The University of Tehran Press

Pollution

https://jpoll.ut.ac.ir/

Print ISSN: 2383-451X
Online ISSN: 2383-4501

Spatial Structure and Visual Pollution in Urban Landscapes: Insights from Tajrish Square

Azadeh Mohajer Milani✉ | Homa Assarzadeh

Department of Environmental Design, Faculty of Environment, University of Tehran, P.O.Box 14155-6135, Tehran, Iran

Article Info

Article type:
Research Article

Article history:
Received: 18 December 2024
Revised: 15 February 2025
Accepted: 10 July 2025

Keywords:
AHP Method in Urban Studies, Public Perception of Visual Pollution, Spatial Structure and Visual Quality, Urban Form and Functional Networks, Visual Graph Analysis

ABSTRACT

Over the 20th and 21st centuries, rapid urban development has significantly altered urban landscape, often resulting in unfavorable changes. These changes have altered user perceptions of visual quality. While prior studies have examined urban aesthetics, few have explored how spatial structure directly shapes visual pollution, particularly in dynamic and rapidly urbanizing contexts. This research addresses the visual quality of urban landscape by asking: *How does spatial structure influence visual pollution?* A mixed-methods approach was employed, using Tajrish Square as a case study. The findings from the questionnaire surveys and visual graph analysis, categorized into four types: form, function, furniture and infrastructure, highlighted the critical role of spatial structure components in contributing to visual pollution of the urban landscape. Key factors include poor urban composition, substandard access networks, inconsistent facades, excessive advertisements, litter, insufficient green spaces, and suspended cables. The studies also showed that visual pollution in the Tajrish area focuses more on urban form factors such as land use patterns, the placement of urban elements—including public transport stations and religious sites—traffic network, congestion nodes, in addition to pedestrian network's geometric continuity and accessibility. The research highlights how poor landmark access and spatial design amplify visual pollution, reducing urban coherence and quality. These findings provide actionable insights for urban planners and policymakers, emphasizing the importance of integrating spatial structure considerations into urban planning to enhance visual coherence and mitigate pollution in similar urban landscapes.

Cite this article: Mohajer Milani, A. & Assarzadeh, H. (2025). Spatial Structure and Visual Pollution in Urban Landscapes: Insights from Tajrish Square. *Pollution*, 11(3), 955-972.
https://doi.org/10.22059/poll.2025.387167.2703

 Publisher: The University of Tehran Press.
DOI: https://doi.org/10.22059/poll.2025.387167.2703

INTRODUCTION

Visual pollution, an evolving and debated concept in urban studies, disrupts the harmony between urban spaces and their users, lacking a universally accepted definition. By disrupting the visual harmony and flow of the environment (Alwah *et al*., 2020), it frequently manifests as elements that obstruct views or detract from defining characteristics of a space (Cvetković *et al*., 2018). Some experts connect it to the overall image of a city, while others see it as a more personal and complex process. It can influence how people perceive and remember a space, often reflecting the lingering effects of poor design and urban performance. Amid diverse perspectives, a shared understanding emerges: physical urban components exert a significant influence on the visual quality of urban environments. Therefore, Visual pollution occurs when urban elements lack harmony or balance, disrupting the visual appeal of a space.

*Corresponding Author Email: *a.milani@ut.ac.ir*

This imbalance can degrade the environment, while well-coordinated elements can improve it. Over time, these influences—whether positive or negative—gradually shape the character of the urban landscape. Spatial structure on another note, pertains to the strategic arrangement of urban components—streets, buildings, and open spaces—which collectively shape visual coherence, accessibility, and functionality in urban environments (Hillier & Hanson, 1984; Živković, 2019). It serves as a framework for analyzing how urban form influences movement patterns, social interactions, and perceptions of urban quality.

Since the 1960s, the preservation and enhancement of the visual quality of urban landscapes have become critical areas of focus, especially within environmental planning. Foundational studies of Lynch (1960) and Jacobs (1961) highlighted the pivotal role of visual access to urban landmarks in fostering social cohesion and shaping the collective memory of citizens. Another pioneer in this field is Donald Appleyard, who specifically linked the visual quality of American cities to traffic levels (Appleyard & Lintell, 1972). The results of his observations and interviews showed that traffic was a major contributor to the increase in visual pollution and the psychological impact on citizens. Gradually over time, various factors such as shape, color, light, size, spatial orientation and the overall configuration of objects have been recognized as closely linked to the visual quality of urban landscapes and, by extension, to mental health and well-being of urban populations (Zhang *et al*., 2023; Gao *et al*., 2024).

Gupta *et al.* (2024) introduced the concept of visual pollution in urban landscapes as one of the essential indicators of urban environmental quality, highlighting its adverse effects on citizens' satisfaction with their environment and overall quality of life. In a comprehensive study conducted across European cities, Borowiak *et al*. (2024) found that the visual quality of billboards and advertising signs, as assessed through attributes like color, lighting, and dimensions, has a significant impact on citizens' perceptions of valued urban environment. Further research has expanded the range of visual pollutants within urban environments. These include visible infrastructure elements such as electrical cables and masts (Ahmed *et al*., 2019), accumulating street litter (Jana & De, 2015), deteriorating sidewalks (AlElaiwi *et al*., 2023), high levels of motor vehicle traffic (Adam *et al*., 2022), and the proliferation of commercial and service activities that clutter public spaces (Ramadan *et al*., 2023). In addition, derelict buildings and poor-quality construction (Alwah *et al*., 2020), as well as inconsistency in the color, material, shape and height of neighboring buildings (Shatwan, 2021) are identified as significant contributors to visual pollution in urban areas. Another study observed that the installation of bulky industrial elements, such as wind turbines, near human settlements and residential areas is perceived as a disturbing visual factor, affecting the aesthetic and environmental quality of urban landscapes (Kirchhoff *et al*., 2022).

Overall, visual pollution factors can be categorized into two primary types: fixed and mobile elements, each varying in scale from small to large, all of which have a direct influence on the quality of the urban landscape. Fixed elements include urban furniture such as street lights, benches, advertising and public transport platforms. Rigid building structures, physical features of pedestrian and vehicular access networks, and urban energy supply elements such as electrical cables fall into this category. Mobile elements on the other hand, include vehicle traffic in urban areas. The lack of adequate management of street vending is also considered a type of mobile visual pollutants. The studies also underscore that the physical quality of urban elements plays a crucial role in shaping both the perception and the lived experience of visual quality in urban environments. These qualities can be significantly altered by the movement and interaction of users within the urban context. While prior research has explored individual visual pollutants (e.g., Chmielewski, 2021; Borowiak *et al*., 2024), limited studies have systematically analyzed how broader spatial structures—such as urban form, land use, and pedestrian networks—interact

to shape visual pollution. This study bridges this gap by systematically analyzing how spatial structures shape visual pollution in Tajrish Square, offering insights to mitigate pollutants and improve environmental quality in historically significant urban spaces. The following sections will delve into studies that explore the effects of visual pollution and its implications for urban life and citizens' overall quality of life.

