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“Spatial DNA” of Traditional Houses as a Catalyst for Resilient and Sustainable Future: The Case of Oman

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ABSTRACT

In the era of globalization, technology, and environmental sustainability requirements, domestic buildings are conceptualized, designed, and constructed with little attention being given to the socio-cultural dimension. This is in spite of the importance of this dimension in creating a truly sustainable and resilient built environment. The socio-cultural dimension was often one of the main drivers behind the vernacular architecture and formed a major part of the identity of the society. However, studies in the field of vernacular architecture have traditionally focused on the documentation, conservation, and rehabilitation strategies while the configurational structures of these houses are often neglected. The need for a proper understanding of the social logic impeded in traditional houses is, therefore, indisputable. By focusing on Oman, this study aims to explore whether traditional houses share a common “spatial DNA” across the different climatic zones of the country in order to inform the development of a distinctive architectural identity for contemporary house typologies. The study employs Space Syntax methodology to quantify the spatial structure of six traditional Omani houses, which cover the three climatic zones of Oman. This was followed by an analytical-comparative exploration and a systematic categorization of the spaces in these houses based on their syntactic characteristics. The results showed that the spatial arrangements of the sample share common spatial features that correspond to the custom of the society. However, these common spatial features are limited to local measures. The study concludes that the spatial identity of traditional houses should be further studied so it could be incorporated in the contemporary house typology in order to preserve the spatial identity that corresponds to people’s values, aspirations, and socio-cultural needs.

KEYWORDS

House genotype; Cultural identity; Oman; Space Syntax; Heritage.

1 INTRODUCTION

No doubt that our built environment has been shaped through history by several interconnected factors such as technology, materials, economy, imagination, authority and religion, politics, climatic conditions, and, equally importantly, the socio-cultural norms. Out of this array of factors, domestic spaces, or homes, are often seen as reflections of the socio-cultural traditions, life style, and the behavioural patterns of their inhabitants (Rapoport, 1969). Unlike their ancestors, built environment professionals in the last decades overlooked this important aspect and focused on more tangible aspects of building design such as climatic and sustainability requirements, form generation processes, and building image, resulting in homes that do not always correspond to the inhabitants' values and cultural legacies.

In fact, this was noted by Bill Hillier in his early work (Hillier & Hanson, 1984; Hillier B. , 1996) who criticised the conventional interpretation of the production of the built environment, which sees architectural and spatial forms as consequences of tangible and inevitable forces such as climate and topography, without proper consideration nor understanding of the substantial role of the socio-cultural factors in shaping our built environment throughout the history (Mustafa & Hassan, 2010). In later publication, he emphasised that the built environment is the product of the spatial dimensions of social processes and not vice versa (Hillier , 2008). He argued that the social and cultural customs and traditions of a certain population are inherently impeded in the global and local spatial relationships that are best manifested in what he called "spatial configuration". The concept of "configuration" looks at a spatial system from a holistic point of view rather than looking at its individual parts, and it does account for the interrelationships between the components of a spatial system and their interconnected nature i.e. a whole is more than the sum of its parts. This innovative way of looking at the socio-spatial relationships led to the development of Space Syntax theory and its associated methodologies that allowed researcher and practitioners alike to quantify the spatial relationships and link them to social, behavioural, perceptual and cultural phenomena.

Since then, space syntax has been used widely in studies that span a large array of topics, and its use was expanded beyond the first focus of the theory which was on behavioural aspects -i.e. pedestrian movement- to cover perception and preference studies, see for example (Alalouch & Aspinall, 2007; Alalouch, Aspinall, & Smith, 2009). Equally importantly, and due to the ability of the theory and its associated methodologies to provide measurable and quantifiable accounts that helped researchers to link spatial attributes to other more soft and behavioural aspects of building design, it is use was expanded to a large number of geographical locations, countries,

and cultures. However, space syntax studies in Sultanate of Oman is rather scarce and seems to be limited to land use distribution (Alalouch et al., 2019) and accessibility to the old town (Alkamali, Alhadhrami, & Alalouch, 2017). It is beneficial, therefore, to study the traditional Omani houses using space syntax in order to shed a light on their spatial structures, a topic that is often understudied. These type of studies are important due to the fact that the formal and spatial distinctive characteristics of domestic spaces of a given society are true reflections of people's identity, values, aspirations, and way of life.

However, due to the strong globalization movement in the last decades, which has influenced all aspects of our life, these spaces started to lose their identity in an attempt to offer a universal lifestyle imposed by the rapid transformation in values and technology that we are witnessing in recent years. These, often undesirable, transformations affected almost all regions of the World. The Gulf Cooperation Council (GCC) countries were not exempted. Nowadays, these transformations can be easily observed in the built environment of almost all major cities in the region.

While the move towards a modern lifestyle seems to be inevitable, the traditional domestic spaces could provide a proper socio-cultural foundation to guide a resilient development towards culturally and socially sensitive modern architecture. In fact, there have been calls for the preservation of the socio-cultural aspects of the region through proper understanding of the architectural identity of the traditional domestic spaces as means to maintain and strengthen the unique socio-cultural features in the GCC countries and form strategies to pursue the sought-after lifestyle while consolidating the cultural identity (Salama, 2005; Fadli & AlSaeed, 2019).

