genotypes could be invested in various formal

styles (phenotypes) so that the original architectural genotypes could be retained with adaptation to today's demands as part of preserving local architecture identity.

### Literature Review on Architectural Genotype

Genotype in biology when translated into architecture identifies the Architectural Genotype (Rahmane & Abbaoui, 2021). The term was first introduced into architecture in space syntax literature by Hillier and Leaman (Bill Hillier & Leaman, 1974) to differentiate between the actual built environment and the spatial logic that governs how the building must be built. (Hillier & Hanson, 1984) define the genotypes within the architectural context as abstract rules underlying spatial shapes which can be revealed using space syntax techniques, they are abstract spatial designs transmitted culturally, for a type of building or settlements (Steadman, 2008, p. 78).

Genotypes in architecture have been discussed on both urban and architectural level, housing genotypes have been investigated previously using space syntax techniques from several perspectives, including analyzing vernacular living spaces in Normandy to prove how cultural ideas are presented equally in both artifacts and builders' minds (Hillier et al., 1987), architects' design strategies, such as looking for a genotypical pattern in early residential plans in Germany designed by Mies Van Der Rohe (Bafna, 1999), suburban houses in London (Hanson, 2003), gender inequality in traditional courtyard house genotype in Baghdad City (Edwards et al., 2004), Evolution of apartment plans in Ankara city in terms of the relation between spatial genotypes and functionality (Guney, 2005), an investigation about the relationship between spatiality and functionality in both traditional and modern house layouts in Erbil City, Iraq (Mustafa et al., 2010), stability and change in apartments spatial genotypes in Brazil from 1930-2000 (Cunha, 2012) finding housing genotypes and transformation of housing codes in Korean apartments (Seo, 2017), an analysis of the consistency of the social and spatial structure in rural domestic type (Ostwald & Dawes, 2018), an analysis of continuity in spatial arrangement of Iranian traditional houses (Raith & Estaji, 2020) and more recently inhabitant modifications on standardized social housing genotypes based on social factors (Elizondo, 2021).

From the literature one can conclude that through identifying similarities and differences in the

internal configuration of several buildings it is possible to identify spatial architectural genotypes (Hanson, 1998, p. 215-241), thereby housing genotype is a stable pattern of spatial structure that underlies the phenotypical formal expressions (Cunha, 2012) or patterns replicated by people for their sense of owing specific characteristics from antiquity into the present-day, they can be transmitted only by means of cultural and socialization, these stable patterns are shaped by internal rules of spatial configuration and reflect the society's character, i.e., complex relational schemes, non-discursive aspects of design that architects cannot talk about because they are architects' unconscious social knowledge (Hillier, 2007), this recurrence of certain morphological features is considered as the genotype index (Bustard, 1999, pp. 219-240).

According to the researchers these patterns are exposed to transformation and change due to the change of socio-cultural codes of the builders over time. For the purpose of translation of these codes into mathematical graphical patterns the researchers suggest space syntax techniques as a reliable scientific technique for analyzing the nature of change in these patterns (Al-Sayed et al., 2014).

In conclusion the previous literature and all study cases are related to foreign or regional areas with different domestic specifications in different climates and cultural contexts, no specific study has discussed either the morphological characteristics of traditional houses' layouts in Sulaymaniyah city or patterns of change in their spatial configuration over time, thus a necessity to reveal the abstract rules behind traditional courtyard houses in the city with patterns of change in their spatial setting.

From these points this study finds out a knowledge gap which forms the study problem that is "Unawareness of the previous studies about types and levels of change in genotypical constants which form morphological attributes of spatial patterns of Sulaymaniyah traditional courtyard houses due to contemporary rebuilding practices" Rebuilding practices in the current study's scope is related to demolishing the original houses and rebuilding them from scratch.