Visual pollution and its effects

Research has underscored the multifaceted impact of visual pollution on socio-cultural (Mandeli, 2019), economic (Chmielewski, 2021), environmental (Gao *et al*., 2023) and psychological (Rachman *et al*., 2014) dimensions of urban life (Fig. 1). Cities are inherently tied to visual factors (Samavati & Desmet, 2022) and improving the visual quality of urban spaces has been shown to significantly enhance the environment's responsiveness and adaptability to the evolving user's needs. This underscores the importance of further studies to identify the factors contributing to visual pollution in urban environments.

From an economic perspective, visual pollution contributes to indirect costs, such as reduced property values. For instance, properties in Greece near visually polluted areas experienced significant value declines (Skenteris *et al*., 2019). Similarly, in Denmark, the installation of wind turbines near residential areas contributed to citizen's dissatisfaction and a diminished quality of life due to their visual impact (Jensen *et al*., 2014). These studies underscore the need for better integration of economic and urban planning policies to address visual pollution.

In addition to these impacts, Visual pollution also presents challenges to nature-based tourism, diminishing the aesthetic value of urban and rural heritage sites. For example, promotional elements, while intended to attract visitors, often detract from the natural appeal of locations (Kamičaitytė-Virbašienė *et al*., 2016). Similarly, advertising in protected areas of Poland and Slovakia disrupted public perception and enjoyment of these sites (Szczepańska *et al*., 2019).

In addition, the visual quality of historic sites is critical to preserving cultural and social identity. For instance, research by El-Ghonaimy's (2019) on historical cities in Bahrain found that visual pollution is harmful to both the environment and cultural heritage, affecting both visual and psychological well-being (Nia, 2019). This demonstrates how visual pollution poses significant challenges to the identity and image of a region. Research underscores the adverse effects of visual pollution in urban environments, contrasting it with the principles of aesthetic

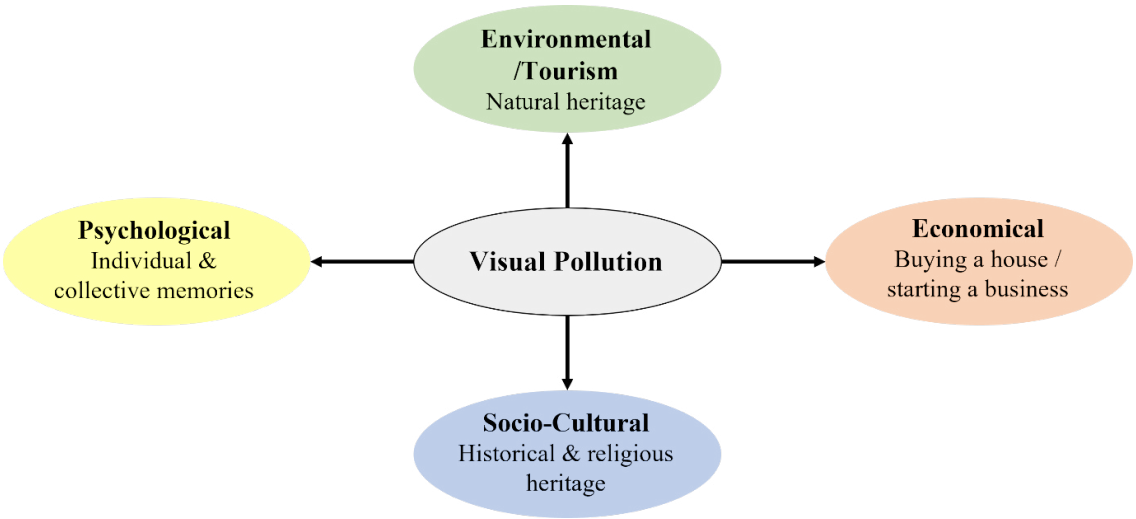

Fig. 1. Visual pollution and its effects

quality, which emphasize the appreciation and perception of a space's intrinsic features. Visual quality is crucial for how people perceive, navigate, and find satisfaction in urban spaces (Portella, 2014). Urban designers employ principles such as balance, color, pattern, and scale to enhance the visual appeal of built environments (Scenic America, 2022).

Psychologically, visually polluted environments negatively affect individual and collective moods and memories, resulting in anxiety, insecurity, mental fatigue and reduced overall well-being (Rangel-Buitrago *et al*., 2023; Gao *et al*., 2024). Researchers (M.A.S. *et al*., 2021) identified six key negative effects of urban visual pollution:

- **Distraction and lack of concentration**

Visual disorder significantly impairs concentration, particularly during tasks that require a high level of focus (Rodrigues & Pandeirada, 2018).

- **Stress**

Both experimental and field research reveal a significant correlation between visual pollution, spatial disarray, and elevated stress levels among individuals exposed to visual irritants (Sadeghpoor *et al*., 2024).

- **Anxiety**

This study has shown that exposure to visually disturbing environments can result in chronic anxiety, panic, and problems related to sleep and cognitive function (Ortiz-Peregrina *et al*., 2023, Zaeimdar *et al*., 2024).

- **Impaired mental processing of visual information**

When the brain is bombarded with excessive and disorganized visual input, it struggles to process and recognize the information effectively. This overload slows down cognitive processes and negatively impacts how individuals interact with their environment (Foley *et al*., 2020, Ishikawa, 2023).

- **Cognitive Misunderstanding**

Visual pollution leads the public to misinterpret the intrinsic value of their surroundings, causing a disconnect with the environment (Burtan *et al*., 2021).

- **Mental health**

Visual pollution can harm the human visual system, making the environment feel unnatural or unpleasant. It also negatively impacts visual memory by creating irregular distractions that disrupt the mind (Sinha, 2024, Helbich *et al*., 2024).

Despite extensive documentation of visual pollution's effects, limited research examines how broader spatial structures—such as urban form, land use, and pedestrian networks—interact to create these effects. This study addresses this gap by focusing on the interplay between spatial structure and visual pollution, particularly in culturally significant urban areas.

