



Architecture Reality and Perception: The Multicultural Nature of Egyptian Domestic Architecture in the Roman Period

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CASE STUDY

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ABSTRACT

Domestic architecture is an essential archaeological component for understanding past societies. As such, recent studies on house and households in Egypt have focused on analyzing vernacular architecture practices from the perspective of the *long durée* or in broader geographical perspective. In this study we investigate Roman period domestic structures to understand the changing social meanings of local and global cultures within the built environment.

Drawing on building archaeology and space syntax analysis, we discuss the application, strengths, and limitations of our approach as well as the results of the study to shed light on the relationship between people, architecture and domestic spaces in Egypt during the Roman period.

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1. INTRODUCTION

In Ancient Egypt, local traditions found expression in the multifaceted nature of domestic architecture in both the Pharaonic and Greco-Roman periods (Arnold 1989; Bietak 1996; Correas-Amador 2013). Specifically, domestic structures built under Roman rule (30 BCE–641 CE) revealed an overall observance of previous canons regarding materiality, making use of, for instance, earthen building materials such as mudbrick and earthen floors, and designs that privileged multiple-story buildings with barrel-vaulted cellars and flat, walkable roofing (Boozer 2015; Davoli 2011; Spence 2015). Drawing on digital methods and space syntax analysis, we discuss their application, strengths, and limitations through the case study of two domestic buildings previously excavated and published in the Egyptian-Roman cities of Karanis and Trimithis.

Our aim is to employ space syntax to analyze previously known Egyptian-Roman domestic contexts with the goal of assessing the validity of the method when applied to well-known archaeological contexts as well as discussing the potential applications and significance of this technique. The analysis makes use of drawings based on original architectural plans, quantitative analysis of the justified plan and depthmap analysis (Ostwald 2011). We employed the space syntax open software, which combines isovist analysis (i.e., the visibility from a specific vantage point) and space syntax, freely available at the Bartlett School, UCL platform (Letesson 2013: 315; Turner 2001, 2004).¹

Romanists have long engaged with the concepts of globalization in the Roman Empire (Boozer 2012; Hingley 2005; Hitchner 2008; Witcher 2000). Boozer (2012) amply discusses how globalization does not equate to homogenization and proposes to look at material culture at the macro-scale to be able to investigate and understand local and global communities' expressions under Roman rule.

Recent studies on house and households in Egypt have focused on analyzing vernacular architecture practices from the perspective of the *long durée* or in broader geographical perspective (Correas-Amador 2013; Davoli 2010; Koltsida 2007; Spence 2015; Tringham 1995).

While there has been increased archaeological interest in domestic architecture in recent decades, this has only recently extended to include Egyptian houses built during the Roman period. Therefore, few studies have given due attention to the idea that building materials and architectural designs can shed light on multiple aspects of ancient society beyond traditional areas of architectural study (Bagnall 2001; Tringham 1995). Space syntax analysis provides a different but complementary perspective compared to traditional approaches, allowing us to investigate the accessibility – also defined as permeability – of ancient buildings and their morphology.

In this contribution, we do not focus on the function of the different rooms, but emphasize the study of house design and quantify the interaction between architecture, people, and movement. For these reasons, we selected two previously published domestic contexts: first, House B1 in Trimithis; second, House C42 in Karanis (Boak and Peterson 1931; Husselman 1979; Boozer 2015) (Figure 1).

Trimithis/Amheida presents a long occupational history from the Pharaonic period up to Roman times, when the site reached its greatest expansion in the 4th century CE (Bagnall et al. 2006; Bagnall and Ruffini 2012; Boozer 2015). House B1, dated to the early to late 4th century CE, was investigated and published in depth, providing us with a full contextualization of its domestic spaces (Boozer 2012: 107; Boozer 2015: 191).

Karanis/Kom Aushim is one of the best-known sites in the Fayyum Oasis, renowned for the extensive preservation of Egyptian/Roman domestic architecture. The site, founded during the Ptolemaic period, presented a continuity of occupation that stretched to the late 5th century–early 6th century CE before its decline (Gazda 2004: 23; Husselman 1979: 9; Simpson 2014; van Minnen 1994). While the reports in the 1930s published a general account of topography and stratigraphy, a detailed publication of all the domestic architecture and its assemblages is still lacking (Husselman 1979). House C42, located in the KAC area of Karanis, which is located in the central-eastern part of the settlement, consisted of a two-story building with an underground cellar dated to the first centuries CE. The house underwent numerous renovations, thus affecting the original plans over the years; in this contribution we employed the plan as drafted by Husselman (1979, plan 25). We selected these two case studies as the buildings present a similar size, function and number of rooms.