### Architectural Genotype Defined

According to Hillier the 'genotype' originated from the discovery of the same potentials in space to solve a certain kind of architectural problem for instance in religious buildings (how

to combine the need for the sacred to be separated from the everyday life) therefore the epicenter of these buildings is in the deepest space, with existence of a single direct line of sight linking the innermost sacred space to the most public space of the entrance (Bill Hillier, 2007, p. 174). The reason behind the repetition of these themes by people was their sense of functionality, therefore they have been transmitted by means of cultural and socialization (Roesler, 2012), they formed a framework of resilience, where changes can occur in function, technology and aesthetics (three Vitruvius principles) with preserving the same genotype, the repetition in these patterns supports finding an identity of that architecture, an identity data can be reused for another modern design in the future for sustainable development. (Sari et al., 2020). The identification of most common recurred elements, organizational qualities that persist across time will lead to discover the genotype of that architecture (Ledent, 2017). Likewise, the residential spatial genotype could be defined as a spatial pattern that commonly appears in some cases (Byun & Choi, 2016), According to specialists every house shows at least one spatial-functional genotype presented as relational and configurational consistency. In some architectural layouts the dominant genotype is easily identified when all the spatial-functional relations are observed, in other layouts they are less likely to be detected when some of the spatial themes are absent (Hillier et al., 1987). House's spatial arrangements can be divided into four sectors (zones) where the sector is defined as a set of spaces with common functional and social requirements, the sector acts as a mega-structure to determine the related spaces organization, boundaries, and their transformation (Amorim, 2001). This classification is essential in terms on comparison between two spatial settings. According to Amorim pre-modern houses sectors can be divided to four sectors as bellow:

- **The visitors sector:** mutual spaces between family and strangers such as vestibule, entrance hall, visitors room (reception), formal dining, library.
- **The family sector:** family private spaces such as living spaces, family dining room, bedrooms, bathroom.

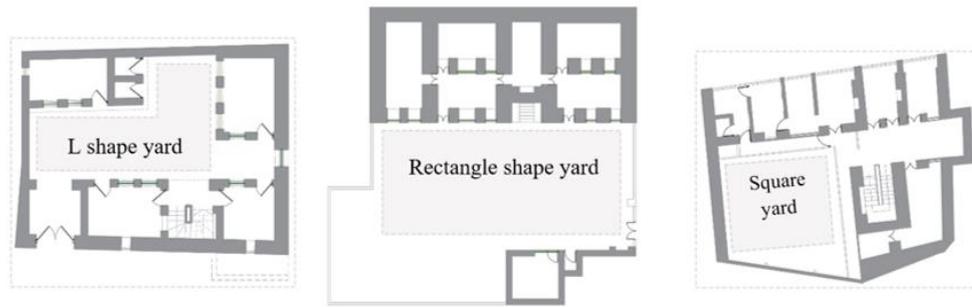
- **The service sector:** such as kitchen, laundry, garage, front yard and backyard, servant room
- **The mediator sector** connects two different sectors with each other such as corridors and transitional spaces.

The above classification of housing spaces into groups is the most related classification within this study's scope and the first practical one which relied on space syntax techniques.

### Traditional Houses in Sulaymaniyah city

The word traditional architecture refers to procedures, materials and elements that have been accepted gradually as a norm or tradition in a society, they transmitted orally, or less frequently by records that contain orally transmitted data, guidelines, and procedures, this does not imply that traditional processes and artifacts do not change with time, they do change, but their change is often slow, and their provenance is clearly seen (Noble, 2009, p. 9). Before 1960 the typical traditional house in Sulaymaniyah city despite showing different typologies (phenotypes) they were influenced by vernacular architecture of local architecture identity in response to climate, religion, socio-cultural factors (Qaradaghi, 2020) however they shared almost similar spatial distribution around the internal courtyard therefore the courtyard house genotype was the dominant type in the city.

Applying sectors classification mentioned above to traditional houses of Sulaymaniyah city one can conclude that each house is consisting of interior open courtyard worked as a mediator between other sectors and functioned as the main distribution core to all other spaces in the house (Fig. 1), In a typical Kurdish traditional house, the house consists of two parts the upper level called (Sar khan) and the lower level (Zher khan) usually occupied by several families particularly after the extension of family members. The (Iwan) was an important semi-open space for family gathering, the closed spaces (rooms) were multifunctional for eating, studying, sleeping. Service sectors like bath and toilets mostly were separated from the rooms and located near the main entrance of the house far away from house rooms (Fig. 2).