In the Sultanate of Oman, preserving the identity of the country and its national heritage and culture is one of the National Priorities stipulated in Oman Vision 2040 (ISFU, 2022). Although the Version calls for "*a balance between the legacy of the Omani civilisation and identity on the one hand, and the optimal exploitation of technical developments on the other hand*" (ISFU, 2022, p. 24), it does not outline a clear action plan to achieve this balance. However, Oman, like any other country in the region, is facing the challenge of identity distortion and, perhaps, loss due to the prevailing tendency towards modernity and technology. This is best observed in the significant change that occurred to the local identity of the domestic traditional architecture since the Oman Renaissance in 1970, which resulted in remarkable socio-economical changes in the country. This issue becomes more important in Oman due to the variation in the climatic conditions across the country, which might have direct and indirect influences on the development of the spatial arrangements of the traditional houses. According to Alalouch et al. (2019), the climate in Oman is classified into three zones i.e. hot dry, hot humid, and warm tropical.

In fact, research on traditional architecture in Oman has been focusing on documentation, reuse, and refunctioning strategies of traditional architecture (Buerkert, et al., 2010; Hegazy, 2014; Benkari, 2019) with particular interest in defensive and military buildings such as forts and towers (Stevens, 1990; Amal, 2016) and mosques (Bandyopadhyay & Sibley, 2003). An exemption of this is the work of Alharthy (1992) who studied the neighbourhood and the traditional dwelling in Sharqiyya, which is a region in the inner Oman. To the authors best knowledge, the spatial structures of Omani traditional houses across different climatic zones have yet to be studied and hence the significance of this study.

Therefore, this study discusses the effect of the socio-cultural factors manifested in the spatial structure of a sample of traditional Omani houses in different climatic zones, and presented using space syntax attributes. The question that this study attempts to answer is whether Omani traditional houses have a common "spatial DNA" in spite of the differences in the climatic conditions of the locations where these houses were built, or do they embed different spatial structures due to the differences in climate? We hypothesize that due to the strong social norms and customs such as privacy, gender segregation requirements, and hospitality in the culture of Oman and the Muslim region (Othman, Aird, & Buys, 2015; Farah & Klarqvist, 2001), the spatial structures of the traditional Omani houses were greatly influenced by these socio-cultural factors regardless of the climatic conditions, and that such factors did provide latent rules for the arrangement of the spatial systems of these houses resulting in a latent and unified "spatial DNA".

2 LITERATURE REVIEW

2.1 A brief background on Oman

Oman is one of the GCC countries that is located in the southeastern corner of the Arabian Peninsula between latitudes 16°40′ and 26°20′ North and longitudes 51°50′ and 59°40′ East. The country's capital is Muscat and the main source of the economy is oil and gas revenues. The climate in Oman is generally very hot, dry, and humid. To the authors' best knowledge, no climate classification has been developed in Oman. The updated Köppen-Geiger map classifies Oman's climate as BWh; a hot, dry desert climate, with the annual average temperature of higher than 18 °C (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006). However, this classification does not recognize the differences in Oman climatic conditions nor its microclimates (Alalouch, Al-Saadi, AlWaer, & Al-Khaled, 2019).

The strategic geographical location rendered Oman a linking point between the eastern and western civilizations through the ancient times and added unique richness and value to the country's history. The old name of Oman, *Magan*, was found in many old texts that dated back to the Sumerians. The communication of the Omani people didn't remain in the local circle but went further beyond to reach different cultures and countries as Omani was also known as a

provider of some unique products as narrated in cuneiform texts from the third millennium B.C (Al-Salimi, Gaube, & Korn, 2010).

Throughout its long history, Oman went through several stages of development and was exposed to several civilizations, religions, and ruling systems. This is reflected in the dense, vibrant and rich culture in the country at several levels. Since the historical transitions effected Omani lifestyle, behavior, buildings, society, and culture, the architecture of the country has been changing with time with Islam being one of the main factor (Damluji, 2008). This rich history deposited many historical buildings that have a great value for the nation. Many forts, houses, mosques and settlements that refer to very old periods are fully or partially still standing. In fact, Omani architecture is a result of long experience and growth that have been accumulated through history to create a coherent and harmonious built environment (Hegazy, 2014).

A new era of Oman started in 1970 under Qaboos bin Said, the leader who began to modernize Oman's economy and set in motion the social, educational and cultural renaissance. Consequently, the country witnessed a rapid and remarkable growth at all levels including architecture (Hawley, 1995). The country directed its efforts in developing the quality of the built environment while preserving its old buildings and architectural identity, and ministries were established for this purpose. However, in recent decades the globalization ideology, the development in buildings materials and technology, and the subsequent rapid change in lifestyle has been drifting the Omani building, homes and houses in particular, away from one of its original missions i.e. to preserve the country's identity. The identity of Omani architecture might be best presented in the Omani traditional houses and therefore they should not be abandoned but have to be documented, studied and preserved to provide guidelines for the development of contemporary residential architecture. In spite of this, research on residential building in Oman has been focusing on energy saving strategies (Alalouch, Al-Saadi, AlWaer, & Al-Khaled, 2019), passive design (Alalouch, Saleh, & Al-Saadi, 2016) and sustainable construction (Saleh & Alalouch, 2020; Salah & Alalouch, 2015) with little attention being given to the role of the spatial forms in the architectural identity of the country.

