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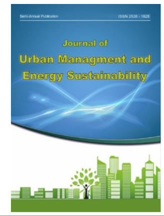

ORIGINAL RESEARCH PAPER

Analyzing Visual Quality in Residential Block Layouts Using Parametric Modeling in Grasshopper

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ABSTRACT

Visual quality is a fundamental component of contemporary residential design, influencing privacy, spatial perception, daylighting, and the psychological well-being of residents. Key visual factors such as views toward surrounding landscapes, inter-visibility between housing units, and visual access to semi-private open spaces play a decisive role in shaping the residential experience. Nevertheless, the effects of different residential block configurations on these visual parameters have not been sufficiently examined. This study investigates three visual criteria-view toward surrounding landscapes, inter-visibility between residential units, and visual access to semi-private open spaces—across five common residential block layouts: linear, detached, mixed, perimeter, and central configurations. A standardized 2×1-meter window on the southern façade of a representative unit was used for evaluation across five floors. Parametric simulations were performed in Grasshopper using the Ladybug and Honeybee plugins to assess sightlines, visibility angles, and visual overlap patterns. The findings show that building orientation, spatial distance, and window alignment have significant impacts on visual performance. More open forms such as detached and perimeter layouts provide broader landscape views, enhanced daylight access, and greater spatial openness. In contrast, denser configurations like central and mixed layouts exhibit increased window-to-window visibility and weaker visual connection to open spaces. Overall, the results highlight the importance of spatial configuration in improving visual comfort and residential quality. These insights can support the development of design guidelines and urban planning policies aimed at enhancing visual performance and the overall livability of residential environments.

Running Title: Visual Quality in Residential Block Layouts

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
27	12	01

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INTRODUCTION

The built environment plays an essential role for the performance and well-being of occupants (Barrett rt al, 2010, Bluyssen, 2017). The visual environment of residential complexes constitutes a significant part of human spatial perception and profoundly influences individuals' spatial experience, sense of belonging, and overall quality of life (Nasar, 1990; Lynch, 1960). In residential architecture, visual access is considered a fundamental design component that, in addition to enabling natural daylight, plays a key role in establishing a psychological connection between residents and their external environment (Heschong, 2021). The presence of desirable visual landscapes through windows can positively affect both mental and physical well-being and even enhance the economic value of buildings (Konstantzos et al., 2017). Studies show that the ability to view natural scenes from within buildings—especially in living and working spaces—plays a significant role in reducing stress and improving focus (Elsadek et al., 2020). This visual component becomes even more critical in dense urban contexts, where the configuration of building masses, block morphology, building height, and window orientation collectively determine the quality and comfort of visual experience. Direct visibility between residential units may reduce privacy and resident satisfaction, while controlled visual access to semi-private spaces, such as inner courtyards, can reinforce a sense of security and spatial attachment (Gehl, 2011).

Different layout typologies in residential blocks—including detached, linear, perimeter, mixed, and central arrangements—create distinct effects on visual access and daylight availability (Ko et al., 2022). Each layout exhibits unique characteristics in terms of visibility to the surroundings, degree of privacy, and interaction with public or semi-public spaces. Among these factors, window view quality represents a combined result of quantitative variables (e.g., view width and depth, number of visual layers, vegetation coverage) and qualitative aspects (e.g., visual clarity, aesthetic composition, and type of visible landscape) (Ko et al., 2022).

In the present study, three essential types of visual access— (1) view to surrounding landscapes, (2) inter-visibility between residential windows, and (3) view toward courtyards—have been analyzed and compared across five common residential block layouts. The analyses were carried out using 3D modeling in Rhinoceros software and quantitative simulation through the Ladybug and Honeybee plugins in the Grasshopper environment. Each floor of the selected residential typologies was evaluated based on viewing angles and elevation, and the average visual performance of each layout was compared. This approach ultimately provides an assessment of how spatial configuration influences visual quality in residential environments.

MATERIALS AND METHODS

1. Theoretical Foundations and Literature Review

Visual perception of space is one of the fundamental principles in architecture and urban design, long studied by designers, sociologists, environmental psychologists, and architects. The concept of visual perception plays a vital role not only in determining residential quality but also in influencing social interaction, sense of place, psychological security, and even property valuation. Consequently, visual analysis at both micro (residential unit) and macro (urban fabric) scales has gained importance and has become a core topic in simulation-based and quantitative design methods.