2. MATERIALS AND METHODS

Space syntax identifies a theoretical and methodological framework in which spatial configurations in architecture and urban planning are the key to understanding the relationship between people and space. In the early 1980s, Bill Hillier and Julienne Hanson formulated space syntax analysis as a tool to quantify people's relations with the built environment based on their movements, accessibility, and field of vision (Hillier and Hanson 1984; Hanson 1998; Hillier 1996; Hillier 2014). Although space syntax was initially established to analyze contemporary built environments, since the 1990s it has been extensively employed in urban studies and more recently in archaeological research (Baumanova 2020; Hillier and Hanson 1984; Ostwald 2011; Letesson 2014; Steadman 1996).

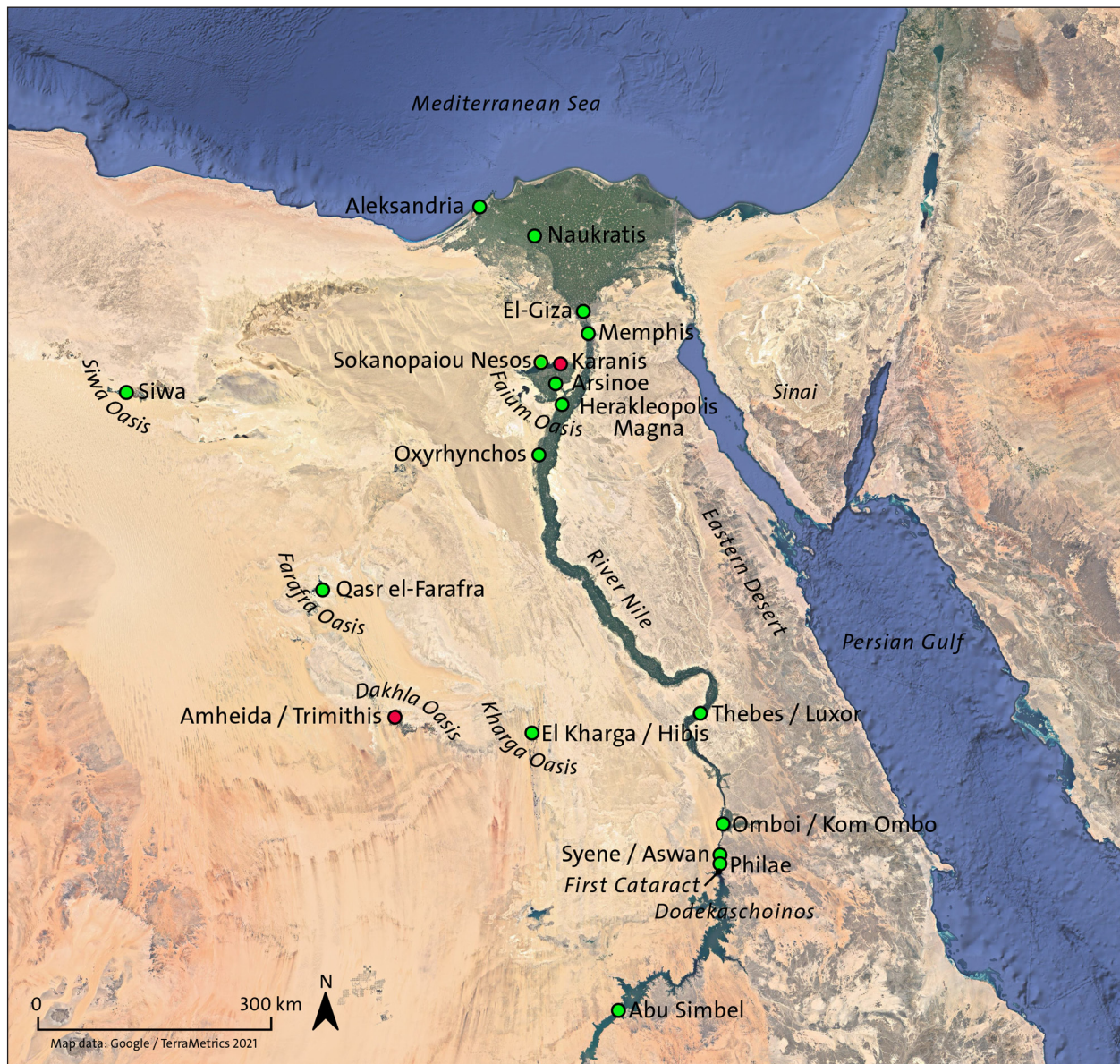


Figure 1 Map with locations of the case studies (Map Data: Google/TerraMetrics 2021. Drawing: Majja Holappa).

