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Exploring the Impact of Privacy and Spatial Configuration on Living Efficiency in Residential Apartments of Duhok City

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ABSTRACT

This study examines the impact of privacy and spatial configuration on the efficiency of residential apartments in Duhok City, focusing on how these factors influence resident satisfaction and functional efficiency in urban housing. Using a mixed-methods approach, the research combines quantitative data from Depthmap X and A-Graph analyses with qualitative insights from interviews conducted with thirty-two residents across 13 apartment complexes. The findings highlight notable variations in spatial metrics such as Connectivity, Integration, and Control Value, which significantly correlate with residents' perceptions of privacy, spatial layout, and overall livability. For example, higher integration values were associated with increased social interaction but occasionally compromised privacy, while greater mean depth values enhanced privacy at the expense of social connectivity. These observations underscore the intricate relationship between architectural design and resident experience. The study advances urban planning and architectural design by showing that thoughtful attention to privacy and spatial configuration can substantially improve the functional efficiency of living spaces. Implications of this research include the formulation of design guidelines that balance individual privacy with communal interaction, potentially guiding future residential development projects in Duhok and similar environments.

1. INTRODUCTION

In residential architecture, the design of internal spaces significantly affects inhabitants' well-being and daily experience, with key factors like functional efficiency, privacy, and layout being crucial for comfort and functionality in densely populated areas, efficient use of space in apartment layouts is crucial for enhancing the livability and functionality of residential units, the optimization of apartment efficiency stands as a central focus in rapidly urbanizing regions like Duhok. Studies by Gong et al. [1] and Tawil et al. [2] emphasized the benefits of biophilic design and the psychological impact of interior aesthetics on emotional and cognitive responses, enhancing space functionality. In Duhok, where urban density is increasing, the design of efficient apartment layouts is imperative for improving life quality and ensuring sustainable living conditions, as emphasized by Muhammed et al. [3] and Hajani [4]. This study seeks to fill this research gap by examining the manner in which spatial Configuration in addition to privacy can improve the functionality of internal spaces in apartments in Duhok City, then, presenting the design factors that may be utilized to improve functionality and privateness of the internal spaces and the architectural suggestions that could be applied in subsequent projects. As far as prior studies are concerned, topographical settings and private domain are well-studied concepts in residential premises out of which Yamu et al. [5], Ghadir [6], and Obeidat et al. [7] have all focused upon on the impact of layouts on privacy and social relationships. Nonetheless, this research will pay more attention to a demonstration of how these configurations may be used to give more efficiency in people’s lives, something that is in line with sustainable and flexible urban residential designs. Conventional patrimonial architectures elude privacy through the strict vertical control of space [8, 9], while space syntax analysis gives directions on layout’s effects; Ostwald [10] has deme anointed such sweeping statement a risky oversimplification of social conduct. although these layouts are predominant in the analyzed region, the main emphasis is on the rational use of these layouts for the needs of a contemporary lifestyle and the growing need for comfort and functionality in homes. Thus, applying both quantitative and qualitative approaches in the context of this research, one can create a rich and multifaceted picture of the relationships between privacy, spatial configuration and apartment productivity. It will also suggest ways in which CAST’s vision of public housing addresses the changing requirements of its users and provides zones that are private and socially responsive while being highly productive. The ultimate aim is to generate suggestions that can be substantiated and proven to optimize the designs and layouts of apartments that will ease future living in urban centers. The study will adopt both quantitative and qualitative methods in evaluating the apartment plans, the analysis will postulate what various layouts of a home have on privacy and efficiency and show them potential modifications that will enhance future apartment living. This systematic strategy aims to close the gap in architectural perception of interior volumes and consequently improve the quality of inhabitation by means of knowledge.

1.1 Privacy and spatial configuration

Privacy and spatial configuration are very crucial features in architectural design and are majorly related to sociocultural contexts. It is an important factor regarding the functionality and well-being of the residential space. Privacy is the control of personal boundaries to manage social interactions to delineate private from public spaces in addition to enhancing well-being through reflecting cultural values and expectations[5, 10-12]. In conservative societies, privacy is structured in layers among neighbors, genders, and families, affecting the dynamics between semi-public and private and private spaces and influencing the design of accessible home areas [13, 14]. Spatial configuration is the optimization of spaces' layout about the functions and socialization it would provide, influencing the inter-relationships of rooms, movement, and sightlines, which in turn influence the courses of daily lives and perceptions of the residential environment [15]. Architectural design that effectively allows for the private conducting of activities also provides accessible and open spaces for social interaction. This equilibrium increases aesthetic beauty and psychological comfort, with increased efficiency of space to accommodate diverse activities and private needs.

1.2 Morphological analysis of space layouts (Space syntax analysis)

A few smart people came up with space syntax in the late 1970s as a method of exploring the impact of our social and cultural life on the design of spaces and places [16]. It is all about understanding how social interactions and structures find reflections in the layout of space, showing us how the design of a building can tell us so much about community values [17, 18]. They do this using a few cool techniques such as the Visibility Graph Analysis (VGA) and J-Graph and the UCL Depthmap X and A-Graph software tools so they can see how the various spatial designs may affect things, for example, how private space feels or how easy it is to see around. One of the key aspects that they look at is known as visual integration, which measures how different areas are visible from a particular point within a space. The hypothesis is that the more integrated a space is, the less private, because it's easier to see and be seen [19]. But space syntax does not rely simply on visibility. It also takes into account how easy it is to get to different rooms or areas, using something known as justified access graphs. This helps in determining how "deep" one is within the building from a given point and organizes the spaces according to their accessibility: offering insights into the layout's complexity with things like Mean Depth (MD), Integration Value, and Relative Asymmetry (RA) [20]. These parameters stand for the influence of the usage of space on the interactions of the residents within and between areas and influence the privacy levels [21]. Privacy levels can be gauged depending on the symmetry/asymmetry and spatial depth; lower MD indicates higher integration, and the other way round. RA is between 0 and 1, where low shows integration and high shows segregation. The RRA gives the most integrated or most segregated spaces [22-25].