Classical studies introduced foundational concepts such as view, urban vista, and spatial transparency, which formed the theoretical basis for visual analysis. Visual stimuli such as landscapes and views with natural features have been indicated as stress-recovery (Ulrich,1981; Ulrich,1986) and attention-restoration boosters (Kaplan,1995), both of which promote cognitive performance (Berman,2008; Tennessen,1995) In the 1970s, Benedikt pioneered the notion of the Isovist, opening new horizons for quantitative visibility analysis. He defined the Isovist Field as the visible area from a given point, unobstructed by physical barriers. This idea laid the groundwork for later methodologies developed by researchers such as Hillier and Hanson, who, through the framework of Space Syntax, investigated the relationship between spatial configuration and user perception (Hillier and Hanson, 1984). Direct views from the window of one residential unit to another are among the most critical challenges related to privacy and visual comfort in dense urban fabrics. If uncontrolled, this unwanted view can cause feelings of intrusion, reduced sense of belonging, and residential dissatisfaction (Altman, 1975). In the following decades, research expanded to examine the relationship between visual access and factors such as privacy, daylighting, neighborhood interaction, and environmental quality. For instance, Turner and Penn demonstrated through Visibility Graph Analysis (VGA) that it is possible to identify blind spots, transparent zones, and dominant visual axes in residential spatial structures (Turner, 1999; Turner and Penn, 2002). The introduction of digital tools such as Rhino, Grasshopper, and plugins like Ladybug, Honeybee, Elk, and Decoding Spaces has enabled architects to conduct precise and dynamic visual simulations. These tools allow the quantitative analysis of inter-window visibility, courtyard views, and sightlines toward urban or natural landscapes using metrics such as viewing angle, sightline length, vegetation density, and geometric obstructions. A study by (Sadeghipour Roudsari et al. 2013) using such tools showed that even minor variations in window placement or massing configuration can significantly impact privacy and visual quality in residential complexes. Additionally, domestic research, including the studies by Khozaei Ravari et al (2024), have explored visual relationships in residential projects within the Iranian socio-cultural context. These works emphasize the importance of privacy, controlling visual access from public to private spaces, and enhancing natural views as key elements in residential design. From a theoretical perspective, recent literature has introduced terms such as view access, dominant view, invasive view, and visual connectivity, all aiming to enhance the lived experience and visual comfort of users.

In recent years, multi-factor simulation studies have integrated visual analysis with other performance metrics such as daylight availability, energy consumption, thermal comfort, and noise pollution. This interdisciplinary approach reflects that visibility is not merely an aesthetic or privacy-related concern, but rather a critical component of the building's overall environmental performance and livability.

Several studies have addressed the impact of daylight penetration and outward visibility through facade openings, some of which are listed in Table 1.

Based on the above table, the following observations can be made:

1.Most studies focus on daylighting, while outward views, such as window-to-window, courtyard, and landscape views, have received less attention.

2.Research on visual access is often computational and sightline-based, with limited simulation-based studies.

3.The impact of minor design variations, like window placement or building massing, on visual quality is underexplored.

4.Few studies systematically compare different residential fabric patterns to evaluate how overall spatial layout affects view quality.

The present study analyzes three main view axes (window-to-window view, views of surrounding landscapes, and courtyard views) across five residential fabric patterns (linear, detached, central, peripheral, and composite). By combining analytical methods, geometric modeling, and numerical simulation, this research aims to develop a realistic model for evaluating view quality in contemporary residential projects.An important aspect of this study is maintaining window positions and controlling conditions across all patterns to isolate and compare the effects of overall fabric geometry on the final view quality.

Table 1: Literature Review on Visual Access through Architectural Openings

Title of Study	Researcher(s) (Year)	Objective	Variables	Methodology	Findings / Results
"Occupants' Responses to Window Views, Daylight, and Indoor Lighting: A Critical Review"	- Natalia Giraldo Vasquez - Ricardo Forgiarini Rupp -Rune Korsholm Andersen -Jørn Toftum (2022)	"A critical review of studies addressing the effects of window views, daylighting, and lighting on occupant behavior, perception, performance, and well-being."	- Daylighting - Comfort - Perception - Behavior	"The data were extracted from selected studies and articles, and a simple model is proposed to predict occupant performance based on illuminance and color temperature."	A preliminary and simplified model was proposed to quantify illuminance and correlated color temperature (CCT) based on occupant performance. This initial model relies on limited and scattered data and therefore provides only a rough estimate of lighting feature impacts on performance.
" Assessing the Visual Comfort, Visual Interest of Sunlight Patterns, and View Quality under Different Window Conditions in an Open-Plan Office."	- Belal Abboushia -Ihab Elzeyadib - Kevin Van Den Wymelenbergb - Richard Taylorc - Margaret Serenod - Grant Jacobsene (2020)	"Exposure to sunlight involves consideration of the visual appeal of sunlight patterns and their potential impact on visual comfort."	-Daylight -Visual interest -Visual comfort -Sunlight patterns	This study employed an experimental method in which 33 office workers were exposed to three different window and sunlight patterns: fractal pattern, striped pattern, and clear condition in an office building for three days (one condition per day). Subjective ratings and physical environmental measurements were collected and analyzed to understand the differences between the three conditions.	"There was no significant difference in visual comfort or visual interest ratings between the fractal pattern, striped pattern, and clear conditions. However, the fractal and striped patterns were associated with a significant reduction in visual quality compared to the clear condition."