2.2 Space Syntax and House Genotype

Space syntax (Hillier , 1996) is a theory supported by a set of representation, quantification, and interpretation techniques to analyses spatial relationships in a given spatial configuration and decode these relationships in way that their underlying social logic can be understood (Dursun & Saglamer, 2007). Due to its ability to quantify the spatial formation, it makes an excellent tool to analyze spatial forms in relation to socio-cultural factors such as privacy, gender segregation, and hospitality, which in turn can be used to explore the impact of these factors on the spatial DNA of traditional houses. The theory is very well-know and has been utilized in a large number of fields that are beyond counting, see for example (El-Darwish, 2022; Urbina, 2021; Güngör & Aslan , 2020; Abdul Nasir, et al., 2020; Arslan & Uraz, 2017; Abbasi , Alalouch, & Bramley, 2016; Barros, Silva, & Holanda, 2007; Rashid, et al., 2005; Hillier, Penn, Hanson, Grajewski, &

Xu, 1993). There are several methods that can be listed under the umbrella of space syntax such as Convex maps, Justified map (j-graphs), Visibility Graph Analysis (VGA), Axial lines/maps, segment analysis, and agent analysis. Space syntax uses the Graph Theory to produce several local and global syntactic and quantifiable measures such as Connectivity, Choice, Mean Depth, Integration, and Visual Control with Integration being the most used one. Detailed explanation of the theory, analysis procedures, and attributes calculations are widely available in the literature, see for example (van Nes & Yamu, 2021; Alalouch, 2009).

Space syntax has been used as the primary method to explore the distinctive spatial characteristics of houses in different cultural settings. According to Dursun and Saglamer (2007), Space Syntax has shown to be an effective method in comparing similarities and differences between different home environments. This is known in space syntax literature as House Genotype which can be defined as "*the ranking of programmatic labeled spaces according to their mean depth (most often represented in terms of integration values) of nodes of the graph of spatial configuration to which they correspond*" (Bafna, 2001, p. 20.1). In fact, the concept of house genotype stems from the classical work of Hillier and colleagues (Hillier, Hanson, & Graham, 1987) and was elaborated further by Julienne Hanson (1999). In highlighting the importance of such type of studies, Bandyopadhyay and Sibley (2003, p. 940) stated, "*The genotype string helps not only in the documentation of valuable information in terms of the spatial organization of a building type, but it may also serve as a tool to compare the organization of spaces in different building types of any geographical region, or across different regions, which can help architects to understand the relationship between spatial organization and different social and cultural patterns*".

The concept of house genotype was extensively used in domestic architecture to explore several socio-cultural constructs such as privacy, spatial segregation, spatial-functional factors, behavioral issues, permeability, and the transformation of house design over history. This course of research covered various cultures, geographical locations, and was applied in houses and homes of different sizes and styles. The spatial structure of houses was particularly investigated in cultures in the Middle East and North Africa (MENA) region, such as Turkey (Guney, 2007; Dursun & Saglamer, 2003), Qatar (Al-Mohannadi & Furlan, 2021), Saudi Arabia (AlNaim, 2021), Iraq (Mustafa & Hassan, 2010; Mustafa, 2010), Iran (Zolfagharkhani & Ostwald, 2021; Alitajer & Nojoumi, 2016) , and Algeria (Barkat, et at., 2020), to mention a few. In most of these studies, VGA was used as one of the main research methods.

3 DATASETS AND METHODS

3.1 The case study

The aim of this study is to explore whether there are sociocultural-related patterns in the spatial arrangements of a sample of traditional Omani houses that cover the different climatic zones of

Oman. We faced two challenges in preparing for data collection. First, there is no formal classification of the climatic zones of Oman as explained earlier. Therefore, we use the climatic zoning that was proposed by Alalouch et al. (2019), who classified the climatic zones of Oman into three zones i.e. hot dry, hot humid, and warm tropical. The warm tropical climate exists in the south of Oman due to the effect of the southwest monsoon, whereas the hot humid climate is located in the coastal area facing the Gulf of Oman. The rest of Oman is mostly deserts with a harsh, hot dry climate.

Second, there are very limited resources related to the traditional houses in Oman with clear floor plans and drawings that are based on proper documentation. Therefore, due to the limitation of the availability of floor plans and historical information, we analyzed two houses from each climate with a total of six traditional houses that reflect the traditional characteristics of the countries' houses as shown in Figure 1 and Table 1. All houses reflect the traditional characteristics of Omani houses and the selection criteria were primarily based on the availability of floor plans, and the location of the house unit. This sample could provide initial insights into the spatial structure of Omani traditional houses, a topic that is rarely addressed in the literature. The authors make no claim about the generalization of the results from this sample and more research is indeed needed once plans of houses are documented and made available. Nonetheless, several space syntax studies on traditional houses considered even smaller samples and fewer house units, see for example (Al-Mohannadi & Furlan, 2021; AlNaim, 2021; Alitajer & Nojoumi, 2016).

Figure 1. A schematic representation showing the locations of houses and their climate zones (Oman map was approved for publication by the National Survey Authority, Oman-Approval No. 1221 on Dec.12, 2018)