**Fig. 1.** the relationship between (open-closed) spaces in different spatial patterns of Sulaymaniyah Courtyard houses (Researcher)



**Fig. 2.** Service sectors (Kitchen, store, bath and toilets) were separated from houses rooms and linked with the inner courtyard (Researcher)

### Contemporary Rebuilding practices within the traditional context

Traditional houses in the city have been deteriorated either by natural forces or demolished by landowners due to a lack of conservation policies, therefore this dominant traditional pattern with inner courtyard has been replaced with different spatial setting. The new

rebuilt houses are imitations of western style of housing organization with no connection with local architecture identity or socio-cultural values. The contemporary rebuilding tends to the demolition of the historic houses and replacing them with commercial buildings or modern houses with new spatial and formal setting (Fig. 3) and (Fig. 4).



**Fig. 3.** Typical traditional houses in Sulaymaniyah city, Iraq (Researcher)



Fig. 4. Contemporary Rebuilt houses on the remains of demolished traditional ones. (Researcher)

**Method and Measures:**

In this research a comparative analytical methodology will be followed to address the similarity and differences between the spatial genotypes of five traditional houses built from (1900-1960) and five contemporary houses built from (1990-2022) in the same traditional neighborhoods, to measure the nature and degree of change in their spatial settings. For this purpose space syntax was first proposed by Hillier and Hanson (Hillier & Hanson, 1984) as a set of techniques that aims for revealing the underlying spatial genotypes of specific layouts to uncover cultural codes behind spatial arrangement of any built environment, it is an applicable methodology on both urban and architectural level, where Alpha -analysis is utilized for analyzing urban settlements and

Gamma-analysis is designed for analyzing building spaces (Hillier et al., 1987) .The main purpose behind this methodology is quantifying the qualities of built environment to uncover the ambiguous relationship between the human factor and the built environment in the form of numerical data. These relations reveal the morphological characteristics of the plans after converting the plans into abstract graphs called “justified graph maps”(Hillier & Hanson, 1989). Fig. 5 shows that the graph consists of nodes represent houses’ functional spaces and lines represent the connection between these spaces, each space is given a depth value from a selected space called the carrier (usually the entrance of the house).

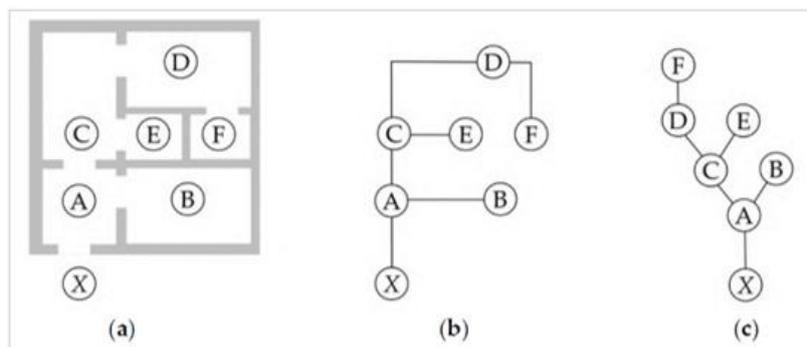


Fig. 5. Example of justified graph map: (a) Architectural layout with six rooms, annotated A–F, with the exterior (X) as carrier; (b) diagram shows the connections between the spaces; (c) justified graph of the plan. (Ostwald & Dawes, 2018, p. 55-56)

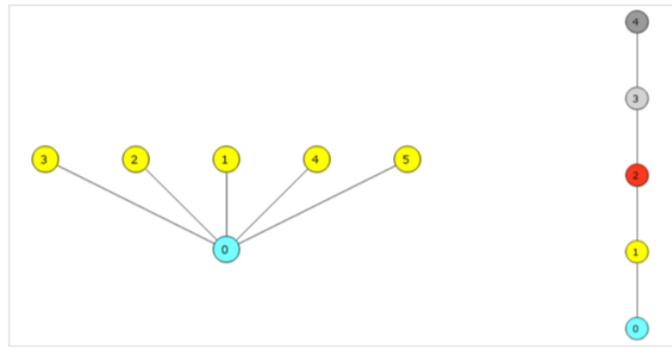
After the graphs are constructed, syntactical measurements of the plans with their calculations are obtained from mathematical formula explained bellow.