1.2.1 Space syntax parameters

Space syntax employs various metrics in Depthmap X and A-Graph software to analyze spatial configurations. In Depthmap X, parameters like Connectivity, Integration HH, Visual step depth, and metric step depth are assessed, while A-Graph calculates Control Value (CV), Total Depth (TD), Mean Depth (MD), Relative Asymmetry (RA), and integration Value (I).

1) Connectivity: This parameter measures the number of direct connections a space has with other spaces. A higher connectivity value often indicates a central or transitional space, which may influence its role as a communal or public area within the apartment, impacting its functional efficiency [5, 26].
2) Integration HH (Global Integration): This metric gauges the accessibility or centrality of space within the entire network. Spaces with higher integration values are typically more accessible and may experience more foot traffic, potentially affecting privacy levels. These spaces often facilitate movement and interaction, which can enhance functionality for communal activities but may reduce privacy in private zones like bedrooms [5, 26].
3) Visual Step Depth (VSD): Measures the number of visual changes or turns one has to make to move from one point to another within a layout. It is primarily concerned with how many times your line of sight is interrupted, making it a measure of visual connectivity and continuity within a space [5, 26].
4) Metric Step Depth (MSD): On the other hand, calculates the shortest physical distance (often in meters) that needs to be covered to traverse between two points. Unlike VSD, which focuses on visual perception, MSD provides a quantitative assessment of physical distance, emphasizing the actual walking path or route that would be taken [5, 26].
5) Control Value (CV): Control Values are calculated by allowing each node to distribute a total value of 1 equally among its connected nodes. The Control Value of node n, CV(n), represents the total value node n receives during this distribution [27, 28].
6) Total Depth (TDn): The Total Depth for a node n, TD(n), represents the sum of the shortest distances from node n to all other nodes within the system, essentially the total of line n (or column n) in the distance matrix [27, 28].
7) Mean Depth (MDn): The Mean Depth for node n is calculated as the average of the shortest distances from node n to every other node in the system. If k represents the total number of nodes, then $MD(n) = TD(n)/(k-1)$ [27, 28].
8) Relative Asymmetry (RA): This metric describes a node's integration with a value between (or equal to) 0 and 1, where a low value indicates high integration. RA is calculated using the formula $RA = 2*(MD-1)/(k-2)$ [27, 28].
9) Integration Value (i): Contrasting with RA, the

Integration Value describes a node's integration with a higher number reflecting higher integration, calculated as i = 1/RA [27, 28].

2. METHODOLOGY

This research investigates the impacts of privacy and spatial configuration on the efficiency of internal space in Duhok City's residential apartments. Employing a mixed-methods approach, our methodology combines quantitative spatial analysis with qualitative resident interviews; the following sections detail the six steps taken to ensure a comprehensive and robust examination of the spatial and experiential aspects of apartment living (see Figure 1).

2.1 First step: Targeted sampling

This study evaluates the efficiency of internal spaces within two-bedroom and three-bedroom residential apartments in Duhok City, focusing on privacy and spatial configurations. To ensure a comprehensive dataset, the selection has been expanded to include apartments of varying types, popularity, economic factors, building ages, and household compositions. Apartments were chosen from thirteen strategically selected multi-family housing complexes, emphasizing layout complexity, size, and diversity in spatial arrangements. This approach captures a broad spectrum of data across different socio-economic backgrounds, building periods, and family structures, enhancing the understanding of residential space utilization.

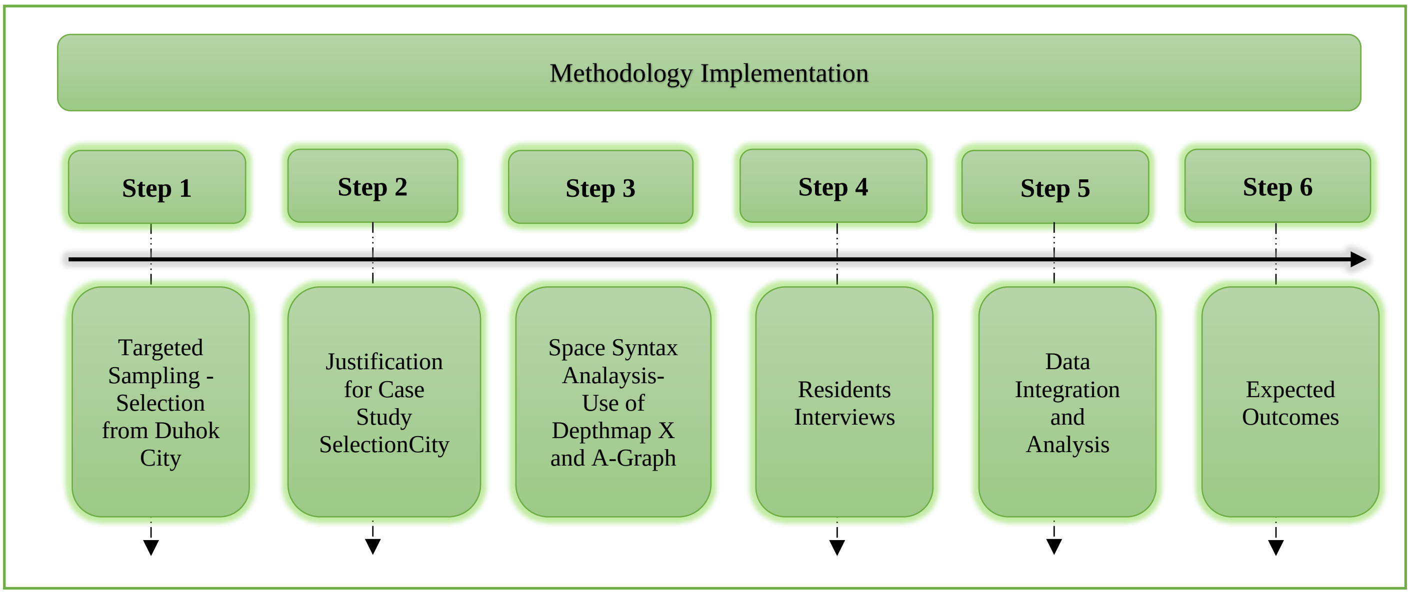


Figure 1. Research methodology steps
Source: The Researcher

2.2 Second step: Justification for case study selection

The case studies chosen for this study are Avro City, French Village 1, Kayar City, Waar City, Rami Land, Nauro City, Lelav City, MRF City, French Village 2, Newland, Zari Land, Bariz City and Lelav Golden Park. These complexes are among the most favored residential areas in Duhok City, known for their architectural diversity. The selection criteria included:

I. Popularity and Residential Preference: To ensure the study's findings are relevant to the majority of Duhok's urban residents.