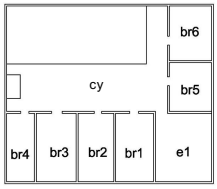
3.2 Functional zoning

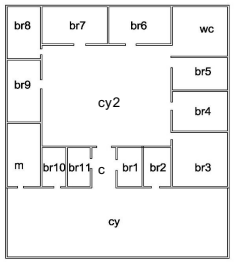
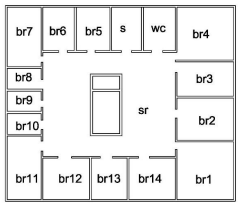
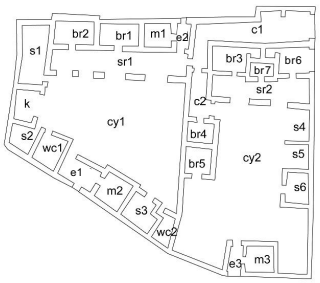
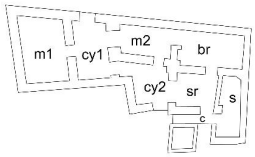
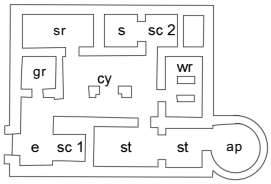
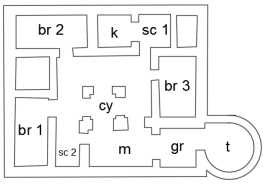
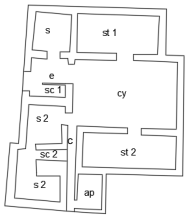
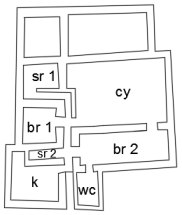
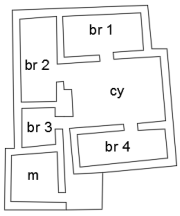
In order to facilitate the exploration of the existence of spatial patterns with regard to the spatial attributes of the sampled traditional houses, the functional spaces of these houses need to be classified to allow meaningful comparison. Earlier studies had grouped house functional spaces in several ways, for example: family zone, private zone, and services zone (Pollowy, 1977); or social, private, services, and transitional (Amorim, 1997). Although these classifications were based on space function, later study showed that there are relationships between the functional sector and its spatial attributes measured by space syntax in some cultures (Mustafa & Hassan, 2010).

In this study, we used a simple classification of the functional spaces of the sampled houses that is aligned with the Omani cultural norms and customs. The aim was to classify the spaces in each house based on the privacy and gender segregation requirements. Omani houses typically have a space dedicated for male guests for hospitality reasons. Whereas female guests have different and separate spaces. Therefore, the functional spaces of the sampled houses were sectioned into public, semi-public and private zones according to the following definitions:

- The public zone includes the spaces that male guests can be present in, such as the entrances and the majlis.
- Semi-public zone includes the spaces that are shared by the family and female guests, and includes courtyards, sitting areas, kitchens, corridors, and stores.
- Private zone includes the spaces that can be accessed by the family members only and is limited to bedrooms.

Table 1. Plans and space function of the houses.

Climate	Region	Floor Plans
Warm Tropical	Dhofar	*House 1: Ground Floor* 

		House 2: Ground Floor  *House 2: Frist Floor* 
Hot Humid	Sohar	*House 3: Ground Floor* 
	Muscat	*House 4: Ground Floor* 
Hot Dry	Ibra	*House 5: Ground Floor*  *House 5: First Floor* 
	Al Hamra	*House 6: Ground Floor*  *House 6: First Floor*  *House 6: Second Floor* 
Key:- e: entrance, cy: courtyard, m: majlis, sr: sitting room, k: kitchen, gr: guest room. wc: toilet, br: bedroom, c: corridor, s: store/date store, wr: washroom, sc: stairs, t: tower, st: stable, ap: animals pens.		

3.3 Space Syntax Analysis

Space syntax literature has developed several types of analysis of spatial configurations with axial/segment analysis and visibility graph analysis (VGA) being the main ones. While both methods can be used to analyse both urban areas and building layouts, axial and segment analysis are often used to analyse movement at an urban level, whereas VGA is used at a building level. VGA is better in simulating the relationship between the spatial configuration when the subject of study shows complex patterns of behaviour, socio-cultural considerations, or requires a high level of resolution in capturing space properties, such as in this study. Please refer to Alalouch (2009, pp. 104-107) for a comparative review between VGA and axial analysis. In simple terms,

VGA is a graph-based technique in which each Isovist –i.e. field of vision- in a configuration is represented as a node, and as consequence the graph consists of a grid of points. These nodes are connected by edges if they are mutually visible allowing a number of syntactic measures to be developed. As noted earlier, there are a wealth of literature on attributes calculation produces e.g. (van Nes & Yamu, 2021).

In this study, we first conducted j-graphs from the main entrances of the case studies using AGRAPH software (Manum et al., 2005) in order to gain an initial insight into the spatial structure of the Omani traditional houses included in this study as shown in Figure 2. We then used DepthMapX to conduct Visibility Graph Analysis for the six houses. Three spatial attributes were considered in VGA: a) Connectivity: The number of nodes each node can see, that is the immediate neighborhood of a node, b) Integration: A measure of how deep the space is within its spatial structure, and c) Visual Control: The area of the current neighborhood with respect to the total area of the immediately adjoining neighborhood. These attributes are often used in similar studies and showed relationships to issues such as privacy and gender segregation in different contexts e.g. (Alalouch & Aspinall, 2007; Alalouch, Aspinall, & Smith, 2009; Mustafa, 2010; Alitajer & Nojoumi, 2016; AlNaim, 2021). A high grid resolution of 0.4 was used when setting the visibility grid in order to capture space properties at the narrowest spaces and allow proper calculation of the values of the spatial attributes for each space and each zone.

4 RESULTS

The j-graphs of the ground floors of the case studies showed variations in the spatial complexity. Bedrooms in the houses that has a single entrance are the deepest within their spatial configuration whereas the majlis is often located at the shallowest position. The courtyard acted as a central distribution spaces in all houses. A point worth noting here is that House 4-Muscat is the only house with a “ring” structure that created a circuit and allowed a non-linear movement. The visibility graphs of Visual Control, Integration and Connectivity obtained from DepthMapX of the case studies are shown in Table 2. The initial visual inspection of the visibility graphs revealed that the courtyards have high attribute values. In fact, this is an expected outcome since the courtyard forms the central hub of the traditional houses in most of the local domestic architecture in the region. Having said that, it is worth noting that these high values might be attributed to the large area of the courtyard when compared to their functional spaces. Larger areas generate more grid points in VGA, which might result in higher Integration and Connectivity values.