**1. The mean Depth (MD)**

This measure explains how integrated or separated the spaces are from each other or in other words the number of steps one should take to pass from the original space (the root) to

another space, it also reveals how deep or shallow the spatial system is .Fig.6 shows that we obtain the less depth when the spaces are connected directly to the root (symmetric system) and the most depth when all the spaces are organized in a liner sequence from the root (Asymmetric system). Mean depth is calculated according to:

$$MD = \frac{TD}{(K - 1)}$$



**Fig. 6.** Left: Symmetric system. Right: Asymmetric system (Researcher depending on Hillier and Hanson) (Hillier & Hanson, 1984, p. 94)

## 2. Relative Asymmetry (RA) and Integration (i)

This indicator refers to the relative isolation of a specific node, and its inverse is (i), which is the level of integration of a node. Simplistically more integrated spaces are more public and accessible, less integrated spaces are more private and less accessible. RA is utilized to compare measures derived from similar size graphs or plans with equal number of spaces by normalizing MD to a range between 0.0 and 1. These two values are calculated according to:

$$RA = \frac{2(MD - 1)}{(K - 2)}$$

$$i = \frac{1}{RA}$$

## 3. Real Relative Asymmetry (RRA) and Integration (i) of (RRA)

This indicator is used instead of RA because architectural plans differ in number of spaces. RRA normalizes the RA values in relative to an ideal diamond-graph D, for K number of spaces according to a specific table (Hillier & Hanson, 1984, p. 112)(Peponis, 1985).RRA also known as integration degree, it indicates how permeable a specific space is, low RRA values mean more integrated space, heigh RRA values mean less integrated space (high segregation) .Depth and integration are first key syntactic measurements when analyzing spatial patterns.

$$RRA = \frac{RA}{D_k}$$

$$i_{RRA} = \frac{1}{RRA}$$

## 4. Control value (CV)

This measure indicates the influence of one space on other spaces in the system in other words it determines to what degree one space controls the access to the neighbours (Klarqvist, 1993,p11). It

may refer to a space with more attraction than other spaces. High cv means more connections with other rooms.

$$CV_a = \sum_{D(a,b)=1} \frac{1}{Val(b)}$$

## 5. Base difference Factor (H) and Relativized Difference Factor (H\*)

This indicator measures the degree of differentiation between the integration values of all the spaces in the house .BDF value ranges from 0-1 , the closer the value to zero the more integrated system (Symmetric system)and the closer value to 1 the more segregated system(Asymmetric) (Hanson, 2003, p. 84).If there was consistency in orders of these values this can refer to cultural pattern in the spatial system , therefore it is an important entropy-based measurement in determining the morphological characteristics of houses layouts because it reveals whether there is a consistency in spatial patterning ,a property which is called “inequality genotypes” (Hillier, 2007, p. 207)

$$H = - \sum \left[ \frac{a}{t} \ln \left( \frac{a}{t} \right) \right] + \left[ \frac{b}{t} \ln \left( \frac{b}{t} \right) \right] + \left[ \frac{c}{t} \ln \left( \frac{c}{t} \right) \right]$$

$$H^* = \frac{(H - \ln 2)}{(\ln 3 - \ln 2)}$$

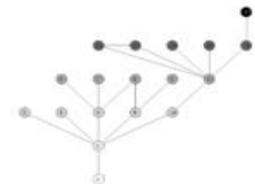
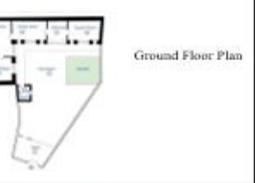
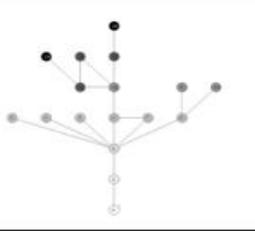
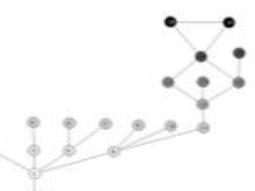
- **Space link Ratio (SLR):** indicates the degree of distributedness or non-distributedness of the layouts or the ringiness degree of the spatial system. If there is only one no-intersecting route from one space to another it is called non-distributed “a tree like structure” without any rings. If there is more than one non-intersecting route for any two spaces in the system, it is called a distributed system “Ringy structure” (Guney & Wineman, 2008).