"Multi-Objective Optimization of Office Window Design Considering View Quality, Daylighting, and Energy Performance"	Pilechiha, P., Mahdavi-Nezhad, M. J., Pourrahimian, F., Carneiro, F., and Seyedzadeh, S. (2022)	"It proposes an approach to quantify view quality in office buildings in balance with energy performance and daylighting, thereby enabling an optimization framework for office window design."	- Window design - Daylighting - Building energy consumption	"Building on previous research, a multi-objective method has been developed to evaluate a reference room, which is parametrically modeled using real climate data."	"The optimization model indicates that room geometry must be adjusted to meet the lighting and view requirements defined by building performance standards. The findings highlight the necessity of configuring the window system during the early stages of design."
Study of spatial and visual comfort in the reception space of traditional houses in Mashhad city, IRAN	Pedram Hessari Maryam Seyf Shojaee Parisa Noormohamadi (2025)	"This study aims to examine the visual comfort of the two sides of the landscape, communication and quality of light and glare in the living room space."	- IRAN -Mashhad city -Space -spatial comfort -traditional house -visual comfort.	The research is based on the existing studies and resources and software simulations.	The spatial configuration and proportions of houses have the potential to be efficient in visual layering, proper perspective, and glare control of the living rooms.
Daylight and window view quality for visual comfort: the case of an office building in Jaffna	- Delosha Thayanithy -Narein Perera(2023)	Determining the perceptual impact of daylight and "window view quality" in achieving visual comfort.	- Window View Quality - Daylight Integration - Visual Comfort - Post Occupancy Evaluation	As a limitation of scope, an environmentally rated building in a specific locality – Jaffna – is selected. Post Occupancy Evaluation forms the primary method adopted. Mapping of the space is undertaken, together with Perceptual Spatial Analysis (PERCIFAL) surveys, and correlate responses to the physically observed spaces.	Results show the occupants agree that natural light is the preferred mode of lighting for the workspace. Although the window views are deemed to enrich the working environment, the emphasis on its preference does not strongly correlate among all respondents.

Quantifying window view quality: A review on view perception assessment and representation methods	- Fedaa Abd-Alhamid - Michael Kent - Yupeng Wu (2023)	an all-inclusive comprehensive approach to quantify view quality using subjective and objective assessments along with an adequate representation method is proposed.	- View perception - Visual perception - Window views - View quality - View quantifying - Virtual reality	This paper systemically reviews studies on view perception in terms of quality and quantity factors affecting view perception (i.e., content-related factors, designrelated factors including window's shape and size, shading devices, mullions, and partitions, dynamic changes in views based on observer-related factors, and view size) and discuss views impact on other visual (i.e., glare) and non-visual (i.e., privacy and thermal comfort) perceptions.	knowledge gaps were identified for future studies in relation to view quality assessment and experimental design; and an all-inclusive comprehensive approach to quantify view quality using subjective and objective assessments along with an adequate representation method is proposed.

2. Research Methodology

This study is applied-analytical in nature and employs a mixed-methods approach combining numerical simulation, spatial analysis, and comparative techniques within the field of residential architecture. The primary objective is to analyze the visual quality of residential spaces across three key view axes: views toward other units, views of surrounding site landscapes, and courtyard views, framed within five typologies of residential fabric patterns, namely linear, central, detached, peripheral, and composite (as detailed in Figs. 1 and 2).

The study area consists of a 5×5×3 m^3 room located on the southern façade of a five-story residential building in Shiraz, featuring a 2×1 m window opening. The five residential fabric layouts—linear, central, detached, peripheral, and composite—are treated as independent variables, while the degree of "view from inside to outside" is considered the dependent variable, assessed through three view conditions: views to surrounding landscapes, views to windows of other units, and views to the courtyard.

To measure the view quality index, the visibility of external spaces from within the room (View Analysis) was employed.

In the first step, high-precision base modeling of forms and fabrics was carried out using Rhinoceros software. Subsequently, these models were transferred to the Grasshopper environment to perform view and parametric analyses. The specialized plugins Ladybug and Honeybee played a central role in calculating visual parameters such as field of view angle, viewing distance, occlusion level, and graphical analysis of sightlines. Accordingly, the research process proceeded step-by-step as shown in Fig. 3.

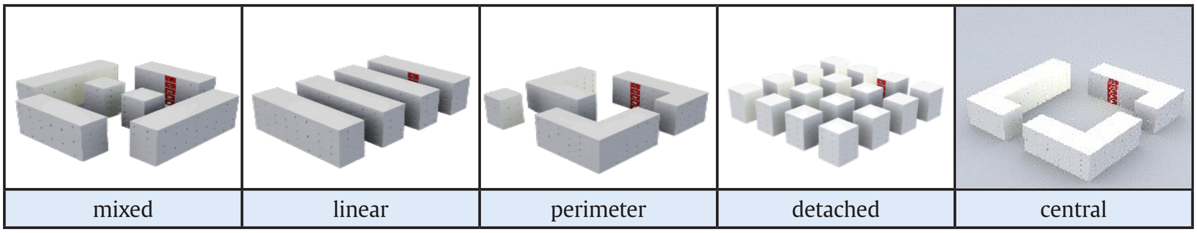


Figure 1: Introduction of case study samples based on five types of residential complex layouts: Central, Detached, Peripheral, Linear, and Composite. (Source: Authors)