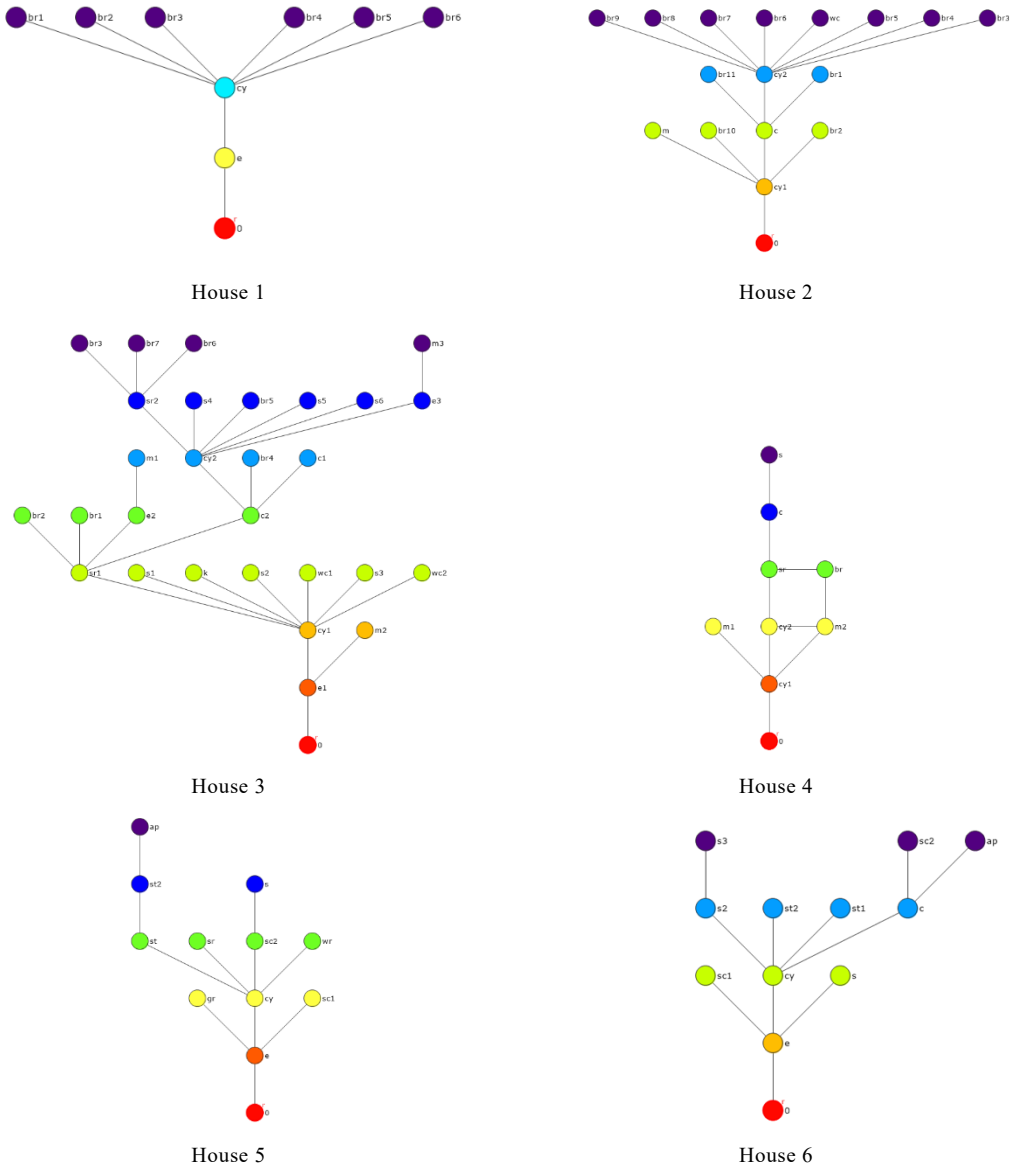


Figure 2. J-graph of the ground floor of the case studies.
Colours represent depth from the root space (r).