- The degree of spaceness (space type):**  
 According to Hillier there are four topological types of the spatial system (a-type, b-type, c-type and d-type) (Hillier, 2007). Where a-type space has one connection to other spaces, b-type space more than one connection and lies on a tree, c-type space has more than one connection and lies on a ring, d-type space has more than two connections and lies on at least two rings, in other words a and b type spaces belong to tree like graphs, c and d type spaces belong to ringy graphs (Hanson,

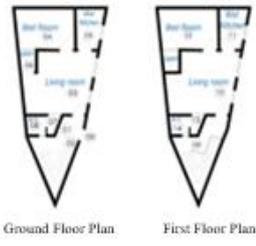
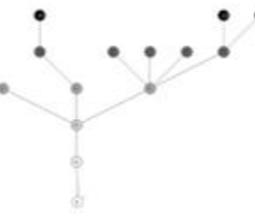
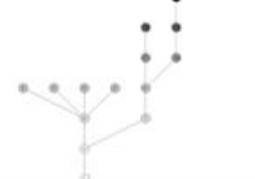
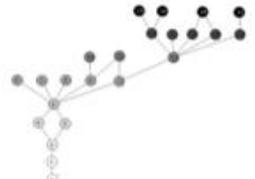
2003, p. 27)(Hillier, 2007, p. 250) (Guney, 2005)

For the purpose of analysis first, data were collected from researcher's field investigation, the selected houses are documented then converted into cad models using AutoCAD software, later architectural plans are converted into graph-based representations or justified plan graph (JPG) using A-graph software in which the exterior of the house, space number (00) is selected as the root, and the other spaces are aligned above (Table 1), (Table 2). The graph consists of nodes (functional spaces) and lines (connections between spaces).

**Table 1.**  
Traditional houses (HT)with their graphic justification diagrams (Researcher)

Traditional Houses samples (1900-1960)					
	House	Architectural style	Plans	Justified Graph	
1	HT01 Azad Nuri Beg House Sabunkaran				
2	HT02 Haji Zahir House Sarshaqam				
3	HT03 Ali Mam Sheikh House Sabunkaran				
4	HT04 Rauf Sarraf House Sabunkaran				
5	HT05 Saeed Mutabchy House Sabunkaran				
Legend		 Least Depth	 Highest Depth	 Depth lines	 spaces connection

**Table 2.**  
Contemporary houses (HC) and graphic justification diagrams (Researcher)

Modern Houses samples (1990-2022)				
	House	Architectural style	Plans	Justified Graph
1	HC01 House Malkandi		 Ground Floor Plan      First Floor Plan	
2	HC02 Salar Ali Hassan Julakan		 Ground Floor Plan      First Floor Plan	
3	HC03 Banaz Muhammed Faraj House Julakan		 Ground Floor Plan      First Floor Plan	
4	HC04 Aram Qasim House, Sabunkaran		 First Floor Plan      First Floor Plan	
5	HC05 Kafya Abdullah House Sabnukaran		 Ground Floor Plan      First Floor Plan	
Legend		○ Least Depth	● Highest Depth	Depth lines      — spaces connection

**Results and Discussion**

This research followed a comparative methodology to investigate the nature of change in spatial genotypes of traditional houses plans in the historical center of Sulaimaneyah city after rebuilding them with new contemporary spatial

setting using one of space syntax measurements techniques to obtain numerical data from mathematical equations then interpreting the results based on space syntax methodology, results of the main benchmarks are presented in Table 3 and Table 4:

**Table 3.**  
*Mean syntactic values for Traditional Courtyard houses*

House Number	MD	Integration (RRA)	SLR	BDF
HT01	3.11	1.09	1.10	0.78
HT02	2.72	1.54	1.00	0.76
HT03	3.08	1.12	1.10	0.76
HT04	3.81	1.37	1.10	0.85
HT05	3.06	1.03	1.15	0.76
<b>Mean Value</b>	<b>3.15</b>	<b>1.23</b>	<b>1.09</b>	<b>0.78</b>