II. Diversity in Design and Layout: To enable a detailed comparative analysis of different spatial configurations and their impacts on privacy and efficiency.

III. Economic Factors: Apartments were selected to represent diverse economic levels to better understand the influence of socioeconomic status on spatial needs and privacy concerns.

IV. Building Age: Included a range of building ages to examine how historical and modern design principles affect living efficiency and privacy.

V. Household Composition: Selections also considered various household compositions to reflect the dynamic needs of single residents, couples, and larger families.

VI. Detailed Plans and Accessible Demographic Data: For thorough spatial analyses and a strong validation of theoretical models against actual usage.

VII. Geographical and Demographical Diversity: To provide insights about location- and community-specific factors in architectural decisions and resident experiences.

1) Avro City: Positioned near the Tenahi District in Duhok, Kurdistan, represents a significant urban residential development, covering an expansive 81.7 hectares. Initiated in 2007 and developed by Gorbag and Guinsal Companies, the project is notable for its integration of modern architectural styles with elements of local heritage. The development boasts a wide array of apartment configurations such as 2+1, 3+1, and 4+1, each differing in size and number of bedrooms to accommodate diverse residential needs and preferences, with a focus on three-bedroom units that enhance comfort, security, and community living. Designed to house over 23,300 residents, Avro City includes 4,532 apartments and 93 villas spread across buildings ranging from 8 to 14 stories. Avro City not only addresses the demand for quality housing but also plays a pivotal role in augmenting the urban fabric of Duhok, contributing to its ongoing growth and development (Avrocity Administration, 2024).

2) Rami Land: Rami Land is a high-rise residential multi-family housing project located on the west of Duhok City at (an 8 km) distance from the city center. It contains (448) dwellings of one type of (3+1) dwellings (Rami Land Administration, 2024).
3) Nauro City: Nauro City is a high-rise residential multi-family housing project located on the west of Duhok City at (an 8.6 km) distance from the city center. It contains (720) dwellings of one type of (3+1) dwellings (Nauro City Administration, 2024).
4) Kayar City: Kayar City in Duhok is a prominent high-rise, multi-family residential project situated just 0.5 kilometers from the city center. This expansive development, designed by Alaa Architect, covers 12,619 square meters and includes 64 buildings, comprising both villas and apartments. The project features 760 units of the 3+1 apartment type—each with three bedrooms plus an additional room—aimed at fostering a community-centric, family-friendly environment. Conforming to Iraqi standards, Kayar City provides essential amenities like green spaces and educational facilities, promoting a comprehensive lifestyle. The combination of recreational and everyday services enhances its attractiveness to both local and international residents, positioning Kayar City as a standout example of contemporary urban development in the area (Kayar City Administration, 2024).
5) Lelav City: Lelav City is a complex of residential multi-family housing located in the east of Duhok City (a 6.4 km) distance from the city center. It contains (1292) dwellings of types of dwellings; (2+1), and (3+1) and dwellings (Lelav City Administration, 2024).
6) Waar City: This is a low-rise residential multi-family housing project located in the south of Duhok City (11.5 km) distance from the city center. It contains (1632) dwellings of one type of (3+1) dwellings (Waar City Administration, 2024).
7) French Village 1: Duhok's French Village 1 epitomizes high-end living, sprawling across 65,000 square meters adjacent to the picturesque Zawa Mountain. This distinguished complex, completed in 2021, features seven 23-story towers and 69 villas, all crafted by Ava Gara Company to meet Iraqi architectural standards. The development offers two apartment layouts, 2+1, and 3+1—each providing varying sizes and bedroom counts to accommodate a range of living requirements. Starting at $74,500, the amenities at French Village 1, including lush greenery and recreational facilities, position it as a premier choice for luxurious living. It establishes a new standard for upscale residential environments in the area, marrying modern comforts with the serene setting of its mountainous surroundings (French Village 1 Administration, 2024).
8) MRF Complex: The MRF Complex is a residential multi-family housing development situated on the eastern edge of Duhok City, approximately 5 kilometers from the city center. It encompasses a total of 1,292 dwellings, available in four distinct configurations: 3+1. This unit type offers residents a range of options to suit different family sizes and lifestyle needs, making the MRF complex a diverse and vibrant community (MRF Complex Administration, 2024).
9) French Village 2: French Village 2 is a distinguished residential complex in Duhok, strategically located near Kevla di Strict, offering (2+1) and (3+1) apartments. This variety ensures a match for different lifestyles and family sizes, enriching the community with luxury amenities and scenic surroundings, only 10 minutes from the city center (French Village 2 Management, 2024).
10) New Land: New Land is a mid-rise residential complex located in the eastern part of Duhok, approximately 7.1 km from the city center. It features 300 (2+1) apartments, offering a consistent and unified living experience ideal for those seeking a modern and streamlined community setup (New Land Management, 2024).
11) Bariz City: Barz City is a mid-rise residential project located on the eastern side of Duhok, approximately 6.6 km from the city center. The development comprises 400 uniform (3+1) apartments, creating a cohesive and contemporary residential environment for its community (Bariz City Management, 2024).
12) Zari Land: Zari Land is a residential complex located on the western side of Duhok, just 3 km from the city center. This development offers 808 dwellings, available in (2+1) configuration, catering to diverse family sizes and providing a variety of living options within a close-knit community (Zari Land Management, 2024).
13) Lelav Golden Park: Lalav Golden Park, one of Iraq's largest housing developments, is prominently located in Duhok Domis. This extensive project comprises 41 buildings with a total of 2520 (3+1) housing units, and it features parks, hospitals, shops, and more, making it a prime destination for those seeking convenience, luxury, and tranquility (Lelav Golden Park Management, 2024).