Under this approach, the spatial configuration of a building is converted into a graphical representation called the Justified Plan Graph (henceforth JPG) (Hillier and Hanson 1984; Hillier, Hanson and Graham 1987). The complexity of any built environment depends on boundaries artificially created by communities – such as walls and doors within a building – that affect the visibility and movement of people through space. The JPG provides a graphic access to the network of rooms and sets the boundaries for the follow-up quantitative computational analysis (Fladd 2017: 127–138; Ostwald 2011: 449–50; Steadman 2015: 114).

In archaeological analysis, space syntax can address two distinct phenomena: the first is the relationship between the inhabitants and visitors by analyzing the attributes of depth and choice (Ostwald 2011; Hillier et al. 1987); the second explores the differences and similarities of social groups within a community by comparing buildings (Fladd 2017: 127–138; Hillier

and Hanson 1984:15). Fladd (2017) argues that space syntax demonstrates the connection between space and social forces to such an extent that spatial changes may reflect societal shifts implemented by people in their active engagement with the built environment.

In the creation of the JPG, we selected the entrance of the building as the access point, or the root, while the different rooms translate into nodes. The connecting lines denote direct access represented by the presence of entryways (Letesson 2013; Hillier and Hanson 1984:97–148; Ostwald 2011). The rooms are then ordered according to their relative distance from the entrance; therefore, the depth level of each node is determined by its proximity to the root (initial access point) (Letesson 2013: 313–316; Ostwald 2011). The mathematical analysis of JPG was implemented following Ostwald's methodology (2011), while the architectural interpretation follows both Letesson (2013) and Fladd (2017).

Thus, we calculated the total number of nodes (K), the depth level (L) for each node in the JPG, and the total depth (TD), which is calculated by multiplying the total number of nodes by the level (L) they are at, and then summing the results.

$$TD = (0 \times n_x) + (1 \times n_x) + (2 \times n_x) + \dots (X \times n_x)$$

The Mean Depth (MD), which is the average value of depth of the nodes, was obtained by dividing the TD by the total number of spaces (K) minus the node itself (Ostwald 2011: 452).

Having acquired the K, TD and MD, we can then obtain Relative Asymmetry (RA), simply a normalization in terms of relative depth that allows us to understand which rooms were less segregated (closer to value 0) and which rooms were more segregated (closer to value 1). Computing the reciprocal of RA provides us with the degree of integration (i) of each room (Ostwald 2011: 453). Once we calculated RA and i for all the spaces, we elaborated a comparison in terms of privacy and isolation between rooms, and therefore between buildings with similar room numbers (Ostwald 2011: 452–3).

Another significant parameter, the Control Value (CV), determines the access points within a network system expressed as the location of natural congregation/passage (Ostwald 2011: 455–6). The calculation process analyses the JPG to see which nodes have a direct connection with the root. Then we find the NC_n value of each of those nodes, i.e., the total number of nodes that a space has a direct connection with. Afterwards, the distributed/shared value of each node is calculated by taking the reciprocal of the NC_n value.

$$Cve = \frac{1}{NC_n}$$

Moving forward, the CV of the root is the sum of the Cve values of each node that had a direct connection with the root (Ostwald 2011: 456).

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

The Difference Factor (H) determines whether a series of buildings with a similar scale have comparable spatial configurations. Ostwald calculated this by first finding the maximum RA (a), mean RA (b), and minimum RA (c) of a system. Then each Relative Asymmetry value (a, b, and c) is divided by the sum (t) of a, b, and c, multiplying the result by the natural logarithm of the same division. Once it is repeated for each RA value (a, b, and c), the summed value gives the unrelativized difference factor (H). The relative difference factor (H*) is a normalization of the (H) value (Ostwald 2011: 457).

As Ostwald's approach indicates, the potential of space syntax analytics is its nature as a relatively straightforwardly quantitative approach to characterise any given space. Rather than relying on potentially subjective and descriptive argumentation on what any given space is like and how it relates to the adjoining spaces, space syntax analytics produce repeatable metrics and computer simulations that denote, for instance, *exactly* how visible or reachable a space is within its own context, actually elevating itself to “social syntax” (Letesson 2013; Fladd 2017). This makes tasks such as ranking the rooms of a house based on how private they were considerably easier, and the results markedly simple to defend. Additionally, when space syntax analytics are combined with material culture, they provide the perfect environment to test hypotheses about cultural behavior (Fladd 2017); for example, if bathing is culturally considered to be a private matter, then the rooms with concentrations of bathing-related artifacts and features should show up in space syntax analytics results amongst the least reachable and visible rooms. The same could be applied in reverse to see if there are noticeable concentrations of thematic finds in the most visible and reachable areas, which would make the related activity likely to be moderately public and/or performative.