**Table 4.**  
*Mean syntactic values for Contemporary Rebuilt Houses*

House Number	MD	Integration (RRA)	SLR	BDF
HC01	3.60	1.53	1.00	0.84
HC02	2.93	1.19	1.00	0.72
HC03	3.40	1.41	1.00	0.72
HC04	3.45	1.51	1.00	0.81
HC05	3.55	1.14	1.10	0.70
<b>Mean Value</b>	<b>3.38</b>	<b>1.36</b>	<b>1.02</b>	<b>0.76</b>

**1. Mean Depth MD**

The mean depth for traditional (courtyard) house layouts, is (3.15); for modern houses layouts, it is (3.38). This indicates that the overall modern house layouts appear in asymmetric order (more linear organization), which refers to spaces organized away from the original space (root space) or the entrance of the house. In contrast, the overall traditional house layouts appear in symmetric order and spaces in these layouts are arranged near from and connected to the root, additionally in the traditional samples the inner courtyard and service sector (kitchen, store, bath, toilet) show the least depth and the bedrooms show the highest depth (private sector) while in the modern samples the hall (living area) and the stairs that connect the ground floor with the first floor have the least depth followed by the bedrooms being directly connected with the hall which means these closed spaces act like distributor spaces (public spaces) instead of the courtyard while the bathroom and toilet in the modern houses are the most remote spaces, this decreased the level of privacy and comfort of the bedrooms being connected to and opened to the hall.

**2. Integration value RRA**

Low RRA indicates more integrated system (accessible), the calculations show lower RRA value of the traditional samples with an average of 1.23 compared with the modern samples 1.36 which means the traditional spatial system was more accessible (permeable).

The syntactic values shows that the inner courtyard of the traditional house has the highest integration value (lower RRA) which means this space was essential and controlled the access to other spaces in the house where family's daily activities took place, while in contemporary houses the hall has the highest integration value and works as the distributor space to other rooms. This is a valuable indicator as it shows how the distributor space changed from being an external open space to internal closed space and the house layout from introverted to extroverted, in other words changing the ratio of open-closed spaces, this can be explained as imitating one of the western styles of rooms organization around closed circulation.

**3. Space Link Ratio SLR**

This property describes the (Distributeness-non Distributness) of the spatial system. The contemporary samples show the recurrence of the value (1.00) with an average value (1.02) of all five houses which means number of connections between the rooms is equal to house spaces (less connectivity) and (non-distributed) or tree like spatial system with one linear path from the carrier (exterior) to other spaces in the house, while the traditional samples show recurrence of (1.10) with an average of (1.09) which means more alternative routes between house's rooms usually more than one access from a room to others this indicates more (Distributed) or ringy-like spatial arrangement with more than one route from the carrier (exterior) to other rooms, usually the rings are seen between the bedrooms as a reflection of socio-cultural values

and lifestyle of the inhabitants .The reoccurrence of SLR in each group is a sign of the existence of two differnt spatial underlying genotypes.

#### 4. Base difference factor $H^*$

In terms of the difference factor both the traditional group and modern one shows convergent low average values with (0.78), (0.76) respectively,  $H^*$  values close to (0) indicates low differentiation between the spaces thus more functional efficiency and values close to (1) indicate strong differentiation between spaces thus low functional efficiency.

The result of this indicator show almost equal functional efficiency for both spatial setting. An important conclusion here is  $H^*$  value ranges from (0.76 – 0.85) for the five traditional samples while this value comprise from (0.70 to 0,84) in the modren samples. This consistency in spatial patterning of tradional samples is called “inequality genotypes” it is a sign of the strength of the cultural genotype.

#### 5. Type of Spaces (Topological Types)

This indicator explains the connectivity bewteen spaces, the a-type spaces are the most parivate spaces they are suitable for bedrooms or spaces specified for women as they cannot be entered from other spaces while the d type is the space with highest connections with other spaces. From the graphs and (Table. 5), (Table. 6) in the traditional samples the courtyard and the vestibule (skifa) are b or c type spaces with two or more than two connetions with other spaces while in the modren samples the entrance and the hall have the most connections with other spaces with direct access to the bedrooms.