2.3 Third step: Space syntax analysis (morphological analysis)

1) Depthmap X: This software will be used for visual graph analysis (VGA) of selected apartment plans to generate quantitative data on visibility and movement patterns. The focus will be on how spatial arrangements influence movement and interaction within the apartments, capturing key spatial data metrics such as Global Integration, Connectivity, and Depth.
2) A-Graph Software: This tool will be used to analyze the spatial configuration of apartments, assessing adjacency and accessibility of different spaces. It helps understand spatial connectivity and its effect on privacy and space utilization, complementing VGA by depicting the relational ties between spaces and their impacts on privacy levels.

2.4 Fourth step: Resident interviews

In the selected complexes, structured interviews will be conducted with residents across diverse age groups to understand the impacts of privacy and spatial configuration on internal space efficiency. The questionnaire, consisting of 30 questions, employs a mix of 5-point Likert scale items for quantifiable insights and open-ended questions for qualitative depth. Topics covered include:

i. Privacy Concerns: Evaluating residents' sense of privacy through both scaled questions on perceived privacy levels and open responses on privacy experiences.
ii. Functional Efficiency: Assessing how effectively the

spatial layout meets residents' needs, with scaled questions on functionality and open-ended responses for detailed examples.

iii. Design Impacts: Exploring the influence of architectural design on residents' lifestyles, including preferences and satisfaction related to spatial aesthetics and utility.

The participant selection includes a balanced representation of younger (18-35), middle-aged (36-55), and older (56 and above) residents to ensure data diversity reflecting varied life stage needs and preferences. This methodological approach, combining quantitative and qualitative data, enriches our dataset and strengthens the comprehensiveness of our analysis.

2.5 Fifth step: Data integration and analysis

This means that data from the Depthmap X and A-Graph analyses will be married to what is captured through the resident interviews. It is a mixed-method approach that will enable one to perform correlation and comparative analyses as a means to determine if there are relationships between the measured spatial attributes with the experiences of the residents and to ascertain the most optimum design practices. Visual representations are created to describe the main findings.

2.6 Six step: Expected outcomes

The study aims to provide a comprehensive understanding of how privacy and spatial configuration impact the functionality of residential spaces. The findings are expected to identify key design elements that enhance or detract from privacy and functionality, inform architectural practices, and guide urban planning and policy decisions, offering evidence-based recommendations based on resident needs and preferences.

3. RESULTS

3.1 Qualitative results (interviews results)

Interviews with thirty-two residents of two-bedroom and three-bedroom apartments across 13 complexes in Duhok City provided deep insights into how privacy and spatial configuration contribute to the functional efficiency of their living spaces. The participants comprising 34% males and 66% females, of younger (18-35), middle-aged (36-55), and older (56 and above) residents to ensure data diversity reflecting varied life stage needs and preferences, discussed themes of privacy, spatial layout and general liveability in alignment with quantitative findings from Depthmap X and A-Graph analysis. Regarding privacy, 28 participants noted the benefits of strategic architectural elements. R01 appreciated the "strategic placement of bedrooms away from living areas enhancing privacy and reducing noise disruptions," while R15 emphasized the "functional separation of children spaces, improving family activity flow" R29 added, "the visual and acoustic privacy from well-designed entryways and corridors significantly boosts comfort and utility". For spatial layout, R18 highlighted, "Our apartments efficient layout makes every square foot functional, reducing clutter and enhancing livability", and R22 celebrated the "line of sight from kitchen to living room, fostering better family interaction. R26 commented on the "smart positioning of windows and doors that optimize natural light and airflow, making our spaces feel more inviting and livable." General livability comments included R30's insight on storage, "Integrated storage solutions enhance our day-to-day efficiency," and R04's point about versatility, "Multipurpose rooms that adapt for work or leisure greatly increase our home's functional use." Additionally, R31 reflected, "The balcony's conversion into a semi-outdoor space provides a flexible area that enriches our home environment." These enriched responses underscore the strong connection between architectural design decisions and the practical, daily benefits experienced by residents, demonstrating that thoughtful consideration of privacy and spatial configuration can dramatically improve the functionality and efficiency of residential apartments.

3.2 Quantitative analysis results

3.2.1 Presentation of data

Our study conducted a detailed analysis of spatial configurations within thirteen residential apartment complexes in Duhok City, differentiating between three-bedroom and two-bedroom units. The findings are meticulously organized:

I. Visual and Metric Analysis: Tables 1 and 2 showcase the results for three-bedroom and two-bedroom units respectively, using Depthmap X for spatial configuration metrics (Connectivity, Global Integration, Visual Step Depth, and Metric Step Depth) and A-Graph for analyzing (Total Depth, Metric Depth, Integration RRA and Control Values.)

II. Quantitative Data: Tables 3 and 4 display numerical data derived from the aforementioned analyses, highlighting key spatial attributes.

3.2.2 Analysis process

I. Data Preparation: We started with 2D architectural plans, simplifying them by removing non-structural elements such as furniture and decorations to enhance accuracy in subsequent analyses in Autocade Software.

II. Software Tools:
- Depthmap X: Used to calculate spatial configuration metrics, focusing on how different layouts influence resident movement and interaction.
- A-Graph: Applied to assess deeper spatial syntax elements, including Mean Depth and Control Value, crucial for evaluating privacy levels.