Depthmap open software requires an architectural plan in which walls and the openings are clearly drawn, since the software analyses the visual connection of each space according to the spatial organization (Turner 2004). The visibility graph communicates the degree of directly visible spaces with a consideration of visual and physical barriers by colour-coding the plan from blue (low visibility) to red (high visibility). On the other hand, the visual step depth analysis is done by choosing a strategic point within the building that holds importance in terms of visual properties. The openings and the communality aspect of a dwelling are the key factors for Roman and Egyptian domestic architecture; therefore, the entryways and the courtyards were picked in our case studies as strategic points to do the visual step depth analysis for this paper.

3. RESULTS

A. CASE STUDY 1: HOUSE B1 IN TRIMITHIS

House B1 has an early occupation count of 12 rooms (i.e., 11 rooms in addition to the staircase, Figure 2a); the house was then expanded in subsequent phases incorporating a neighboring structure (rooms 12–14) that was originally a school (Figure 2b) (Boozer 2015). For the purpose of this analysis we look at House B1 in its original configuration before expansion.

The spatial configuration of House B1 in Trimithis features a relatively symmetrical rhizomorphous

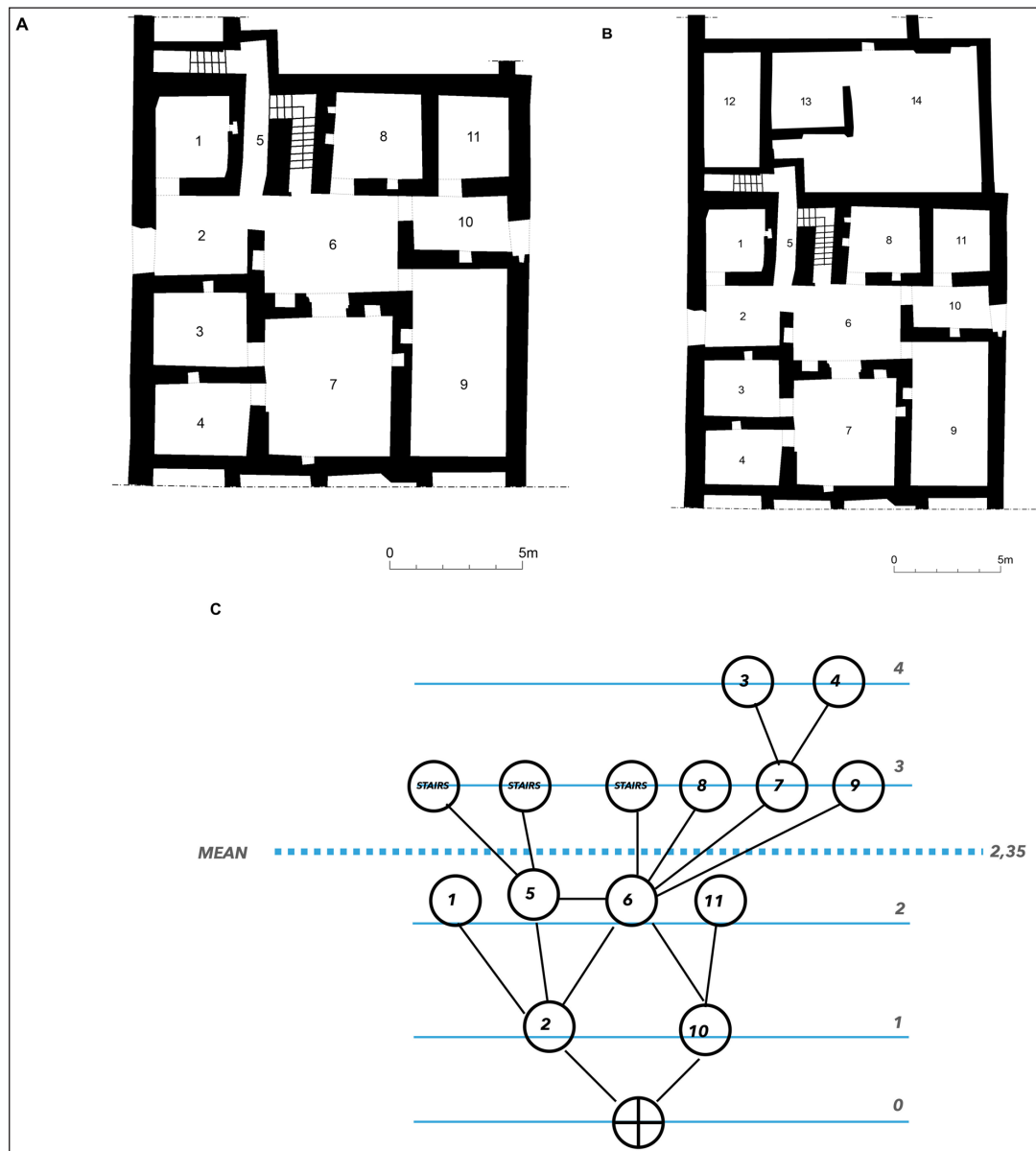


Figure 2 House B1 plan, **a.** Original house; **b.** The subsequent expansion (Drawing by Cansu Pylkkänen, adapted from Boozer 2015, figure 6); **c.** Justified Plan Graph.

structure with flexible circulation (Figure 2c). It is a ‘ring-like’, or ‘tree-like’, spatial distribution with a depth of four layers. The plan has a mean depth at 2.35, which means spaces at levels 3 and 4 are the least accessible – indicating a high level of privacy associated with these rooms. The arborescent spatial configuration reflects how rooms 7, 8, and 9 and the staircase are evenly connected with room 6 and present a hierarchical control system.