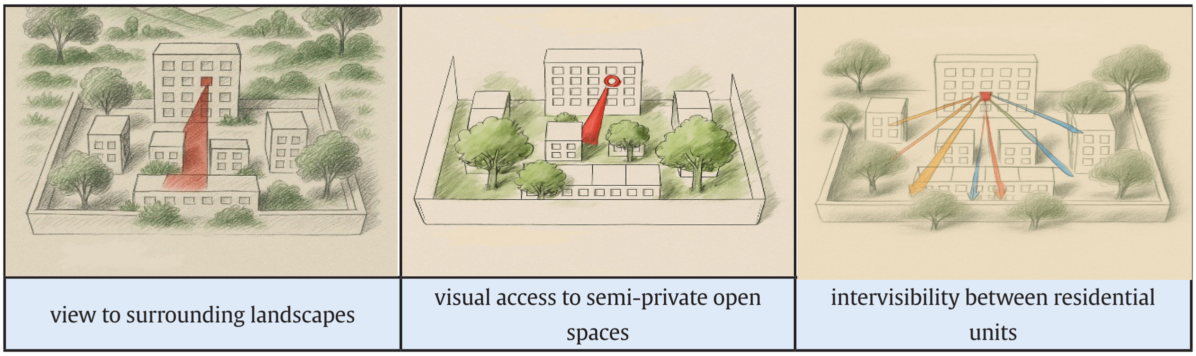


Figure 2: Introduction of three key view axes: views to other units, views to surrounding site landscapes, and courtyard views. (Source: Authors)

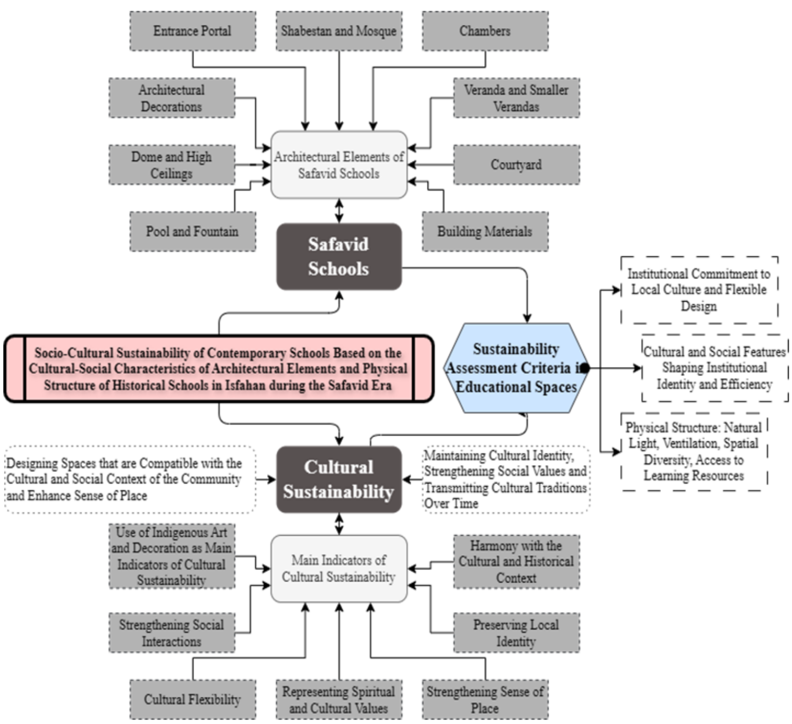


Figure 3:Research Process Diagram

DISCUSSION AND FINDINGS

In this section, the research findings are presented separately based on the three view categories: “views to surrounding landscapes”, “window-to-window views of units”, and “window-to-courtyard views”.

4.1 Views to Surrounding Landscapes

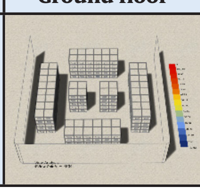
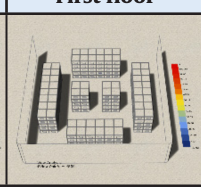
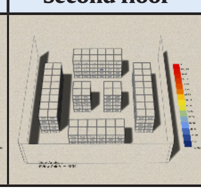
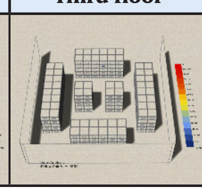
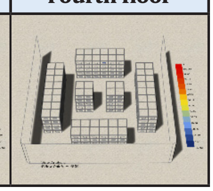
The contour lines of the Views to Surrounding Landscapes of Units are shown in Fig. 4. The results of the view quality analysis toward surrounding landscapes are presented in Figs. 5 and 6 below. The findings from the data analysis generally indicate that the extent of views to surrounding landscapes varies significantly depending on the type of urban fabric. Among these, the central fabric exhibits the highest view quality index toward surrounding landscapes. More precisely, the average view index across all examined samples in this fabric type is 8.89, which reflects a considerably more favorable visual condition compared to other urban fabrics. This can be attributed to specific morphological characteristics of the central fabric, such as the arrangement of streets, the positioning of buildings, lower density, or open spaces between structures that provide broader views for residents.