III. Statistical Analysis:
- Data Processing: After extracting data from the software, we used Excel for preliminary data processing, calculating mean values and standard deviations to understand variability and trends.
- Correlation and Regression Analysis: To discover the associations between spatial metrics and perceived resident privacy and functionality, correlation analysis was conducted to find out the significant relationships, and regression models were used to estimate the effect of design features on the outcomes of resident experience (Tables 1, 2, 3 and 4).

3.2.3 Explanation of spatial metrics (Depthmap X and A-Graph)

I. **Connectivity:**

- Graphical Representation: Shaded with blue color in Depthmap X visualizations which means that areas with deeper blue are more connected and thus, residents of the apartment have easier access to each other and interact more often with one another.
- Numerical Correspondence: The numbers in the tables correlate with the darker blue shades, indicating that the regions marked with these shades improve accessibility and social contact, quantifiably supporting the apartment's design within the layout.

II. **Global Integration:**

- Graphical Representation**:** Shown using a gradient from green to red in Depthmap X graphs, with red highlighting the most integrated areas at the heart of the apartment's social and movement dynamics.
- Numerical Correspondence**:** Numerically higher values match the redder areas in the graphs, denoting spaces that are central and accessible to the majority of other spaces, thereby enhancing potential social interactions.

III. **Visual and Metric Step Depth:**

- Graphical Representation: Depicted by transitioning from yellow to deep purple, where darker purples indicate zones of greater seclusion or depth within the apartment, suggesting areas enhanced for privacy.
- Numerical Correspondence: Larger numbers in Tables 3 and 4 reflect these darker purple areas, quantifying the extent of seclusion and indicating spaces that are physically or visually less accessible from common areas.

IV. **A-Graph Analysis:**

Graphical Representation:

- Utilizes node-link diagrams, where:
- Nodes indicate different spaces within the apartment, with size and color representing control values and depth. Larger, darker nodes signify strategic areas with higher control or depth.
- Links between nodes highlight connectivity and spatial flow.

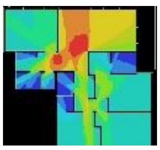
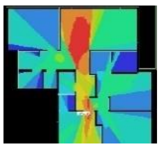
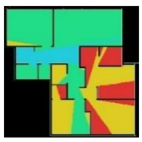
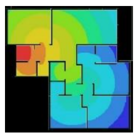
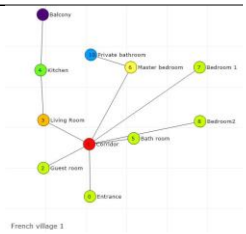
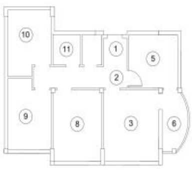
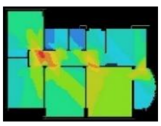
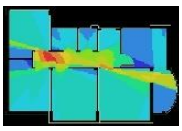
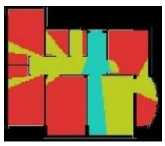
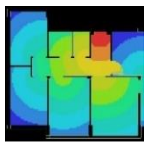
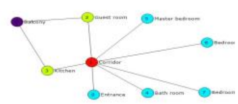
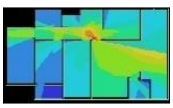
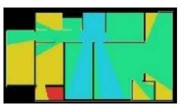
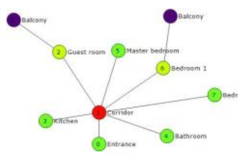
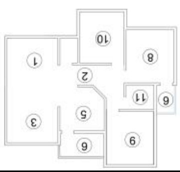
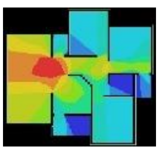
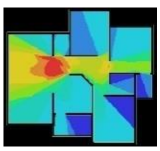
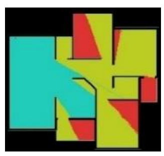
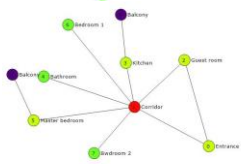
Color Coding and Size Indication:

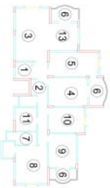
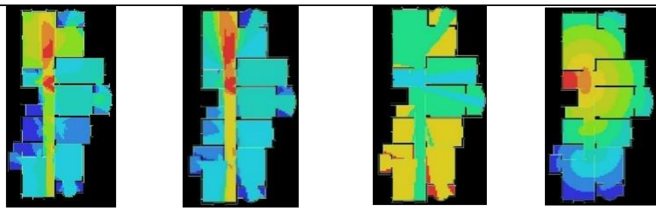
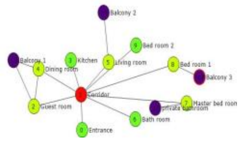
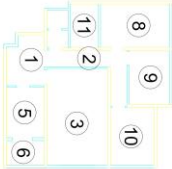
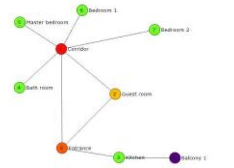
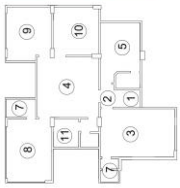
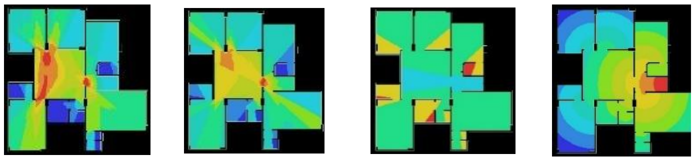
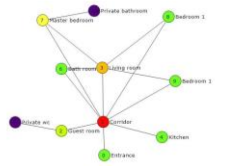
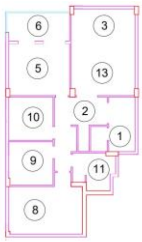
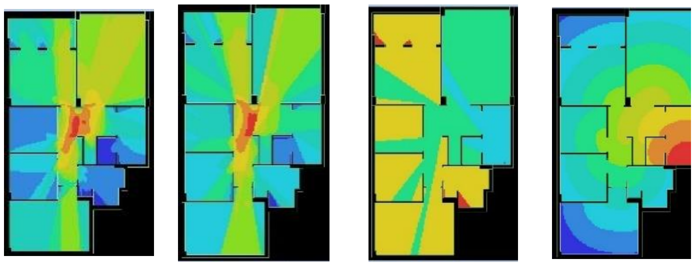
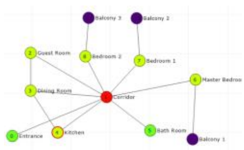
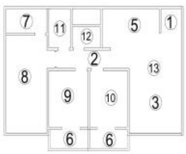
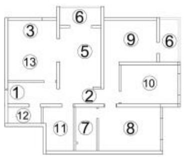
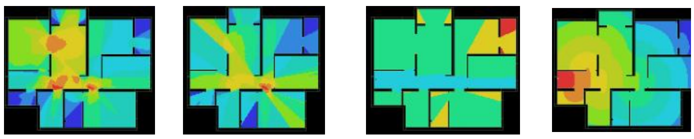
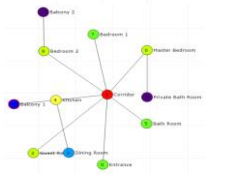
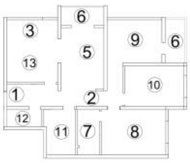
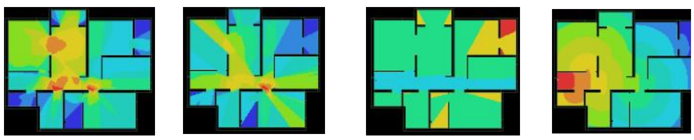
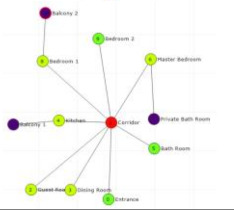
- Integration: Vibrant hues (like red or orange) on nodes denote higher integration, suggesting central and accessible areas.
- Depth (Total and Mean): Deeper shades indicate greater seclusion, marking less accessible, private areas.
- Control Value: Node size correlates with Control Value, with larger nodes showing significant influence on movement and interaction.

Numerical Correspondence:

- Integration, Depth, and Control Value: Tables 3 and 4 numerically reflect the graphical attributes—brighter and larger nodes have higher values, pointing to their key roles in accessibility and resident dynamics.

Table 1. Space syntax analysis for three-bedroom units in Duhok using Depthmap X and A-Graph

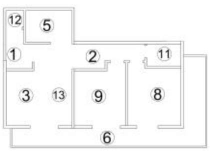
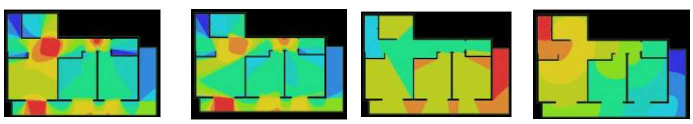
Spatial Configuration Metrics							
No.	**Residential Apartment Name**	**Apartment Plan**	**Connectivity Graph (Depthmap X)**	**Global Integration Graph (Depthmap X)**	**Visual Step Depth Graph (Depthmap X)**	**Metric Step Depth Graph (Depthmap X)**	**J-Graph**
1	French Village 1						
2	Waar City						
3	Kayar City						
4	Rami Land						

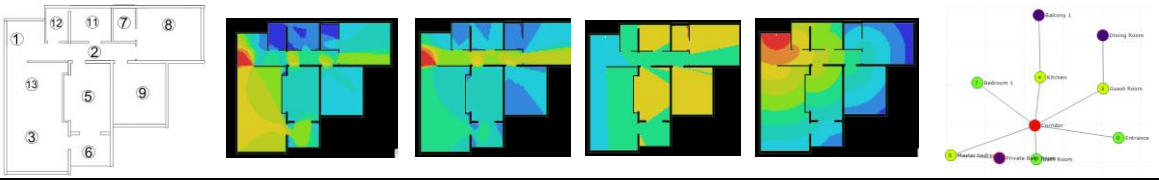
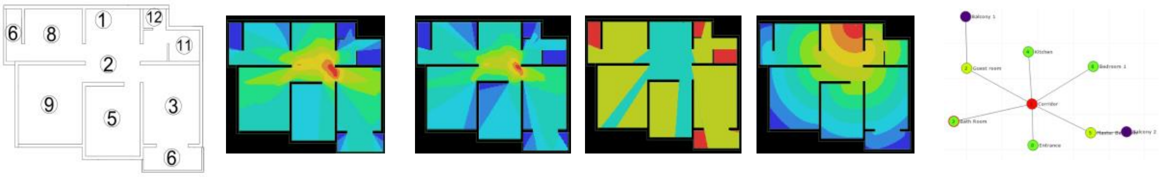
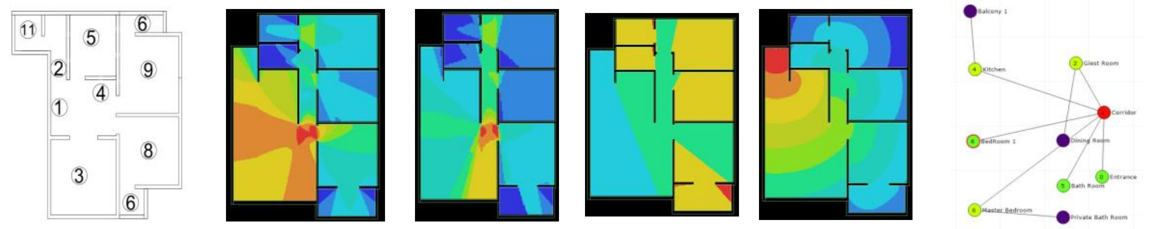
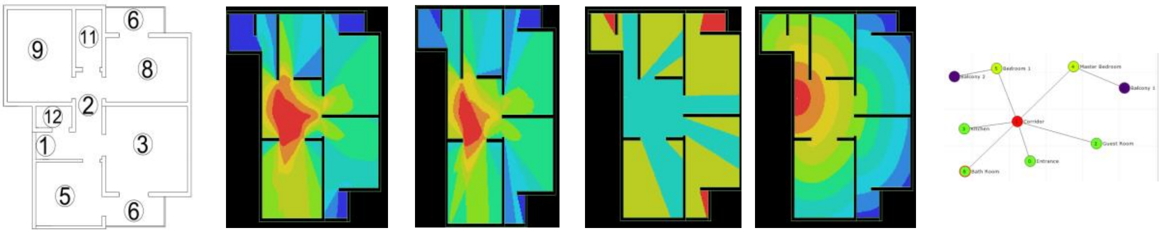
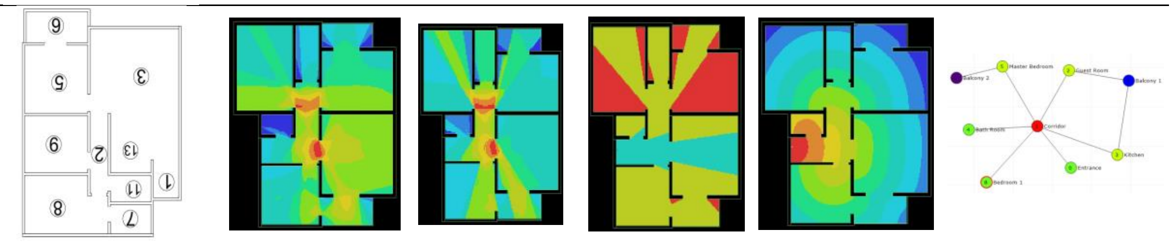
5	Avro City						
6	Nauro City						
7	Lelav City						
8	MRF Project						
9	French Village 2						
10	Golden Park						
11	Bariz City						