Two transitional spaces are linked directly to the exterior at depth 1, rooms 2 and 10. The double entrance diminishes spatial separation and control of space. These transitional rooms at depth level 1 lead to two rooms (1 and 11), which might have been used as storage, but also connect with two transitional spaces (rooms 5 and 6) (Boozer, 2012: 102). Room 5 connects the ground floor to the basement and upper level, and is directly linked to the most integrated room (room 6). House B1 is clustered around a central room (room 6), which serves as a critical

access point to the rest of the rooms. Room 7 provides access to private nodes of the house (rooms 3 and 4) (Boozer 2015: 193). According to Boozer (2012: 102), rooms 7, 3, and 4 were the most significant and intimate spaces based on the wall paintings, but this hypothesis is also confirmed by their spatial analysis in the JPG.

The data summary table presents the integration value of all spaces (Table 1). For House B1, the inequality genotype is: node 6 (4,00), node 2 and node 5 (both 3.12), exterior, node 7 and node 10 (all 2.77), node 8 and node 9 (both 2.50), node 1 (2.08), and node 3, node 4, node 11 (all 1.96).

The data reveals that room 6, the internal courtyard (*aithrion*), is also the least isolated and the most integrated space of the entire house, and as such it has impressive syntactic properties: 1) it connects directly to the majority of rooms; and 2) it is the space with the greatest natural attraction. The transition spaces, rooms

2, 5, and 10, are more integrated than the main living spaces. It would appear that they have a Control Value (CV) above 1.00. The data supports the fact that those spaces are important access points, and they obtain significant natural attraction right after room no. 6. Four living spaces – rooms 1, 3, 4, and 11 – all have quite similar attributes in terms of RA, *i*, and CV. They are all relatively deep and isolated spaces. Whereas the rest of the living spaces – rooms 8 and 9 – show morphological similarities among themselves, they share a low degree of isolation, integration, and natural attraction within the complex.

Analyzing the degree of variation among the integration values of different functions confirms room 6 as the most integrated space, followed by the transitional spaces, and lastly living spaces (Table 1).

The relative difference factor H^* for House B1 is 0.901 ($H = 1,0586$), which suggests the plan can be classified as a homogenized graph, in which the integration values are relatively equal.

In the visibility graph, the red zones indicate high visual integration as well as a high frequency of usage and movement of the space (Figure 3). The depth map, selecting the entrance as location to showcase visual depth, shows a high degree of heterogeneity regarding visual properties (Figure 4). While the graph also reiterates the natural attraction of room 6 as connector to the majority of rooms in the house, it also highlights that room 7 has comparable visual properties, which was not clear from the syntactical results. Hence, both rooms 6 and 7 are visually well integrated, while the other rooms feature degrees of visual segregation (Figure 3). Finally, room 6 also shows a high potential for visual control across the entire building.

#	space V α	TDn	MDn	RA	<i>i</i>	CV
0	exterior	33	2,35	0,36	2,77	0,58
1	1	44	3,14	0,48	2,08	0,33
2	2	30	2,14	0,32	3,12	2,39
3	3	47	3,35	0,51	1,96	0,33
4	4	47	3,35	0,51	1,96	0,33
5	5	30	2,14	0,32	3,12	2,39
6	6	23	1,64	0,25	4,00	3,16
7	7	33	2,35	0,36	2,77	2,14
8	8	37	2,64	0,40	2,50	0,14
9	9	37	2,64	0,40	2,50	0,14
10	10	33	2,35	0,36	2,77	2,14
11	11	47	3,35	0,51	1,96	0,33
Min		23,00	1,64	0,25	1,96	0,14
Mean		36,75	2,62	0,39	5,25	1,20
Max		47,00	3,35	0,51	3,12	2,39

Table 1 Data summary for House B1.



Figure 3 Visibility Graphs Analysis of House B1.

B. CASE STUDY 2: HOUSE C42 IN KARANIS

The spatial configuration of House C42 is a rhizomorphic plan that incorporates the courtyard in the ring, while the house develops as an arborescent plan (Figure 5 a–b). At the entrance level permeability is high, but well-defined areas within the house indicate spatial configuration based on hierarchical control. The building has a relatively deep plan made up of four layers.