The role of spatial structure of the built environment on visual pollution

The concept of urban structure is multidimensional, encompassing geometric aspects like distance, morphology and urban form (Bunge, 1966). Streets, blocks, plots and buildings, as categorized by Živković (2019), form the backbone of spatial structures in cities. These attributes significantly influence visual quality and, when poorly executed, contribute to visual pollution. Further sections of this study will explore how these inconsistencies manifest in specific urban contexts.

Defining Spatial Structure Components

Spatial structure also focuses on the arrangement of space and urban composition (Garrison, 1959), often referred to as land use patterns (Guo *et al*., 2024). The way these patterns are logically and thoughtfully organized can have lasting visual effects on the urban landscape, with their impact often becoming more evident even decades later. According to Horton & Reynolds (2016), spatial structure can be categorized into linear features, such as transportation networks, and point features, including commercial hubs and public open spaces. Pedestrian and street networks in particular, are considered as linear paths that create a mobility system for both pedestrians and vehicles. They create mobility systems that connect densely populated areas to social nodes like transit stations and commercial centers (Chen *et al.*, 2019). This connectivity underpins urban accessibility, shaping how people perceive and interact with their surroundings (Liu *et al*., 2020). While these components are integral to urban design, their mismanagement can contribute significantly to visual clutter, as evidenced by inconsistent facade designs and poorly maintained urban furniture.

Urban furniture—such as benches, lighting, signage, and pedestrian bridges—is another critical component of spatial structure. These elements, while designed to enhance urban usability, often contribute to visual clutter when poorly designed or excessively used (Urban furniture: identity of the city, 2022). Similarly, energy infrastructure, including wind turbines, communication towers, and power cables, has been identified as both a necessary utility and a source of visual disorganization in urban landscapes (DaiDung, 2023).

Historical Perspectives on Spatial Structure and Urban Functionality

The relationship between spatial structure and urban functionality has been extensively studied. Foundational studies by Lynch (1960) and Jacobs (1961) emphasized the role of spatial structure in shaping urban functionality, focusing on landmarks and social cohesion. Hillier & Hanson (1984) expanded this understanding by linking spatial configurations to user behavior and visual accessibility. Similarly, Carmona (2021) underscored the influence of spatial characteristics on urban aesthetics, linking the quality of urban form to the visual appeal and functionality of public spaces.

As mentioned before, building structures and facades—characterized by attributes such as color, material, skyline, and geometric details—also play a critical role in determining urban visual quality (Živković, 2019; Zhang *et al*., 2024). Disruptions in these attributes, such as irregular building heights or poorly coordinated materials, can amplify visual tension, detracting from the overall aesthetic experience. One major takeaway is that people's preferences go beyond just the aesthetic aspects of urban spaces. Socio-cultural elements are often considered more important visual indicators of quality. These elements, identified by urban landmarks, constitute the historical, religious and social identity of a society.

Challenges in Spatial Structure Design

Table 1 summarizes various spatial structure components identified in the literature, categorizing them into form, function, furniture, and infrastructure. Each category highlights key factors and subfactors that contribute to urban design and visual quality. The factors outlined in Table 1 highlight how poorly integrated spatial structures—such as misaligned facades, disorganized pedestrian networks, and excessive advertising—can amplify visual pollution, particularly in high-density urban areas.

This paper builds on the theoretical foundations of spatial structure and urban form to analyze their implications for visual pollution. While prior studies (e.g., Hillier & Hanson, 1984; Carmona, 2021) have examined spatial structure, limited research explores its role in

visual pollution, especially in rapidly urbanizing and culturally significant areas. This study addresses this gap by integrating AHP and Space Syntax analyses.

MATERIALS AND METHODS

This research is practical and employs a hybrid methodology. The study addresses the research question: how spatial structure components—such as urban form, land use, and pedestrian networks—contribute to visual pollution in urban landscapes of Tajrish Square, utilizing both analytical techniques and a systematic review of the relevant literature. This approach bridges subjective user perceptions with objective spatial analysis, enabling a holistic understanding of the interplay between spatial structures and visual pollution. The objective of this research is to assess the impact of spatial structure on the visual quality of the urban landscape, and by extension, on the overall quality of the urban environment. The results aim to provide actionable insights for urban planners to mitigate visual pollution and enhance the visual and functional quality of public spaces.

Primary Research Approaches

The primary research approaches are survey research and spatial analysis. The questionnaire gauges users' satisfaction with the visual quality of the environment, focusing on the degree to which the current spatial structure aligns with citizens' visual needs and the extent to which physical factors interfere with urban index phenomena. The responses were compiled using a 5-point Likert scale and distributed to 50 local and non-local citizens in consultation with experts.

Table 1. Summarized studies on spatial structure

Key factors	Subfactors	References
Form	**Land use patterns** (Urban composition, Location of urban elements)	(Garrison, 1959) (Bunge, 1966) (Chen *et al*., 2019) (Guo *et al*., 2024)
	Building structures & facades (Color, Shape, Material, Skyline, Geometric features in details)	(Živković, 2019) (Zhang *et al*., 2024)
	Pedestrian network & Street network (Width, Material, Shape, Human scale, Geometric features, Continuity)	(Carmona, 2021)
Function	**Pedestrian network & Street network** (Population nodes, Congestion & Traffic nodes)	(Horton & Reynolds, 2016)
	Fixed & Periodic activities (Street vending, Commercial activities)	(Lynch, 1960) (Jacobs, 1961)
Furniture	**Advertising & Decorative elements** (Lighting columns, Trash bins Pedestrian bridges, Benches, Town information board, Traffic signs)	(Urban furniture: identity of the city, 2022)
Infrastructure	**Waste collection** **Green spaces** **Energy supply** **(**Wind turbines, Transmission towers, Electrical cables)	(Jayasinghe *et al*., 2023) (Korkou *et al*., 2023) (DaiDung, 2023)

Analytical Hierarchy Process (AHP)

The collected data was analyzed using the Analytic Hierarchy Process (AHP), a robust method for evaluating multiple criteria. AHP allowed for the ranking of visual pollution factors based on their perceived impact, validated through consistency indices (CR ≤ 0.1). Previous studies have effectively employed AHP in similar contexts. For example, Nami *et al*. (2015) identified visual pollutants through public surveys and proposed strategies to mitigate visual pollution in historic urban landscapes.

Space Syntax Analysis

This study integrates the Space Syntax method, using Visual Graph Analysis (VGA) as the sole metric to assess the spatial relationships and configurations within Tajrish Square. VGA measures the continuity of users' vision and their field of view, enabling the evaluation of spatial accessibility and visual continuity. The analysis highlights disruptions in landmark visibility caused by spatial inconsistencies, providing critical insights into how these elements exacerbate visual pollution. Color imagery in VGA enhances the transparency of mass and space in the urban fabric, helping to determine the level of visual access to landmarks.