Notes : 1-Entrance 2-Corridor 3-Guest Room 4-Living Room 5-Kitchen 6-Balcony 7-Private Bath Room 8-Master Bedroom 9-Bedroom 1 10-Bedroom 2 11-Bath Room 12-WC 13-Dining Room

Source: The Researcher

Table 2. Space syntax analysis for two-bedroom units in Duhok using Depthmap X and A-Graph

			Spatial Configuration Metrics				
No.	Residential Apartment Name	Apartment Plan	Connectivity Graph (Depthmap X)	Global Integration Graph (Depthmap X)	Visual Step Depth Graph (Depthmap X)	Metric Step Depth Graph (Depthmap X)	J-Graph
1	French Village 1						

2	Avro City	
3	Lelav City	
4	French Village 2	
5	New Land	
6	Zari Land	

Notes: 1-Entrance 2-Corridor 3-Guest Room 4-Living Room 5-Kitchen 6-Balcony 7-Private Bath Room 8-Master Bedroom 9-Bedroom 1 10-Bedroom 2 11-Bath Room 12-WC 13-Dining Room

Source: The Researcher

Table 3. Combined VGA and A-Graph results for three-bedroom apartment layouts in Duhok using Depthmap X and A-Graph

		Depthmap X Analyses			
Apartment No.	**Residential Apartment Name**	**Average VGA Connectivity Value**	**Average VGA Global Integration**	**Average VGA Visual Step Depth**	**Average VGA Metric Step Depth**
1	French Village 1	5320.67 Std Dev/2268.49	9.00376 Std Dev/2.46574	2.50798 Std Dev/0.868125	9.57456 Std Dev/03.83358
2	Waar City	1388.89 Std Dev/416.811	9.32129 Std Dev/2.37241	2.44375 Std Dev/0.710973	616.668 Std Dev/195.945
3	Kayar City	5845.44 Std Dev/2928.79	10.5968 Std Dev/2.68369	2.10433 Std Dev/0.728561	7.38979 Std Dev/2.74014
4	Rami Land	5664.86 Std Dev/2811.95	11.9933 Std Dev/3.89613	1.78486 Std Dev/0.700823	8.39214 Std Dev/3.36253
5	Avro City	743.334 Std Dev/377.222	7.80168 Std Dev/ 2.40349	2.32458 Std Dev/0.713911	940.078 Std Dev/374.45
6	Nauro City	2027.23 Std Dev/831.21	8.39006 Std Dev/2.10024	1.8022 Std Dev/0.546712	727.288 Std Dev/321.585
7	Lelav City	6165.67 Std Dev/2732.29	11.2932 Std Dev/3.03201	2.07388 Std Dev/0.557855	8.30751 Std Dev/3.0174
8	MRF Project	3083.69 Std Dev/1288.42	11.0022 Std Dev/2.69616	21.8022 Std Dev/0.546712.4138 Std Dev/0.6669	937.087 Std Dev/318.388
9	French Village 2	11307.08 Std Dev/5536.87	12.2765 Std Dev/4.1135	2.33072 Std Dev/0.870331	9.27891 Std Dev/3.99518
10	Golden Park	2407.43 Std Dev/1020.96	9.32129 Std Dev/2.37241	2.01913Std Dev/ 0.593788	851.656Std Dev/ 335.535
11	Bariz City	2407.43 Std Dev/1020.96	9.32129 Std Dev/2.37241	2.01913Std Dev/ 0.593788	851.656Std Dev/ 335.535

A-Graph Analyses					
Apartment No.	Mean Total Depth (TDn)	Mean Depth (MDn)	Mean Relative Asymmetry (RA)	Mean Integration Value (i)	Mean Control Value (CV)
1	23	2	0	4	1
2	15	1	0	6	1
3	19	2	0	4	1
4	18	2	0	5	1
5	30	2	0	5	1
6	17	2	0	3	1
7	20	2	0	6	1
8	15	1	0	6	1
9	24	2	0	5	1
10	25	2	0	4	1
11	24	2	0	5	1

Source: The Researcher

Table 4. Combined VGA and A-Graph results for two-bedroom apartment layouts in Duhok using Depthmap X and A-Graph