The plan has a mean depth of 2.58, which means rooms 1, 2, 3, 6, 7, 8, 10, and 11 are the least accessible – moreover, the highest level of privacy was realized in room 3. Most of the living spaces are at intermediate depth with a balanced space division.

The transition spaces, rooms 9 and 4, the latter being the courtyard, are linked directly to the exterior at depth 1, providing alternative circulation options for the inhabitants as well as for visitors. According to Husselman (1979: 67–68), the courtyard had a stone pavement that provided direct access; one can access additional storage spaces (rooms 5 and 6). Room 5 and room 9 function as transitional space; they both lead to the staircase which provides access to the other rooms of the house, including the basement and the second storey.

The integration values of the nodes show that the transitional/storage rooms (5 and 9) are the most integrated spaces, followed by living spaces (rooms 1, 2, 8, 10, and 11) and the storage room (room 7), then the courtyard (room 4) and finally, the rest of the storage rooms (3 and 6) (Table 2). The four living spaces – rooms 1, 8, 10, and 11 – and the storage room – room 7 – share the same attributes in terms of RA, *i*, and CV. They are deep and segregated spaces that present the lowest degree of natural attraction in the complex. Room 3 is

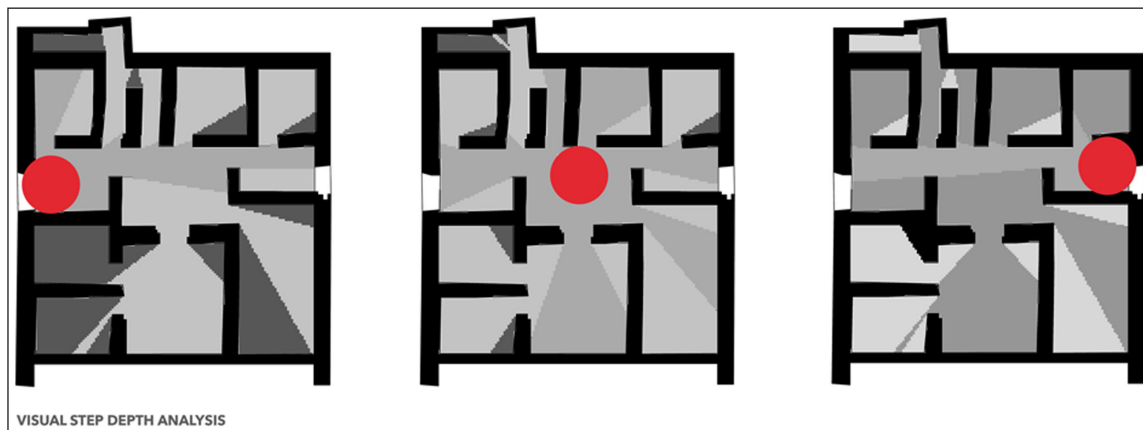


Figure 4 Visual Step Depth Analysis of House B1.

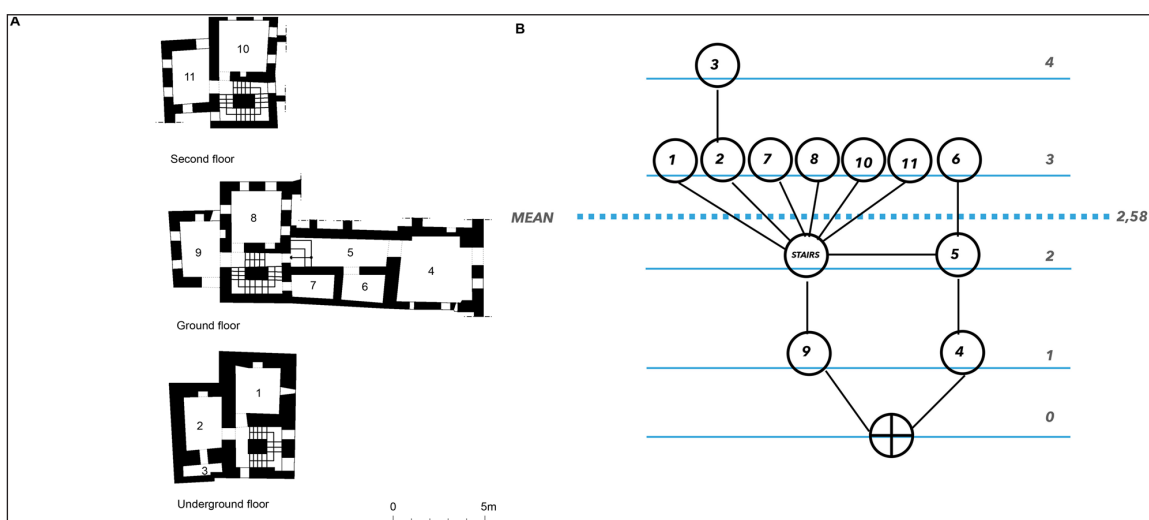


Figure 5 a. House C42 Plan (Drawing by Cansu Pylkkänen, adapted from Husselman 1979: 66); **b.** Justified Plan Graph.