While numerous studies (e.g., Hillier & Hanson, 1984; Carmona, 2021) have examined spatial structure, there is limited research integrating AHP with VGA-based Space Syntax analysis to analyze visual pollution. Together, VGA results and questionnaire data offer a comprehensive understanding of the area's visual quality and inform urban planning strategies for mitigating visual pollution. Therefore, this study aims to fill the research gap by using a combination of information-gathering techniques that contribute to an understanding of how spatial structure influences the visual quality of the urban landscape. Although the study focuses on Tajrish Square, the methodological approach can be adapted for broader urban contexts.

RESULTS

Study Area Context

Tajrish Square, located in the northern part of Tehran (District 1), serves as a major social, cultural, and commercial hub. It is home to key landmarks, including the Imamzadeh Saleh Shrine and the Qaem Traditional Bazaar, which attract a diverse population of locals and visitors. However, rapid urbanization since the 1980s has resulted in significant visual and spatial inconsistencies. This rapid urbanization has led to a shift in land use priorities, creating a visual and functional imbalance between historic landmarks and contemporary urban developments, which is central to understanding the spatial drivers of visual pollution. This study examines these challenges to understand the relationship between spatial structure and visual pollution.

Examples of visual pollutants in this area include the disproportionate allocation of space to vehicles over pedestrians, the traffic junctions surrounding the square, the BRT bus station and parking facilities, the lack of adequate cohesion between new and historic buildings in terms of height, material, color and facade composition, along with abandoned buildings, deteriorating pavements, and diverse advertising elements. These factors contribute to visual pollution (Fig. 2). These factors underscore the need for a detailed analysis of spatial structures and their contributions to visual pollution, forming the foundation for the methodologies applied in this study.

AHP Analysis

The questionnaire was designed to identify the existing barriers to visual access and evaluate how citizens perceive the visual quality of Tajrish Square. Visual pollution prevents users from

having a clear visual connection with important urban landmarks and broader urban space. Using the Analytic Hierarchy Process (AHP), responses were scored according to citizen preferences, and visual pollution factors were ranked based on their perceived significance. The AHP methodology was chosen for its ability to systematically prioritize multiple criteria and its proven reliability in urban studies. The analysis maintained a consistency rate (CR ≤ 2%), ensuring the credibility of the ranking process.

The AHP analysis identified four primary contributors to visual pollution in Tajrish Square, as shown in Figure 3:

1. **Urban Form (60.6%):** The dominant factor, reflecting inconsistencies in building facades, inappropriate urban land-use, mismatched color schemes, and height variations. These inconsistencies disrupt visual harmony and create barriers to landmark visibility, particularly affecting key sites such as Imamzadeh Saleh shrine and the Qaem Traditional Bazaar.
2. **Functionality (17.9%):** Disruptions caused by the overcrowded and poorly placed public transport facilities, misaligned pedestrian pathways, and traffic congestion, which exacerbate usability issues and reduce the square's aesthetic appeal.
3. **Urban Furniture (12.8%):** Oversized advertising boards, mismatched street furniture, and poorly integrated decorative elements intensify visual clutter and further obstruct landmark visibility.
4. **Infrastructure (8.7%):** Poor placement of utilities, hanging power cables, insufficient green spaces and poor waste management degrade the urban environment's visual and functional quality.

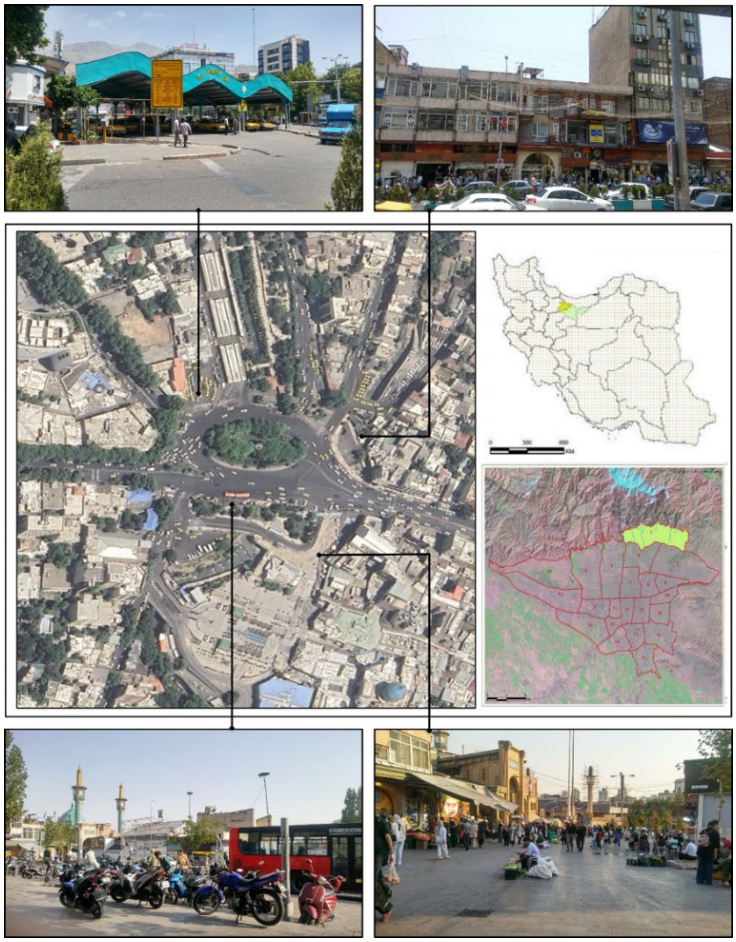

Fig. 2. The context of the study area and examples of visual pollution in Tajrish Square

Figure 3 illustrates the weighted contributions of these factors, with urban form dominating the rankings. These findings suggest that targeted interventions in urban form, functionality, and urban furniture are critical to addressing visual pollution, with an emphasis on harmonizing facades, reorganizing public transport, and improving pedestrian networks. The dominance of urban form reflects the impact of mismatched facades, irregular building heights, and structural obstructions, which collectively hinder the visibility of key landmarks. These findings highlight the need for strategic interventions to harmonize architectural elements and prioritize pedestrian-centric urban design.