In contrast, the composite fabric is identified as having the weakest condition regarding views to surrounding landscapes. The average view index in this fabric is 1.42, indicating a severe decline in visual quality compared to other fabric patterns. This substantial reduction in view quality is likely due to the improper placement and arrangement of buildings, which are often designed irregularly, densely, and with minimal spacing between them. Such configurations obstruct sightlines and limit the urban landscape visible to users.

Referring to the data presented in Fig. 5, comparative analysis among fabric types shows that peripheral, detached, linear, and central fabrics offer 193%, 207%, 456%, and 520% more view, respectively, than the composite fabric. This significant difference clearly highlights the importance of urban fabric patterns in enhancing or diminishing the quality of views to surrounding landscapes and underscores the need for appropriate urban design patterns in spatial planning processes.

Moreover, the findings reveal a significant correlation between the extent of views to surrounding landscapes and the elevation of the window or opening being examined (such as windows or balconies). In other words, the higher the floor level, the wider and more expansive the view of the surroundings. This is evident in the floor comparison data: the average view at the fourth floor is reported as 8.89, approximately 113% higher than the average view at the ground floor, which is 4.17 (Fig. 6). This difference likely results from fewer visual obstructions at higher floors and occupants’ dominance over the urban open space views.

Overall, the quality of urban landscape views depends on urban fabric type, building arrangement, and building height. The central fabric provides the best views due to organized street layout, lower density, and open spaces, whereas the composite fabric shows the poorest views because of irregular, dense building arrangements that obstruct sightlines. Additionally, higher floors offer wider and unobstructed views. These insights can play a crucial role in urban development policies, residential space design, and construction regulations to enhance residents’ quality of life.

	Ground floor	First floor	Second floor	Third floor	Fourth floor
mixed					

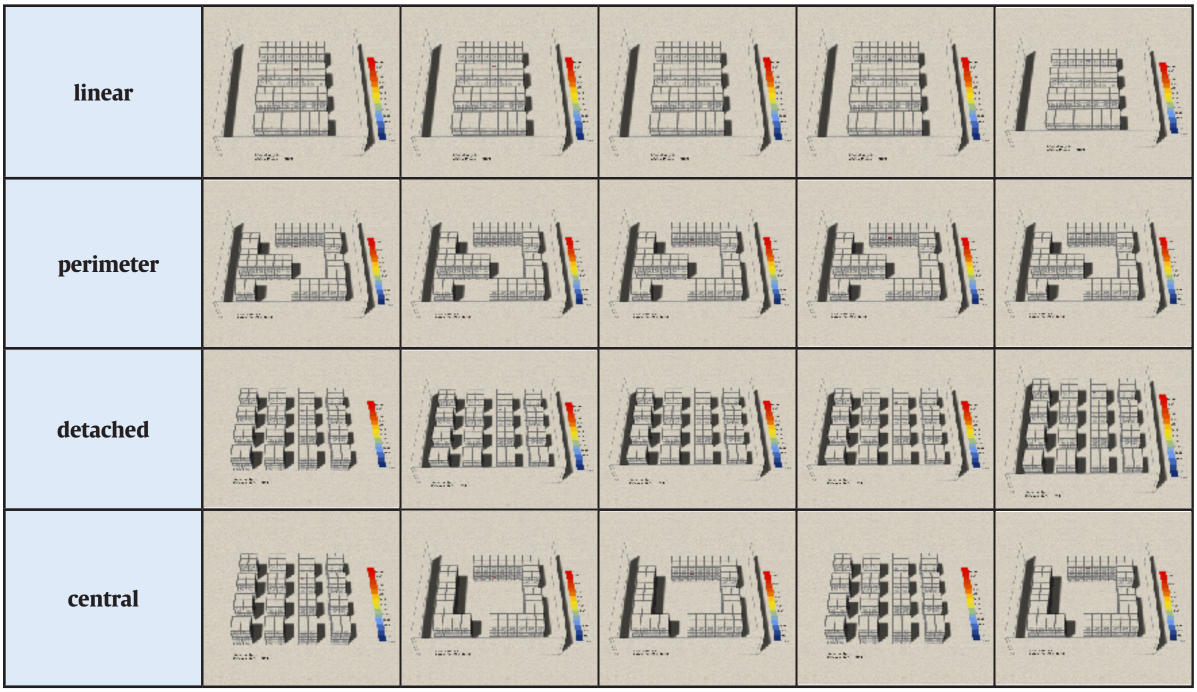


Figure 4: Contour indicating the Views to Surrounding Landscapes. (Source: Authors)