#	space V α	TDn	MDn	RA	i	CV
0	exterior	31	2,58	0,46	2,17	1,00
1	1	27	2,25	0,40	2,50	0,13
2	2	25	2,08	0,37	2,70	1,13
3	3	36	3,00	0,54	1,85	0,50
4	4	30	2,50	0,45	2,22	0,83
5	5	22	1,83	0,33	3,03	1,63
6	6	33	2,75	0,50	2,00	0,33
7	7	27	2,25	0,40	2,50	0,13
8	8	27	2,25	0,40	2,50	0,13
9	9	24	2,00	0,36	2,77	0,63
10	10	27	2,25	0,40	2,50	0,13
11	11	27	2,25	0,40	2,50	0,13
Min		22,00	1,83	0,33	1,85	1,63
Mean		28,00	2,33	0,84	2,43	0,56
Max		36,00	3,00	0,54	3,03	0,13

Table 2 Data Summary for House C42.

the most secluded space situated at depth level 4 and the endpoint in the justified plan graph. Table 2 highlights that the transitional room 5 is the most integrated space, followed by room 9, then living spaces and storage rooms.

The relative difference factor H^* for House C42 is 0,834 ($H = 1,0314$), indicating a homogenized graph.

The depth map analysis, in which the observer is positioned at the entrances, shows a clear heterogeneity in terms of visual and syntactical properties (Figure 7). The visual analysis also confirms room 5 as a visually well integrated and naturally attractive space, which also emerges as a center for visual control. On the other hand, the courtyard (room 4) has a rather low integration value and does not stand out in terms of syntactical properties (Figure 6). The visibility graph pinpoints the staircase and the courtyard as having the highest visibility relationship among spaces within the complex. The visibility graph shows that House C42 has a ring layout reaching a depth of 4; rooms 1, 2, 5 and 4 are visually integrated and stand out in visual control while the rest of the house features a great degree of visual segregation (Figure 6).

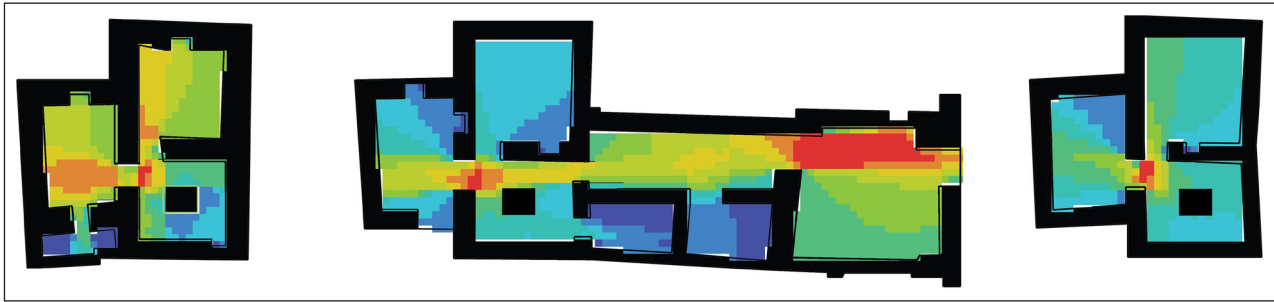


Figure 6 Visibility Graph Analysis of House C42.



Figure 7 Visual Step depth analysis of House C42.

4. DISCUSSION

Quantifying architecture with the methodologies of space syntax analytics and the follow up computational visualization has the potential to examine hybridization and cultural change through comparative lenses. Clearly, this interdisciplinary analysis could be useful in the Egyptian archaeological context, specifically in analyzing domestic structures. The Roman and Egyptian styles of domestic architecture have their own distinct and in many aspects opposite features: Roman architecture shows an ethos for rather public private life via visually open houses with shallow and clustered access between rooms, while Egyptian domestic architecture is generally more prone to closed floor plans with more straitened room access, but also ample courtyards with direct access from the entrance. These distinct starting points of architectural styles lend themselves well to studying the influences between them, prompting us to ask whether one design starts to resemble the other and if it does, to what extent? Tracking these similarities between different sites and buildings could provide a demonstrable way to map the advance of cultural influences. A further advantage to consider in the numerical nature of space syntax metrics might be in the possibility of refining the data further with statistical analysis like Correspondence Analysis, which could then yield interesting insights into the analysis of buildings.