The a and b type spaces have higher rates in the modren houses than the traditional ones , a type spaces indicate no through circulation spaces such as the bedrooms and b type spaces mean transitional spaces with lower rates of c and d type of spaces in other words less rings in the spatial system and non distributed ssystem , while the traditional samples have more spaces from c and d type which indicated more rings in their spatial configuration to pass from one space to another through more than one path thus more distributed spatial arrangemnet.

**Table 5.**  
*Degree of space-ness (topological types) of Traditional samples*

House Number	a-ness	b-ness	c-ness	d-ness
HT01	0.53	0.11	0.41	0.00
HT02	0.50	0.62	0.00	0.00
HT03	0.50	0.18	0.38	0.00
HT04	0.44	0.27	0.27	0.55
HT05	0.47	0.29	0.17	0.17
<b>Mean</b>	<b>0.48</b>	<b>0.29</b>	<b>0.24</b>	<b>0.14</b>

**Table 6.**  
*Degree of space-ness (topological types) of contemporary samples*

House Number	a-ness	b-ness	c-ness	d-ness
HC01	0.57	0.50	0.00	0.00
HC02	0.61	0.46	0.00	0.00
HC03	0.50	0.57	0.00	0.00
HC04	0.53	0.53	0.00	0.00
HC05	0.53	0.20	0.66	0.06
<b>Mean</b>	<b>0.54</b>	<b>0.45</b>	<b>0.13</b>	<b>0.01</b>

#### Houses Genotypes

Genotypes exist when there is consistency in the rank order of ingeration values of houses spaces which means the presence of socio-cultural patterns in housing layout (Hillier & Hanson, 1984) .(Table.7) shows abbrivations of houses spaces to faciliate the processs of oredering integration values of all spaces so that spatial

genotypes could be determined, (Table. 8) and (Table. 9) respectively show relative assymetry values of both traditional and contemporary samples, from lowest RA value (most integrated) to heighest RA value (less integrated).

Table.8 shows recurrence of the ranking order of traditional samples that four of the five samples are structured around the courtyard except of

house HT02 which is structured around transitional space this repeated pattern in spatial organization is an evidence of underlying genotype in this group , while (Table 9) shows that contemporary samples HC01, HC03, HC04 are structured around the corridor which is closed

transitional space and HC02 and HC05 are structured around the guest room and staircase respectively ,this proves the absence of strong specific cultural genotype in the selected samples thus fundamental differences between first and second group in terms of spatial organization.

**Table 7.**  
*Abbreviations for houses spaces*

space	code	space	code
1 Courtyard	crt	12 skifa	skif
2 Bedroom	br	13 House main entrance	Ext.
3 Exterior staircase	Str1	14 kitchen	kit
4 Interior staircase	Str2	15 Bath	bth
5 Guest room	gst	16 Toilet	wc
6 Living room	Liv	17 Store	sto
7 Iwan	Iw	18 corridor	corr
8 Balconey	Bl	19 Laundry	Lr
9 Roof	Rf	20 Entrance(foyer)	Ent.
10 Open	Op.	21 penthouse	ph
11 Garage	Gr	22 Hall	hall

**Table 8.**  
*Genotypes for Traditional samples*

House Number	Mean RA	Order of Integration (Exterior Included)
HT01	0.26	Crt=0.13<str1=0.14<corr=0.17<hall1=0.20<hall2=0.22<ext, kit=wc=0.25<br1=0.27<gst1=br2=0.28<hall3=gst2=Iw=0.29<br3=gst=0.32<br4=0.33<Str2=0.39
HT02	0.49	Ent=0.25<Crt=0.28<Liv=0.35<skif=0.46<gst=0.50<kit=bth&wc=0.53<ext=0.71<br=0.78
HT03	0.27	Crt=0.13<Str1=0.15<Str2=0.19<gst1=0.20<corr1=0.22<skif=0.24<kit=bth=wc=0.25<corr2=0.29<gst2=Liv2=0.30<liv=br1=0.35<ext=0.36<br2=0.41<br3=0.42
HT04	0.31	Crt=0.18<Str2=0.19<Liv=0.20<corr=0.21<hall1=0.27<hall2=gst1=gst2=gst3=0.28<kit=0.29<ext=skif=0.30<br1=0.32<gst4=0.34<br2=0.38<bth=wc=0.39<Sto=0.40<gst5=Bl=0.44
HT05	0.24	Crt=0.10<Str1=0.13<Ent=Liv1=0.18<skif=Liv2=0.20<Sto=kit=bth=wc=0.21<Liv3=0.27<gst1=br1=0.28<gst2=br2=0.30<Ext=br3=0.31<br4=0.37