Questionnaire responses highlighted that non-local, who primarily access the area via public transport, face significant barriers to visual access. Solid buildings structures, particularly in the southern part of the square, block views of landmarks such as the Imamzadeh Saleh shrine. Similarly, the placement of service facilities, such as the taxi and BRT stations, further reduces visibility and contributes to congestion. The southern part of Tajrish Square, designated for bus parking and passenger boarding, is visually dominated by the overcrowding of BRT buses, exacerbating visual pollution.

The analysis reveals that urban furniture, particularly advertising boards and lighting elements, disrupts visual coherence. Large billboards at bus stops obscure landmark visibility, while the use of diverse materials and designs for street furniture, lighting, and litter bins detracts from the area's visual coherence. Infrastructure issues, such as the excessive presence of hanging power cables and insufficient green spaces, further degrade the cityscape. These findings underscore the interconnectedness of spatial configurations and visual pollution in Tajrish Square.

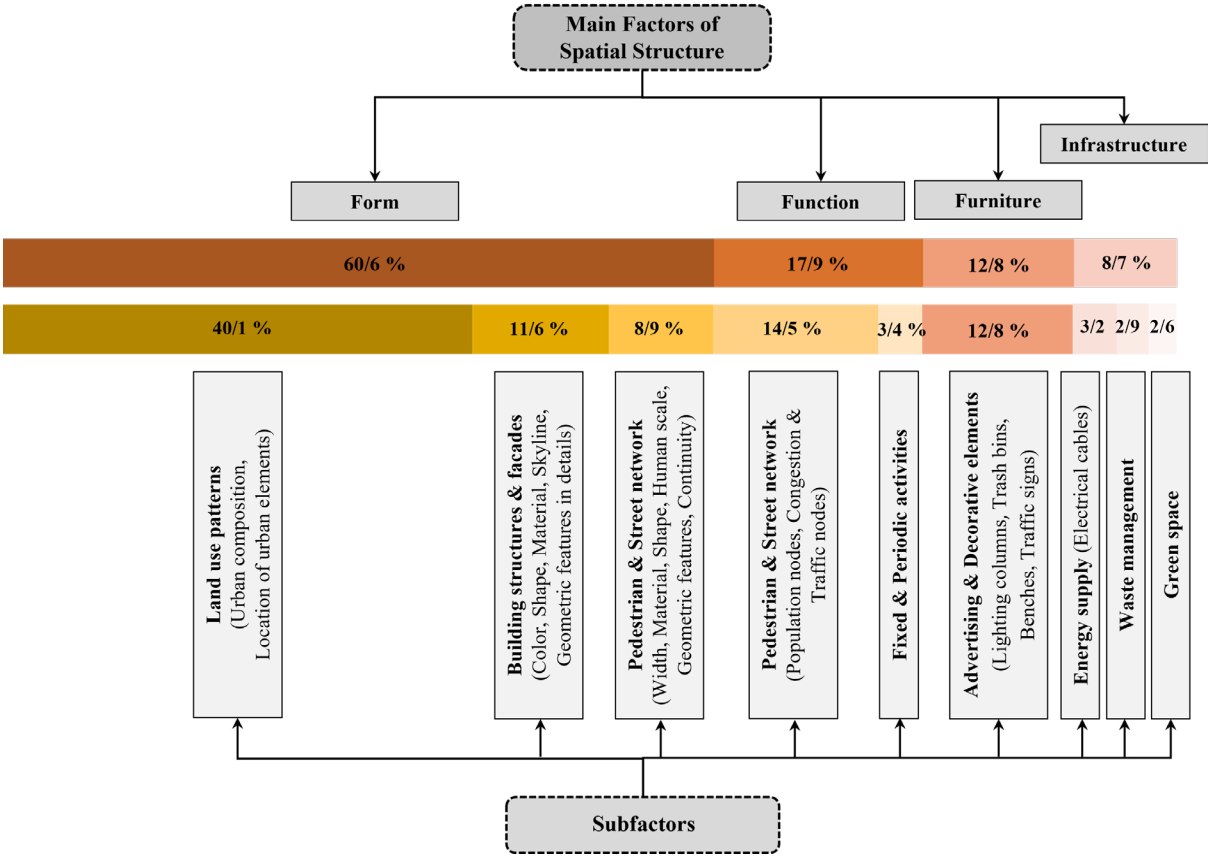

Fig. 3. AHP Analysis of Visual Pollutants

Beyond structural barriers, the lack of harmony between traditional and modern buildings in terms of color, skyline, material, and facade composition intensifies the sense of visual disconnection. For example, the contrasting appearances of traditional bazaars and contemporary developments diminish its prominence in the urban context. Geometric imbalances in building proportions further create visual confusion, disrupting the square's legibility.

The analysis also revealed that misplaced public transport services and sidewalk width reduction significantly disrupted pedestrian movement, creating traffic congestion and population nodes along key streets such as Valiasr and Shahrdari Street. These issues lead to functional disruption, compounded by noise and air pollution, which further diminish the visual quality of the area. Public transport services contribute both fixed and mobile visual pollution, adding to the area's four main sources of visual tension:

1. Congestion from bulky vehicles;
2. Traffic nodes caused by private vehicles;
3. Disrupted pedestrian flows and population nodes;
4. Oversized advertising billboards.

In addition to the poor pedestrian network quality, the presence of numerous street vendors near Imamzadeh Saleh shrine and the Qaem bazaar increase congestion, intensifying visual pollution, and reducing the focus on landmarks. Current pedestrian pathways are segregated and lack continuity, with narrowed sidewalks and inconsistent paving materials further detracting from the visual appeal. Enhancing pedestrian infrastructure—through uniform paving materials, optimized sidewalk widths, and the integration of green spaces—is essential for reducing visual pollution and improving public access in the area.

Urban furniture, including oversized advertising boards and diverse street furniture designs, emerged as significant visual pollutants. These elements detract from the visual coherence of the area, obstructing views of landmarks. The installation of decorative lighting and flags adds to the clutter, creating further visual tension.

Finally, infrastructure issues, such as the excessive presence of hanging power cables and the lack of sufficient green spaces, further degrade the cityscape. These factors collectively contribute to the inconsistency and visual pollution in Tajrish Square, as highlighted by the public survey analysis.

Visual Graph Analysis

The use of space syntax in this research, particularly through Visual Graph Analysis (VGA), provides a quantitative method to evaluate spatial accessibility and visual connections. This approach is especially suited to identifying how structural and spatial barriers contribute to visual pollution in urban environments. The analysis revealed relatively heterogeneous areas of visual communication in Tajrish Square.