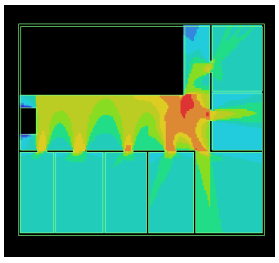
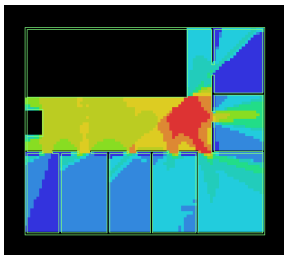
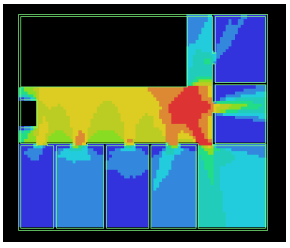
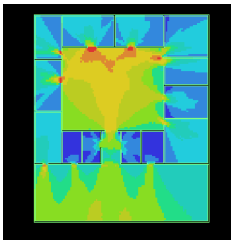
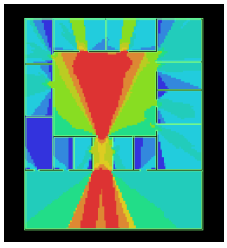
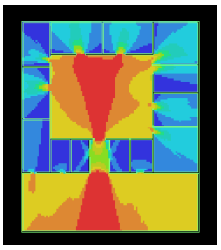
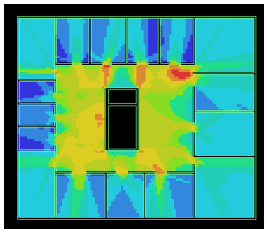
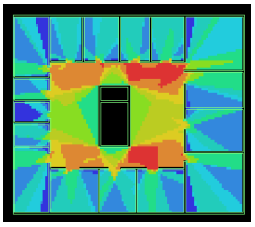
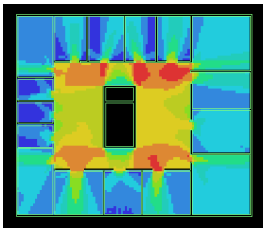
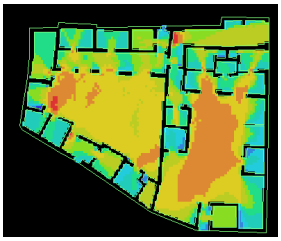
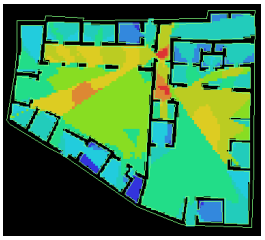
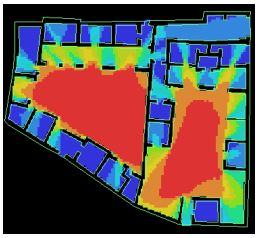
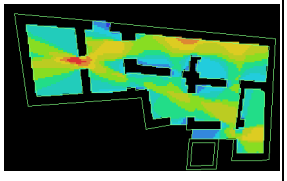
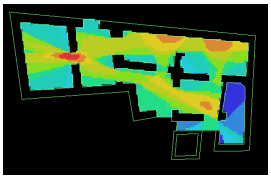
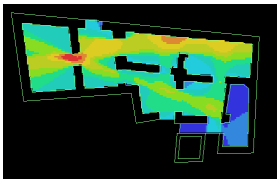
Therefore, we compared the values of the three spatial attributes in order to identify spaces with the highest and lowest values. The results are shown in Table 3 and indicate that spaces with the highest values of spatial attributes in most of the cases are the spaces that are accessible by male guests and thus require less privacy and more accessibility to fulfill the hospitality social requirements. Whereas the female-only spaces have less values of the spatial attributes and thus provide a notably high level of privacy to the family members and less accessibility to those who are not part of the family.

In order to address the aim of this study and shed light on the spatial patterns in Omani traditional houses, the next step involved systematic categorization of the functional spaces in three zones as explained in the methodology section i.e. public, semi-public, and private. Accordingly, the average values of the spatial attributes were calculated based on the raw values

exported from DepthMapX. Consequently, a rank order of the zones for each spatial attribute was driven from the data.

The results shown in Table 4 indicate that Integration did not show any meaningful pattern. Integration is a global measure that is often associated with movement in space syntax literature. Global measures are those which describe the relationships between a space and all other spaces in the spatial configuration (Hillier & Hanson, 1984).

Table 2. The visibility graphs of the case studies (Visual Control, Integration, and Connectivity).

Climate	Region	Floor	Visual Control	Integration	Connectivity
Worm Tropical	Dhofar	*House 1: Ground*			
		House 2 : Ground floor			
		House 2 : First floor			
Hot Humid	Sohar	*House 3: Ground*			
	Muscat	*House 4: Ground*			