**Table 9.**  
*Genotypes for Contemporary samples*

House Number	Mean RA	Order of Integration (Exterior Included)
HC01	0.40	Corr1=0.24<Str1=0.25<hall1=0.27<corr2=0.28<hall2=0.34<Ext=0.38<Lr1=0.39<br1=kit1=op=0.41<Lr2=0.46<br2=kit20.48<wc=0.53<Bth=0.60
HC02	0.32	Gst=hall=0.15<Str2=Lr=0.25<op1=0.28<kit=br1=br2=op=0.30<ph=0.38<bth=wc=0.41<Ext=0.43<Rf=0.53
HC03	0.37	Corr=0.19<kit=0.20<hall=0.24<pt=0.29<br=0.31<br2=Ent=Bth=0.34<kit=0.36<Rf=Sto=0.43<op1=op2=0.46<op3=0.50<Ext=0.60
HC04	0.40	Corr1=Str1=0.24<corr2=0.26<hall1=0.29<bth=wc=0.37<Ent=ext=0.39<br=hall2=bth=wc=0.44<Ph=0.50<kit=0.55<Rf=0.65
HC05	0.24	Str2=0.12<hall1=0.13<hall2=0.14<kit=gst=0.19<Lr1=bth1=0.20<Lr2=0.21<op1=op2=br1=br2=br3=Ph=0.22<br4=0.23<Ent=0.26<wc=0.29<wc2=bth2=Bl=0.30<Rf=0.31<Gr=0.34<EXT=0.43

## Conclusions

The present research was conducted to compare between genotypes of the spatial configuration of a sample of traditional and modern houses in the historical center of Sulaymaniyah city, Iraq. Changes in the spatial genotypes due to demolition of original traditional houses and rebuilding new ones are revealed to show the impact of contemporary rebuilding practices achieved by landowners on generating different spatial configuration and morphological characteristics, the selected houses represent the dominant typology for the two models.

The study aimed to detect genotypical constants and organizational rules behind their architectural layouts. To fulfill this aim, the researcher followed a quantitative approach for data analysis included syntax techniques designed to uncover the relationship between houses spaces for both traditional and modern samples. For this purpose, syntactic indicators were calculated and compared in terms of (hierarchical structure, accessibility, structuring modes and spatial morphology). The study revealed to:

1. The importance of space syntax tools in revealing the impact of socio-cultural beliefs of the builders and inhabitants in depending on a specific spatial structure for house's architectural layout.
2. Genotype patterns of traditional houses layouts differ from modern rebuilt layouts in term of the relationship between open-closed spaces, hierarchy of the rooms, levels of privacy and social interactions. The open courtyard and semi-closed Iwan in the traditional setting constituted an important part of housing organization in the traditional setting while in rebuilt

houses these spaces transformed into the closed hall and small balcony respectively which both function as a transitional area.

3. In terms of the relationship with the street, the numerical syntactic values prove that traditional samples are introverted houses facing the inner courtyard separated with solid walls from outside and show weak relationship with the street while the modern rebuilt samples are extroverted with more spaces facing the street.
4. Traditional houses in the city although they were not built by architects with no formalistic standards, there is a unique common organizational system rooted in their spatial configurations, despite their different observable forms (phenotypes), this spatial genotype was influenced by local cultural values until the beginning of the 60s later these patterns evolved dramatically over the course of time in response to changes in people beliefs, values and behavioral patterns particularly under the absence of conservation polices and legislations.
5. In order to fulfill contemporary demands and preserving local architecture identity, designers need to derive modern models from the inherited spatial genotypes as these solutions proved to be more adapted with the local context and influenced by inhabitants' original cultural values and traditions.

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