Figure 4 visualizes the 360-degree visibility from three observer positions in Tajrish Square. Grey areas indicate full visibility, while darker areas highlight limited visual access due to structural obstructions. These gradients provide a clear representation of visual barriers affecting urban landmarks and pedestrian navigation. For instance, the southern part of Tajrish Square, dominated by transport hubs and dense urban structures, exhibits the lowest visibility. In contrast, areas closer to the central pathways show better visibility due to their openness and alignment with pedestrian movement.

The cross in the first image of Figure 4 marks the observer's position within the landmark, revealing no visual access to public transport services in the northern and southern parts of the square. Similarly, the crosses in images 2 and 3 represent observer positions at the BRT bus station and taxi stand, respectively, where users also lack direct visual access to urban

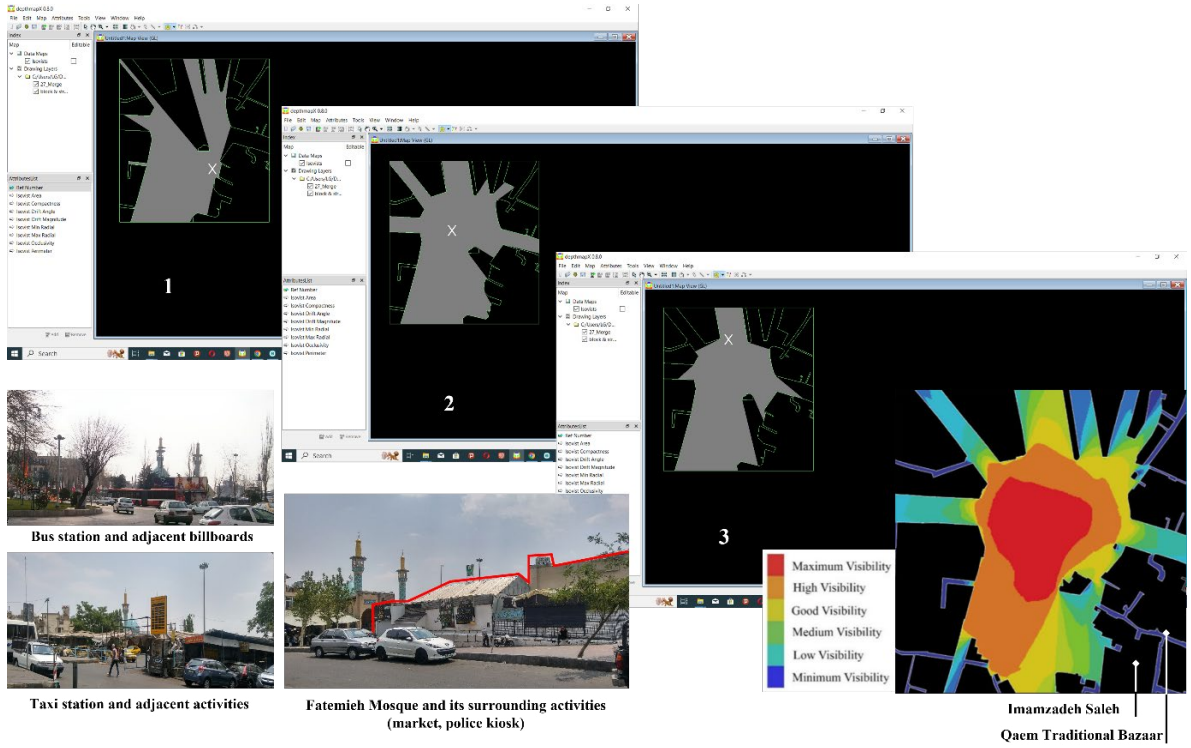

Fig. 4. Tajrish Square Visual Graph Analysis Output of the Depth Map Software

landmarks. The findings from Figure 4 also align with the questionnaire results, highlighting visual barriers in the current environment. Medium to low visibility is observed in the Qaem traditional Bazaar and Imamzadeh Saleh shrine areas.

The Tajrish Fatemieh Mosque and surrounding activities obstruct visual access to key landmarks, significantly diminishing the area's spatial coherence and citizens' perception of the urban landscape. These findings demonstrate the interconnectedness of spatial structure components and their collective impact on visual pollution, reinforcing the need for urban design interventions that prioritize visibility, connectivity, and environmental legibility.

DISCUSSION

The VGA analysis underscore the critical role of spatial configurations in shaping visual access. These results align with the study's objectives by demonstrating how urban form, land use, and pedestrian networks collectively contribute to visual pollution. Specifically, limited visibility in key areas such as the Qaem traditional Bazaar and Imamzadeh Saleh shrine areas results in confusion in spatial orientation (environmental legibility) and a gradual loss of sense of place.

As noted earlier, visual access to landmarks enhances the quality of the urban environment, and any factor that impedes this access is considered as a visual pollutant. In Tajrish Square, certain buildings obstruct the view of key elements from north to south. Notably, the Tajrish Fatemieh Mosque and its surrounding activities have been identified as key contributors to the disruption of the visual connection. This is consistent with the AHP survey results, which indicated that urban form (60.6%) is the dominant contributor to visual pollution. The Space Syntax analysis corroborates this finding, revealing poor pedestrian connectivity in areas with high visual obstruction (Figure 4).

The results of the visual graph analysis also positively correlate with the findings of the questionnaire. Mixed-methods research indicates a low visual access rate for pedestrians in the southern areas of Tajrish Square. Additionally, the findings highlight that the urban elements such as the Fatemieh Mosque and its surroundings structures are the primary visual pollutants affecting the northern side of the square.

This study specifically found that visual pollutants are created by urban form through the shaping of urban mass and space, which gradually affects the functional, furniture and infrastructure aspects. For instance, allocating land use to purposes other than green space reduces natural areas, transforming the urban natural landscape into a predominantly built environment. Building structures and the location of public transport stations emerges as the dominant physical feature, serving as the most significant barrier to visual access and contributing to the aesthetic challenges posed by facades. The increasing population density in these areas has further incentivized commercial advertisers to install large billboards, exacerbating visual clutter. Consequently, the strategic placement of key urban elements—such as public transportation facilities, religious sites, and commercial activities—requires meticulous planning to prevent the proliferation of advertising and decorative structures.

A related challenge is the improper siting of bus stops, which disrupts vehicular and pedestrian networks and exacerbating congestion when not carefully planned. Similarly, the inappropriate placement of commercial and religious buildings in the southern part of Tajrish Square, combined with infrastructure elements such as overhead power cables, has further intensified visual pollution.

Effective land-use allocation around key landmarks and careful planning of building locations in Tajrish Square can directly enhance the quality of pedestrian and vehicular access networks. These measures could also mitigate the proliferation of street vendors and indirectly reduce the strain on urban furniture and energy supply infrastructure. Conversely, urban furniture and infrastructure exacerbate visual clutter when they do not align with the area's fundamental physical structure.