In the comparisons between House B1 and House C42, the space syntax analysis provides us with quantitative data to equate relative depth, visibility, and symmetry in plans and movements. The comparison of TD – 47 in B1 and 36 in C42 – indicates that House B1 has the most

controlled room permeability, but both houses can be described as extended houses, in which additional space was created by either adding more floors, or acquiring the next-door building. The JPGs of Houses B1 and C42 showcase a division of the houses into two main sections; at first, houses have a flexible spatial composition, which then develops into a well-controlled hierarchical system. When comparing the spatial configurations, House B1 reflects more of a rhizomorphous structure with a high degree of permeability, while House C42 features both a rhizomorph and arborescent structure indicating an added level of complexity linked to the transformation of the building over time, but especially to the use of the ground and second floors as private spaces. This difference in movement is also reflected in the opening in the courtyard, room 4, sealed by the progressive elevation of the street due to debris; thus, in a relative short period of time, rooms 7, 6, and 5 were buried and disused (Husselman 1979: 67–68). In terms of communality and social interaction, we can see significant differences, as in House B1 the communality occurs in two central spaces. The first room (room 6), which is located at depth level 2, allows flexible accessibility throughout the house, whereas the second room (room 7) controls access to the most private areas. In House C42, the communal aspect was found in the courtyard, which had a direct connection to the entrance. After the closure of the entryway connected to room 4, transitional room 9 became the most integrated space, creating a direct analogue to the structuration and movements in House B1.

These comparisons emphasized that space syntax analysis can be used to gain new perspectives on the local

practices of movement and visibility in Egyptian-Roman domestic architecture, but it can likewise show its worth in corroborating archaeological data on the social aspects of architecture. This possibility is best demonstrated by using once more House B1 of Trimithis as an example. House B1 and its owner's cultural identity cannot be solely classified as Roman, Egyptian, or Greek according to the previous research, but as an amalgamation of these cultural identities, which is well-reflected in the architectural plan and space usage (Boozer 2012, 2015). The archaeological record of prestige items, elements of classical Roman education, and a depiction of a *pater familias* in a typically Roman dining setting, combined with the owner's position as a city councilor make the presence of Roman sensibilities and social power evident (Boozer 2012: 102–105). These findings are also in line with our results, as the house's syntactic properties show a clustered plan with designated open and accessible spaces befitting a Roman expression of status. Egyptian and Hellenistic elements are present more in construction and room disposition: for instance, the Egyptian vaulted ceiling and the Hellenistic features of interrupted line of sight in transitional rooms and food preparation spaces (room 11) easily connected with the second entrance. The inner walls of rooms 2 and 10, the transitional spaces, are another typical Egyptian architectural feature dictated by the need to stop sand from coming in with the wind. Roman influences are also reflected in the analysis of the house's permeability, visual properties, and central role of the courtyard (room 7). Aside from the use of walls as windbreakers, the characteristic Egyptian storage positioned under the staircase provides further evidence of the combination of Hellenistic and Egyptian canons alongside Roman design in the Trimithis domestic context (Boozer 2012: 108; Simpson 2014: 63). House C42 in Karanis presents more Egyptian features while still also characterized by Roman traits. A similarity to traditional Egyptian domestic context can be found in the accessible courtyard and the food preparation location near the entrance as well as the controlled access to living spaces, especially the one located on the upper floor. Roman influences are visible in the JPG plan and a hierarchical control system.

In closing, it is worth mentioning the limits of space syntax analysis. As space syntax analysis tools are mathematical, they consider only permanent planimetry. While the physical constraints of walls are easily translated into data that is analyzable, the same cannot be said of constraints which were created through movable objects such as furniture. Despite these blind spots, space syntax analysis remains a viable tool in analyzing humans and their relationships to their surroundings as long as the results are not treated as existing in a vacuum, but rather interpreted and cross-referenced holistically against previous knowledge. Finally, comparative spatial analysis has illustrated that quantitative analysis and visual tools

can be complementary to archaeological investigations and interpretation of the built environment. Although the results of space syntax are not always fruitful for fragmentary archaeological contexts, they can be a useful tool for visualizing and discussing the internal configuration of well-preserved spaces and people's movements through them. Our analysis here highlighted how Egyptian, Roman, and more Mediterranean traditions are integrally mixed in the domestic architecture of Roman Egypt.

ADDITIONAL FILES

The additional files for this article can be found as follows:

- **Supplementary Table 1.** House B1. DOI: <https://doi.org/10.5334/jcaa.95.s1>
- **Supplementary Table 2.** House C42. DOI: <https://doi.org/10.5334/jcaa.95.s2>

NOTE

- 1 <https://www.spacesyntax.online/software-and-manuals/depthmap/>.

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COMPETING INTERESTS

The authors have no competing interests to declare.

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