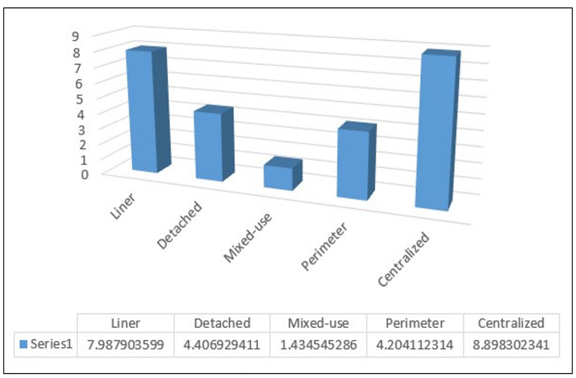


Figure 5: Numerical results of the view quality index toward surrounding landscapes in case study samples, comparing fabric typologies. (Source: Authors)

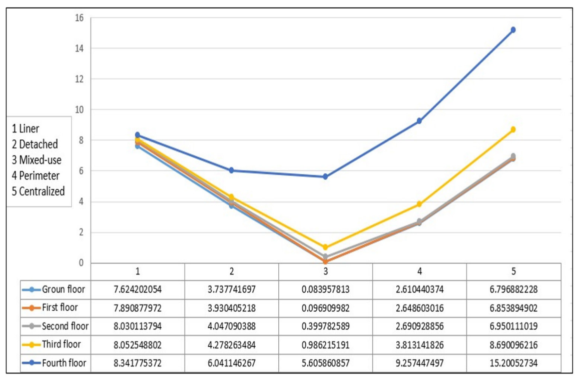


Figure 6: Numerical results of the view quality index toward surrounding landscapes in case study samples, comparing corresponding floors. (Source: Authors)

4.2 Window-to-Window Views of Units

The contour lines of the Window-to-Window Views of Units are shown in Fig. 7. The results of the window-to-window view index analysis are presented in Figs. 8 and 9. The results obtained from the analysis of window-to-window views in residential units across different urban fabric types indicate significant and meaningful differences in the level of visual privacy among these fabrics. This variable, as a qualitative index in assessing residents' comfort and psychological security, reflects the extent of visual contact and penetration between the interior spaces of buildings.

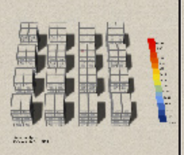
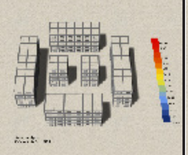
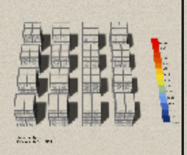
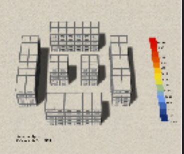
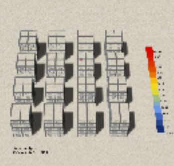
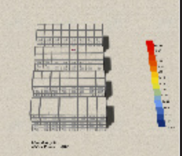
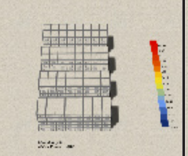
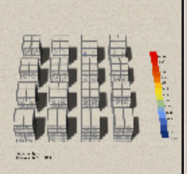
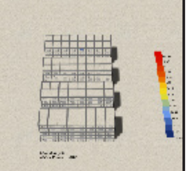
Among them, the central fabric recorded the highest direct view index between opposite unit windows with an average value of 32.68. This suggests that in this type of fabric, due to high density, narrow street widths, and compact arrangement of buildings, the distances between building blocks are reduced, consequently increasing the possibility of direct visual connections between interior spaces. Such a condition may lead to a diminished sense of privacy for residents and negatively affect spatial perception quality within residential units.

In contrast, the linear fabric, with an average of 11.34, experiences the lowest level of window-to-window visibility. This significant difference—approximately a 65% reduction compared to the central fabric—can be attributed to the linear and continuous arrangement of buildings, wider street widths, and more controlled window orientations, all of which collectively reduce mutual sightlines and thereby increase visual privacy. Such structures are commonly observed in modern or planned urban designs where greater control over spatial relationships between buildings is applied.

Comparative analysis of other fabric patterns shows that the detached fabric has 34% more view compared to the linear fabric, the composite fabric 136%, the peripheral fabric 155%, and again the central fabric 188% more visual penetration. These substantial differences can be attributed to a combination of morphological and design factors such as irregular orientation of units, building height variations, absence of buffer spaces (e.g., courtyards, gardens, or semi-private spaces), and lack of consideration for climatic and cultural design principles that were more prevalent in the past (Fig. 8).