There exists, therefore, a clear interrelationship among the various components of the spatial structure (Fig. 5), with each element potentially influencing the proliferation and expansion of others. Over time, both sudden and gradual physical transformations in the urban landscape significantly impact its overall visual quality.

The research identified the primary visual pollutants in Tajrish Square affected by the **urban form** as follows:

1. **Land use patterns, urban composition, and building structures** (40.1%)**:** Dense urban development forms a non-transparent shell that disrupts the urban landscape.
2. **Building structures and facades (**11.6%)**:** Aesthetic inconsistencies, including color, material, shape, skyline, and facade composition, significantly contribute to visual pollution.
3. **Pedestrian and street network (**8.9%)**:** Issues such as width, continuity, material, shape, geometric features, and poor human scale reduce pedestrian connectivity.

Additionally, the main **urban functions** impacting visual pollution include:

- **Pedestrian and street network** (14.5%)**;**
- **Fixed and periodic activities, like street vending** (3/4%)**;**
- **Urban furniture** (12.8%)**,** including advertising and decorative elements such as lighting columns, trash bins, pedestrian bridges, benches, and town information boards.
- **Urban Infrastructure:**
- **Energy supply,** such as **hanging electrical cables** (3/2%)**,**
- **Waste management** (2/9%)**,**
- **Green spaces,** which are insufficiently allocated (2.6%).

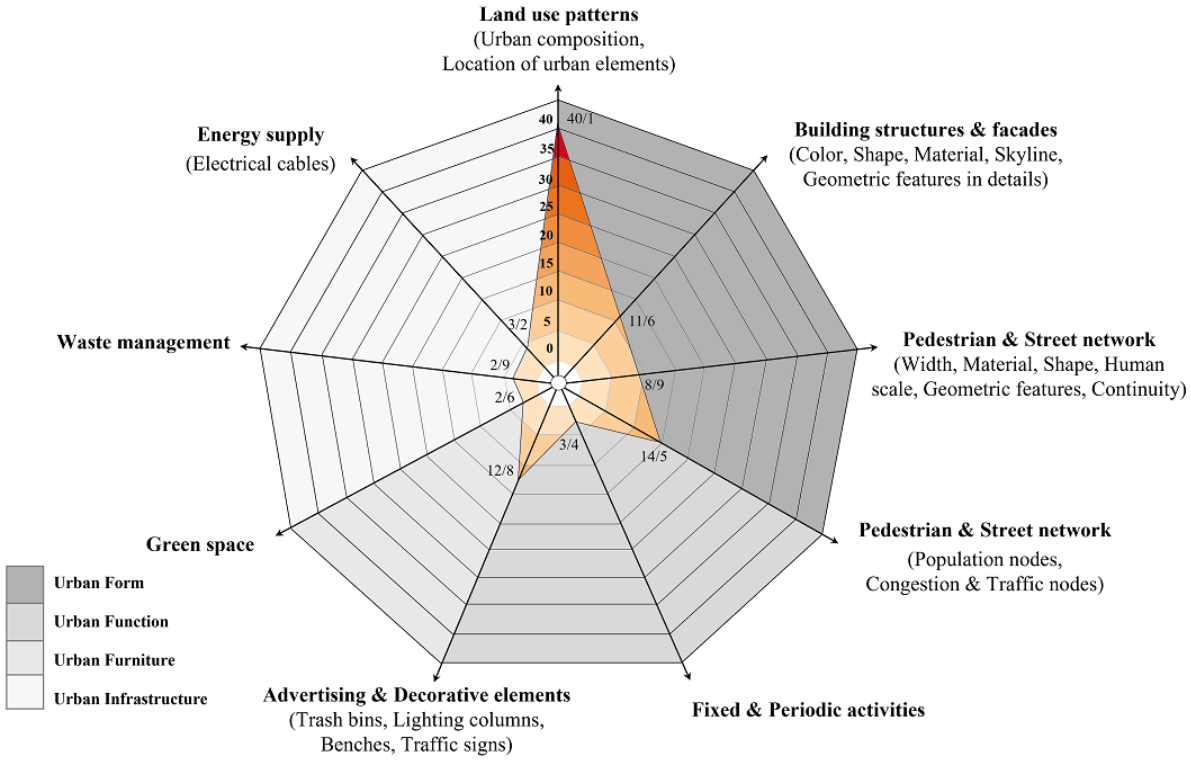

Fig. 5. Spatial structure components and their interactions

Overall, the urban landscape of Tajrish area is characterized by significant inconsistencies, including faded buildings, numerous billboards, hanging electrical cables, worn sidewalks and a stark contrast between old and new structures. These inconsistencies disrupt spatial coherence and diminish the overall visual quality of the urban environment. The findings of this study correlate with the work of Adam *et al*. (2022), which highlighted the impact of vehicular traffic on visual pollution. However, unlike previous studies that primarily focused on individual factors such as urban land use, building structures, or the location of public transport stations, this research adopts a mixed-methods approach to explore the multifaceted effects of spatial structure on visual pollution.

The AHP and Space Syntax analyses collectively revealed that the overall structure of urban space serves as the primary visual pollutant from the perspective of residents. Fixed land use patterns, combined with the placement of large-scale constructions, emerged as key contributors to visual disconnection. Non-transparent physical structures, such as high-rise buildings and poorly planned transport hubs, obstruct visual connections to landmarks, gradually degrading the urban landscape's visual quality. These findings emphasize the long-term consequences of poor urban planning decisions, which are not only noticeable to the general public but also undermine the functional and aesthetic integrity of urban spaces.

Figure 6 illustrates the research results, emphasizing the interconnectedness of urban design components. It highlights the critical relationship between the allocation of urban land use, the placement of urban elements, and the form of building structures with pedestrian and vehicular network infrastructure. The study underscores the importance of logical urban design that enhances citizens' visual connection to key landmarks while ensuring continuity and harmony in spatial arrangements.