Depthmap X Analyses					
Apartment No.	**Residential Apartment Name**	**Average VGA Connectivity Value**	**Average VGA Global Integration**	**Average VGA Visual Step Depth**	**Average VGA Metric Step Depth**
1	French Village 1	10368.3 Std Dev/4406.47	12.8138 Std Dev/3.24226	2.48532 Std Dev/0.888637	4.48339 Std Dev/3.8399
2	Avro City	2371.98 Std Dev/971.319	9.8755 Std Dev/2.49552	2.24328 Std Dev/0.733764	750.766 Std Dev/292.154
3	Lelav City	8952.86 Std Dev/3582.41	13.5792 Std Dev/3.46365	1.79519 Std Dev/0.541461	5.9576 Std Dev/2.16253
4	French Village 2	12636.8 Std Dev/6029.26	10.7891 Std Dev/3.40656	2,19196 Std Dev/0.813015	9.61212 Std Dev/3.56659
5	New Land	9780.49 Std Dev/4326.42	13.3983 Std Dev/4.13412	1.600762 Std Dev/0.548757	5.33192 Std Dev/2.16677
6	Zari Land	7977.49 Std Dev/2375.61	12.333 Std Dev/2.59237	2.09742 Std Dev/0.629699	5.82486 Std Dev/1.87038
A-Graph Analyses					
Apartment No.	**Mean Total Depth (TDn) (A-Graph)**	**Mean Depth (MDn)**	**Mean Relative Asymmetry (RA)**	**Mean Integration Value (i) (A-Graph)**	**Mean Control Value (CV) (A-Graph)**
1	16	2	0	4	1
2	20	2	0	4	1
3	16	2	0	4	1
4	20	2	0	4	1
5	16	2	0	4	1
6	16	2	0	4	1

Source: The Researcher

4. DISCUSSION

The in-depth analysis of space syntax parameters across 13 residential apartment complexes in Duhok City, when integrated with qualitative feedback from interviews and how the results support or refute hypotheses as below:

4.1 Connectivity and global integration

In the analysis of connectivity and global integration within French Village 1 (Table 3), the low connectivity value of 9.00376 indicates a design tailored to minimize social interruptions by reducing direct connections between units, thereby enhancing the privacy of the living spaces. This aspect of the design is vividly supported by qualitative feedback from resident R01, who values the strategic placement of bedrooms away from living areas to boost privacy and minimize noise disruptions. This feedback not only underscores the benefits of reduced connectivity in supporting privacy but also aligns perfectly with the hypothesis that lower connectivity enhances residential privacy. The connection between the architectural design of French Village 1 and R01's lived experience highlights how effectively quantitative measures of reduced connectivity can enhance privacy, corroborating the hypothesis and demonstrating the tangible impact of architectural decisions on the quality of daily living (Tables 1-4).

4.2 Visual and metric step depth

The quantitative analysis for Golden Park and Bariz City reveals significant visual (2.24328) and metric step depths (750.766 and 851.66568 respectively), suggesting that these architectural features effectively create barriers that enhance privacy within the apartment spaces. This enhancement is vividly reflected in the qualitative feedback from R29, who appreciates the visual and acoustic privacy afforded by well-designed entryways and corridors, thereby boosting comfort. This direct correlation between R29's experiences and the quantitative measurements underscores how step depth significantly contributes to privacy and functional efficiency. The perfect synchrony of this quantitative data with the qualitative feedback makes one realize how architectural design contributes to the improvement of the private and practical features of living spaces and directly designates the hypothesis that greater step depths help in the promotion of privacy.

4.3 Mean Depth, Relative Asymmetry, and Control Value

The quantitative findings of the present study conducted in Lelav City indicated that the Mean Depth of this reservoir was 2. A monitored value of 07388 and the Control Value 8 were identified. 30751 shows that the layout of the apartments does not allow the residents to be easily disturbed which makes them suitable for carrying out activities, which may be confidential. Supporting the above design observations is resident R18's qualitative appraisal of the functional suitability of the apartment layout. R18 reminds that every area is actively used, there is no excess furniture and items crowding the space, which again translates to the comfort identified in the research with the help of the deeper, more metered layouts. Thus, overlaying the quantitative data with qualitative feedback shows how such designs contribute to better privacy and functionality and affirms the hypothesis of how much deeper and more controlled architecture layout schemes enhance privacy and functional efficiency in the house. These are summarized in Tables 1, 2, 3, and 4.

5. CONCLUSIONS

This research work provides an extensive analysis of the research questions formulated and investigates the intricate relationship between architectural design, privacy, and space configuration of the residential apartments in the Duhok City and demonstrates that although the design integrating values lead to social interactions, they pose a threat to privacy. On the other hand, configurations with larger mean depths help in securing privacy but at the same time, limit the social contacts one has. These highlights, therefore, underline the apt importance of the architects as well as the urban planners to ensure that these components are well-measured to accommodate the different tastes of the residents within the urban centres. There are strategic design recommendations that have been suggested to reduce privacy issues while at the same time improving social interaction; this is by designing living areas near access points to encourage social interaction and sating private areas to minimize noise interference when people are relaxing or sleeping. Furthermore, the application of mobile spaces such as movable walls and changeable furniture will possibly contribute even more to the utilization of space and comfort of residents since they permit occupants to alter their living conditions in accordance with their constant requirements. However, based on the study, there are limitations that include; cross sectional study conducted in one city and the use of self reports data which also limit the comparison and generalization of the study findings. Directions for future research entering are suggested to be the expansion of the studies to different cities and application of more quantitive and quantitative data analysis techniques to support and elaborate these findings. Also, the constantly shifting work culture requiring concentration to be worked as telecommuting, merging or creating concentrated spaces is an essential part of residential design since the workspaces need to be converted into the living ones in the future. It is evident from this study that proper architectural design contributes significantly to the improvement of urban living quality, and further studies addressing the complex interrelationships of the design aspects can result in more flexible, comfortable, and efficient residential spaces in cities in relation to today's urban lifestyle dynamics.

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