Vertically, the results indicate that middle floors—especially the second floor—exhibit the highest window-to-window visibility. The average value recorded for the second floor is 23.42, about 2% higher than both the ground and fourth floors (each approximately 22.9). Although this difference is slight, it is meaningful and relates to the viewing position on middle floors. In these floors, the viewing angle is more balanced compared to others, and the vertical distance relative to opposite units is optimal, facilitating direct visual connections. Higher floors, due to increased elevation, and ground floors, due to horizontal obstructions (such as walls or vegetation), face viewing limitations (Fig. 9).

In summary, Window-to-window visibility is influenced by urban fabric type, building arrangement, and street width. The central fabric shows the highest direct visibility due to high density, narrow streets, and compact building layout, which reduce distances between blocks and increase inter-unit sightlines, whereas the linear fabric shows the lowest visibility due to linear arrangement, wider streets, and controlled window orientation, enhancing residents' visual privacy. Additionally, middle floors provide greater visibility because their viewing angles and vertical distances relative to opposite units are optimal.

	Ground floor	**First floor**	**Second floor**	**Third floor**	**Fourth floor**
mixed					
linear					

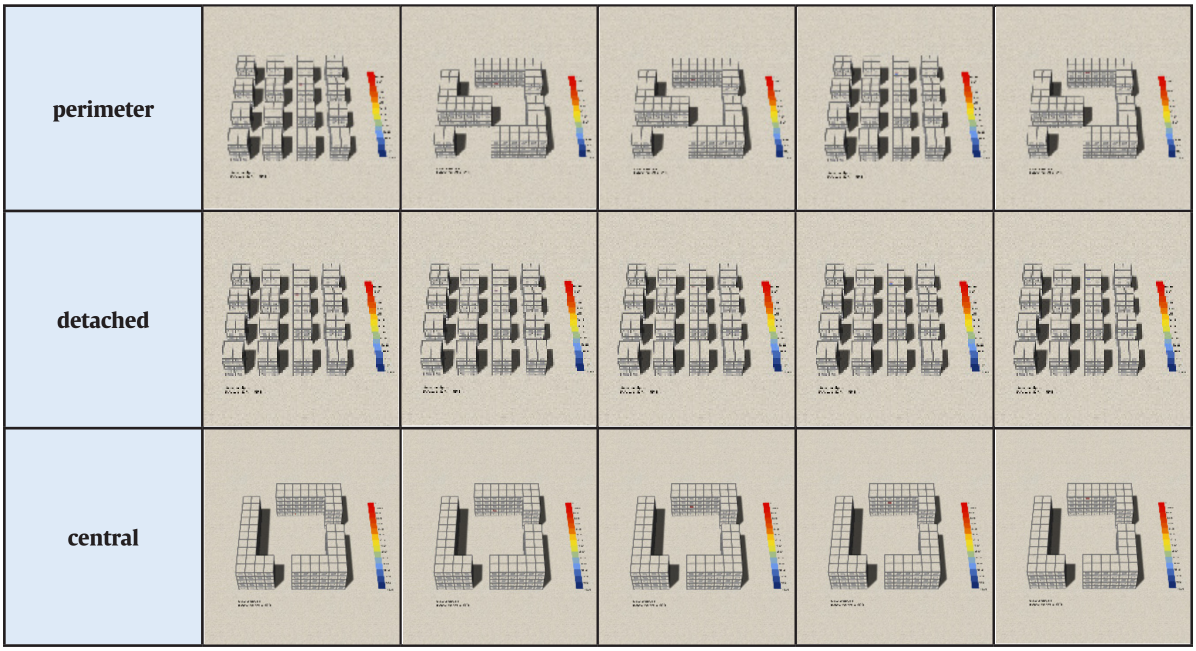
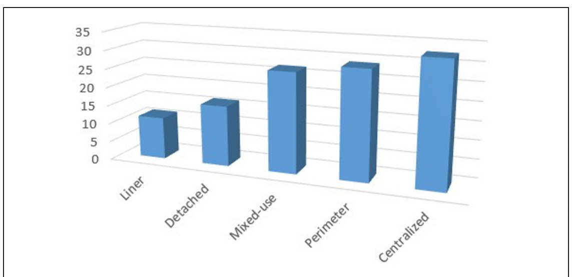
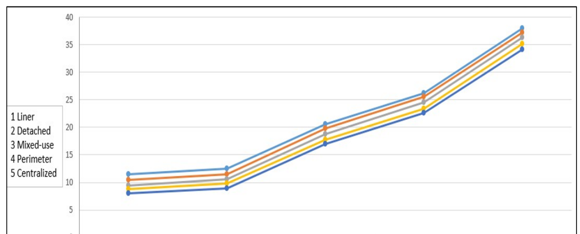


Figure 7: Contour indicating the Window-to-Window Views of Units. (Source: Authors)



	Liner	Detached	Mixed-use	Perimeter	Centralized
Series1	11.34497354	16.26190476	26.78165785	28.96516008	32.68925926

Figure 11: Numerical results of the window-to-courtyard view index in case study samples, comparing fabric typologies. (Source: Authors)