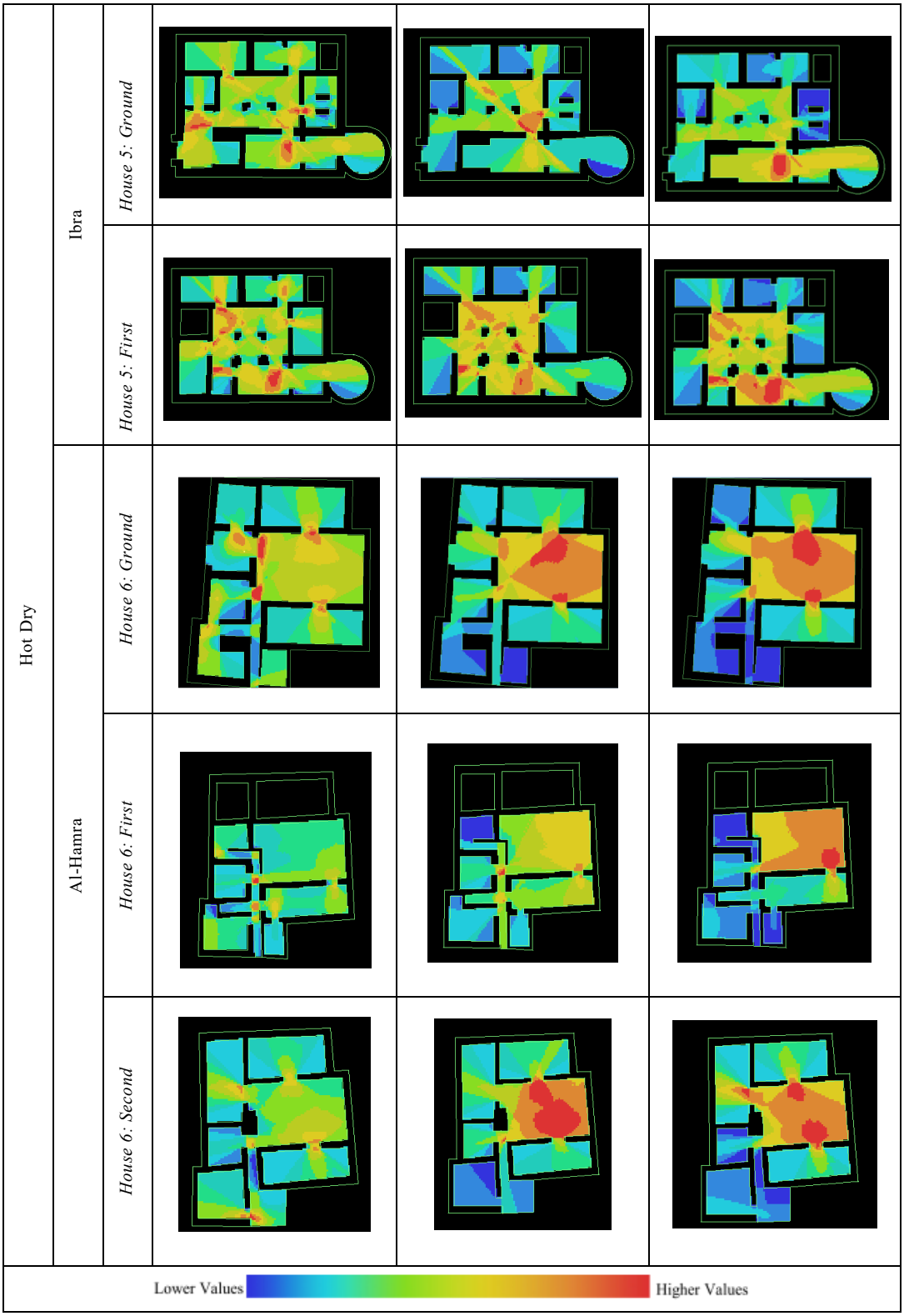

Hot Dry
Ibra
Al-Hamra
House 5: Ground
House 5: First
House 6: Ground
House 6: First
House 6: Second
Lower Values
Higher Values

Table 3. Spaces with highest and lowest values of Control, Integration and Connectivity.

			Visual Control		Integration		Connectivity	
			Highest	**lowest**	**Highest**	**lowest**	**Highest**	**lowest**
Tropical	Dhofar: House 1		Entrance	Bed room	Entrance	Sitting room	Entrance	Sitting room
	Dhofar: House 2	GF	Corridor	Bed room	Corridor & courtyard	Bed room	Corridor & courtyard	Bed room
		FF	Living room	Bed room	Sitting room	Bed room	Main living room	Bed room
Hot Humid	Sohar: : House 3		Courtyard1	Date store	Corridor	Majlis & toilet	Courtyards	Date store, bed rooms
	Muscat: House 4		Courtyard1	Date store	Majlis	Date store	Majlis	Date store
Hot Dry	Ibra: House 5	GF	Entrance	Keeper room	Courtyard	Date store	Stable	Date store, washroom
		FF	Majlis	Kitchen	Courtyard	Date kitchen	Majlis	Date store, kitchen
	Hamra: House 6	GF	Entrance	Staircase	Animal pens	Date store	Animal pens	Date store
		FF	Room1	Toilet	Hall	Date store, kitchen	Hall	Toilet
		SF	Hall	Bed Room	Hall	Majlis	Hall	Date store

In contrast, both local measures –i.e. Connectivity and Visual Control- showed clear patterns in the spatial values of the private zone. Local measures are those that take into account the relationship between the space and the spaces that are immediately accessible from it. For both measures, the private zone yielded lower values than the semi-public and the public zones. The only exception is the house in Muscat (house 4) where the semi-public zone achieved lower values than the private zone. This particular house is significantly smaller than all other houses and much less complex in terms of functional and spatial relationships and it is the only house that has a ring spatial structure as evident in it is j-graph. Equally important, the floor plan shows that the house, unlike the others, is clustered into two distinctive sectors with separate entrances for each one. The first sector includes the entrance to the first courtyard, which in turn leads to the majlis, forming the public zone. Whereas the semi-public and private zones are accessible from the entrance of the second courtyard forming another sector. The clustering of the semi-public and private sector might have resulted in altering the average values of the zones.

Table 4. Rank order of the average values of the spatial attributes in the three zones.

Climate	**House**	**Rank order of zones based on average values** **high**		**low**
Visual Control				
Tropical	Dhofar: House 1	Semi-public	Public	Private
	Dhofar: House 2	Public	Semi-public	Private
Hot Humid	Sohar: House 3	Semi-public	Public	Private
	Muscat: House 4	Public	Private	Semi-Public
Hot Dry	Ibra: House 5	Public	Semi- public	Private
	Hamra: House 6	Public	Semi- public	Private
Integration				
Tropical	Dhofar: House 1	Semi- public	Public	Public
	Dhofar: House 2	Public	Semi-public	Private
Hot Humid	Sohar: House 3	Semi-public	Private	Public
	Muscat: House 4	Public	Semi-public	Private

Hot Dry	Ibra: House 5	Semi-public	Private	Public
	Hamra: House 6	Semi-public	Public	Private
Connectivity				
Tropical	Dhofar: House 1	Semi-public	Public	Private
	Dhofar: House 2	Public	Semi-public	Private
Hot Humid	Sohar: House 3	Semi-public	Public	Private
	Muscat: House 4	Public	Private	Semi-Public
Hot Dry	Ibra: House 5	Semi-public	Public	Private
	Hamra: House 6	Public	Semi- public	Private

5 DISCUSSION AND CONCLUSIONS

This study contributes to the long-lasting discourse on the architectural identity of traditional houses by shading light on the often-neglected aspects related to what the authors prefer to call "Spatial DNA" of traditional houses. The study attempts to shift the focus from how traditional dwellings look, to how they actually work to achieve social sustainability and respect the cultural attributes of their inhabitants. This is not to say that the geometry, decorative language, and climatic influences of traditional architecture is less important, but to emphasize that our understanding of the architectural identity in a society should extend beyond what we see to include the latent and the equally influential socio-cultural factors that are manifested in the way by which the spaces are arrangement at local and global levels in any traditional spatial system. Therefore, this study calls for a comprehensive understanding of the local architectural identity that includes spatial arrangements, spatial relationships, and the interplay between the two in a way that creates culturally and socially sensitive dwellings. Such understanding could guide the development of contemporary residential buildings that could not only fulfil the requirements of the current life style but also respect the societal values, cultural customs, and region's particularities.

Rapoport stated when describing the relationship between the physical, personal and social spheres of the built environment, "*The environment is a series of relationships among elements and people and these relationships are orderly - they have pattern. The environment has a structure and is not a random assemblage of things. It both reflects and facilitates relations and transactions between people and the physical elements of the world. These relationships in the physical environment are primarily spatial — basically objects and people are related through separation in and by space*" (Rapoport, 1977, p. 9). With this understanding, we argue that the interaction between how spaces are arranged in a spatial system on one hand, and the socio-cultural norms of the inhabitants on the other, forms a major component of the architectural identity of the society. The architectural identity of the built heritage should not be limited to the physical nor climate-driven architectural attributes such as building form and orientation; architectural language; colours and materials; ornamentations; courtyard-based design; introverted/extroverted design approach; opening size; proportions; shape and location; etc. This way of understanding the evolution of our built environment seems to be neglected by mainstream theories that attempt to marry traditional architecture with contemporary approaches

by focusing on the tectonics and technologies of the built environment. For example, Critical Regionalism is seen as a mid-position between the old and the new ideologies. However, it endeavours to employ technology and science in order to define and reuse regional elements in unusual ways; it mediates the effect of the universal culture by using region's particularities. According to Kenneth Frampton the focus should be on topography, climate and light with particular emphasis on the tectonic form rather than 'scenography'; and the tactile sense rather than the visual (Frampton, 1983). Such proposals describe the architectural form of buildings rather than focusing on the spatial identity of traditional buildings. The mutual effect between the spatial configuration as a whole and people's cultural and social customs and norms must be, therefore, studied and understood in a syntactic and meaningful way. This study explored the spatial pattern in traditional houses across the three climatic conditions of Oman using space syntax's Visibility Graph Analysis.

The results suggested that the private zone has consistently the lower values of the two studied local attributes, which are Connectivity and Visual Control. Whereas Integration, the famous and widely used global measure in space syntax, did not show relation to a clear spatial pattern. Connectivity can be defined as the number of spaces at a depth of one (directly connected) from a particular space, and simply measures how well connected a space is locally. Therefore, higher connectivity indicates less privacy and more accessibility from the surrounding spaces. On the other hand, Control is another local measure and it measures the amount of choice a space presents to its neighbours as a possible first step in a journey. For detailed explanation of the control measure, please refer to (Alalouch, 2009, pp. 212-214). The larger the control value, the larger the chance of the space to be visited when moving from a neighbouring space. Control has been linked in earlier studies to locational preference of privacy (Alalouch & Aspinall, 2007). It was also found the size and complexity of the houses might affect their spatial patterns.

To sum up, the family-only spaces that require a high level of privacy were less connected with their immediate neighbouring spaces and offered less visual control. While these results are not surprising, it is of importance due to the fact that they shed a light on the Omani context and link it to the wider debate on architectural identity of the GCC region as a whole. The spatial structures of Omani houses are rarely studied and space syntax applications in Oman are limited.

Although VGA was the technique used as the main technique to analyse the spatial configuration of the six traditional houses selected for this study, other methods could have been also used such as convex analysis. Moreover, j-graph has been often used in analysing traditional houses (Aluclu & Özyılmaz, 2012; Mustafa & Hassan, 2010). In this study, j-graph was used to gain initial insights into the spatial structure of the case study. However, since VGA is a point analysis technique that is based on the topological distance and not on metric distance, it is able to describe the space at a fine enough level to capture relationships between building spaces and intangible aspects of the space such as privacy, as in this study. Therefore, VGA was widely used

in similar studies related to investigations into traditional buildings as discussed earlier. Due to the relatively small sample of houses included in this study, the analysis were limited to descriptive analysis and no statistical significances were established.

Future research should consider a larger sample of traditional Omani houses and analyse more houses from each climate in order to provide a better understanding of the "spatial DNA" of these houses. Due to the lack of well-documented traditional Omani houses, funds should be made available to document existing traditional houses and allow a more accurate analysis. Another limitation associated with this study is that it is based on a simple ranking exercise. Future research should consider more sophisticated inferential statistics in order to provide an in-depth insight into the spatial patterns in these houses. Nonetheless, the rank order provided in this study could pave the way for more detailed studies that concern Omani traditional houses. Another point that needs further study is the effect of the ring" structure on the ranking of spaces and zones in terms of accessibility and visibility in tradition Omani houses.

Our findings do not suggest that the socio-cultural factors and their relationships to the spatial structures of traditional houses are the only factor that may have an impact on the architectural evolution of the traditional houses; they rather suggest that these relationships, once they are understood, could indeed add a great value to the contemporary house typology in order to preserve the spatial identity that corresponds to people's values, aspiration, and socio-cultural needs.

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