	1	2	3	4	5
Groun floor	11.47442464	12.46635078	20.5083425	26.22414821	37.93616337
First floor	10.46802795	11.45984984	19.75316282	25.51990187	37.23060667
Second floor	9.477679893	10.54124891	18.72696645	24.56275508	36.27167896
Third floor	8.739898473	9.762738635	17.73377338	23.44178475	35.14862288
Fourth floor	8.017824216	8.97816234	17.04173542	22.60249003	34.13571314

Figure 12: Numerical results of the window-to-courtyard view index in case study samples, comparing corresponding floors. (Source: Authors)

RESULT AND CONCLUSION

The findings of this study, based on the analysis of visual privacy and view-related indices across various urban fabric typologies, highlight the significant role of spatial configuration and built form in shaping visual privacy in residential units. Analyses focused on three main axes—view to surrounding landscapes, window-to-window visibility, and window-to-courtyard visibility—each illustrating a distinct aspect of how urban form affects visual quality in residential environments.

•*View to Surrounding Landscapes*

Data indicate that visibility to surrounding landscapes varies considerably among urban fabrics, primarily due to spatial openness, design logic, and building density. Stand-alone and hybrid typologies allow broader views, likely because of greater inter-building distances, moderate heights, and the presence of open or semi-open spaces. In contrast, denser fabrics such as central and linear types restrict landscape views due to compact layouts and enclosed spatial patterns. Access to external landscapes is crucial for residents' sense of place, satisfaction, and psychological well-being.

•*Window-to-Window Visibility*

Significant differences in visual contact between units were observed. The central fabric, with the highest index of 32.68, exhibits the most direct sightlines due to narrow spacing, window orientation, and absence of buffer zones, reducing visual privacy. Conversely, the linear fabric, with an index of 11.34, minimizes direct contact thanks to its row-based arrangement and orientation toward streets or courtyards. Vertical analysis shows middle floors—particularly the second—experience the highest visibility due to favorable angles, while ground and upper floors have reduced contact because of obstructions or less optimal viewing positions. Increased direct visibility can diminish perceived privacy and should be considered in urban design and building regulations.

•*Window-to-Courtyard Visibility*

The central fabric shows the highest window-to-courtyard visibility (36.14), reflecting well-integrated semi-public courtyards. Linear fabrics record the lowest value (9.63), due to elongated street arrangements and enclosed designs that limit visual access. Stand-alone, hybrid, and perimeter block typologies show intermediate values, reflecting their varied integration of open spaces. Vertical comparison reveals lower floors, particularly the ground level, provide greater visual access (21.72 vs. 18.15 on the fourth floor, a 19% decrease), owing to shorter vertical distances, better viewing angles, and fewer obstructions. Lower floors thus offer stronger physical and visual connections to courtyards.

Overall, the results of this spatial visibility triad demonstrate the critical impact of urban fabric and residential unit arrangement on visual quality, privacy, and residents' spatial experience. Future design strategies should prioritize balanced density, optimal window orientation, and strategic placement of open spaces and courtyards to enhance visual privacy, access to views, and residential quality. Such considerations can contribute to healthier, more humane, and more satisfying living environments.

Conclusion

The results of this study reveal that urban fabric types significantly influence residents' visual experiences, including views to surrounding landscapes, window-to-window interactions, and access to internal courtyards. Central fabrics consistently show higher view quality and greater visual penetration, while linear and composite fabrics often limit visibility due to dense or linear arrangements. These findings align with the research objective of examining how morphological characteristics of urban fabrics affect visual quality and residents' psychological comfort, demonstrating that urban design patterns are crucial in shaping everyday experiences.

Specifically, the superior landscape views in central fabrics can be attributed to organized street layouts, lower building density, and open spaces, which collectively enhance the extent of visible surroundings. Conversely, composite and linear fabrics restrict views because of irregular, dense, or continuous building arrangements. This outcome highlights the direct link between morphological design decisions and the environmental quality of residential units, supporting the study's aim to identify key spatial factors that improve urban livability.

The analysis of window-to-window visibility further emphasizes the role of urban density and building arrangement in influencing privacy perception. Central fabrics exhibit the highest inter-unit visual contact due to narrow streets and compact layouts, potentially compromising residents' sense of privacy. In contrast, linear fabrics, with controlled orientations and wider streets, reduce direct visual interactions, enhancing comfort. These results reinforce the importance of considering both visual access and privacy in residential design, fulfilling the research goal of understanding the interplay between spatial layout and occupant well-being.

Finally, window-to-courtyard analyses show that access to semi-private open spaces depends on both building configuration and floor level. Central fabrics maintain high courtyard visibility through well-placed openings, whereas linear fabrics limit visual access due to narrow rear yards and adjacent walls. Additionally, lower floors generally provide better visual connections to courtyards, offering improved daylight, ventilation, and sense of spatial belonging. These insights suggest that integrating morphological and vertical design considerations can optimize both environmental quality and psychological comfort, providing actionable guidance for urban planners and architects.

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