In conclusion, this research demonstrates that spatial configurations play a central role in shaping the visual quality of urban landscapes. By addressing spatial barriers and prioritizing

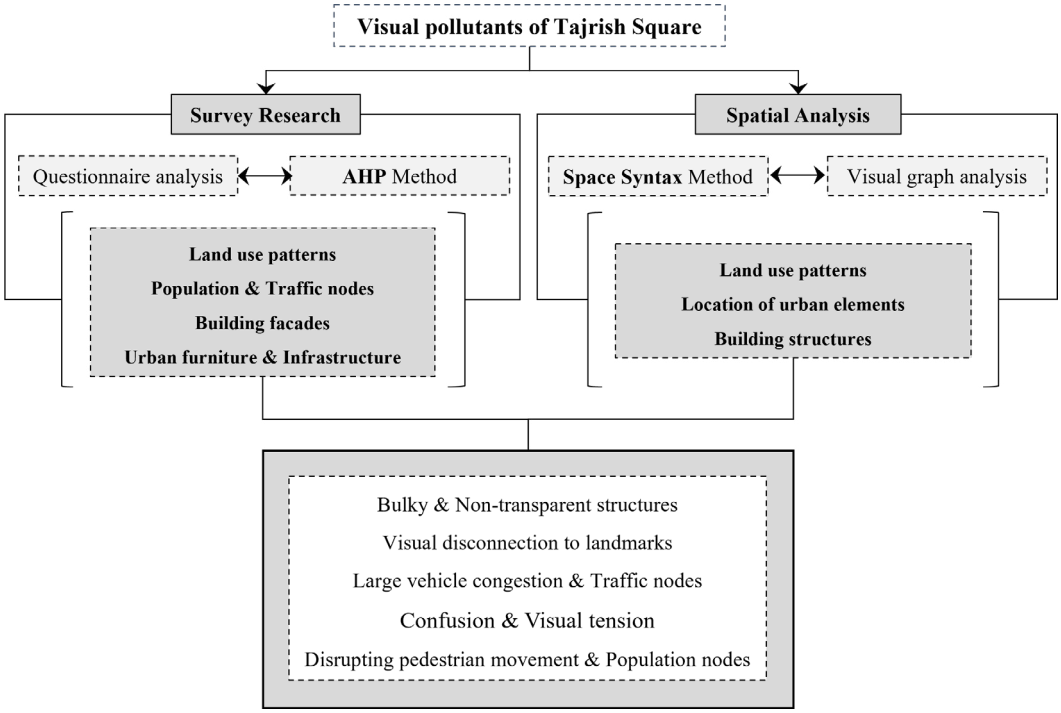

Fig. 6. Research results diagram

proportional urban design, city planners can mitigate visual pollution and foster environments that are visually coherent and user-friendly. The findings provide actionable insights for rethinking urban planning strategies in rapidly urbanizing areas like Tajrish Square.

CONCLUSION

The analyses identified the most significant factors contributing to visual pollution in Tajrish Square, ranked as follows: design and composition of urban elements, physical and functional characteristics of pedestrian and street networks, urban furniture (including advertising and decorative elements), and urban infrastructure issues such as waste management, green spaces, and electrical cables. These findings underscore the multifaceted impact of urban form design on urban function and urban furniture, revealing the interconnectedness of these spatial components in shaping visual pollution.

In response to the research question, the primary visual pollutants influenced by urban form include inappropriate land-use allocation, non-transparent building structures to the south of the Square, and the location of public transport stations to the north and south of Tajrish Square. These factors significantly disrupt pedestrian and vehicular traffic, exacerbate congestion, and intensify the presence of commercial advertising. The study further revealed that these pollutants reduced non-locals' awareness of valuable religious and historical landmarks, directly affecting the legibility and coherence of the urban fabric.

Findings from Tajrish Square offer insights applicable to other rapidly urbanizing regions, emphasizing the need for strategic spatial planning to balance modern development with historical preservation. Issues such as visually obstructive structures, poor land-use allocation, and misaligned public transport networks are common to many urban environments undergoing similar transformations. The methodological framework used in this study —integrating AHP and Space Syntax—can be adapted to other culturally and historically significant urban areas to

develop strategies for mitigating visual pollution globally.

This research emphasizes the importance of enhancing urban structural factors, including land use and public transport networks, to improve the visual and functional quality of urban landscapes. Addressing visually disruptive structures and ensuring their integration within the broader urban context is essential for fostering a harmonious and legible urban environment. Strategic planning for the placement of these structures must precede facade design, emphasizing a foundation rooted in urban space analysis tools such as Space Syntax. The combination of AHP and Space Syntax analyses offers a robust framework for assessing visual pollution, demonstrating how subjective perceptions and spatial metrics align to reveal actionable urban planning insights. This methodological integration can guide future research into urban spatial quality and inform evidence-based policy interventions.

By offering practical recommendations, this study provides urban planners and designers with critical insights to enhance the sense of place in spaces like Tajrish Square. Efforts to preserve regional and urban heritage must be coupled with comprehensive spatial planning to maintain both visual coherence and functional efficiency. Future research should explore the integration of machine learning and GIS-based approaches to monitor urban aesthetic changes and conduct longitudinal studies to assess the impact of interventions on visual pollution over time.

Ultimately, this study contributes to urban studies by providing a replicable methodology for addressing visual pollution in diverse urban contexts. The insights derived from Tajrish Square can inform strategies for similar spaces worldwide, reinforcing the importance of preserving cultural and historical landmarks while improving urban aesthetics and functionality.

GRANT SUPPORT DETAILS

The present research did not receive any financial support.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

REFERENCES

Adam, M., Al-Sharaa, A., & Ghafar, N. A. (2022). The effects of colour content and cumulative area of outdoor advertisement billboards on the visual quality of urban streets. *ISPRS International Journal of Geo-Information*.

Ahmed, N., Islam, M. N., & Tuba, A. S. (2019). Solving visual pollution with deep learning: A new nexus in environmental management. *Journal of environmental management, 248*.

AlElaiwi, M., Al-antari, M. A., & Ahmad, H. F. (2023). Visual pollution real images benchmark dataset on the public roads. *Data in Brief, 50*. doi:10.1016/j.dib.2023.109491

Alwah, A. A., Li, W., & Alwah, M. A. (2020). Difficulty and complexity in dealing with visual pollution in historical cities: The historical city of Ibb, Yemen as a case study. *IOP Conf. Series: Earth and Environmental Science.* Montréal, Canada. doi:10.1088/1755-1315/601/1/012045

Appleyard, D., & Lintell, M. (1972). The Environmental Quality of City Streets: The Residents' Viewpoint.

Journal of the American Institute of Planners, 38(2), 84-101. doi:10.1080/01944367208977410
Borowiak, K., Budka, A., & Lisiak-Zielińs, M. e. (2024). Urban visual pollution: comparison of two ways of evaluation—a case study from Europe. *Scientific Reports, 14*.
Bunge, W. (1966). *Theoretical geography.* Lund Studies in Geography, Series C.
Burtan, D., Joyce, K., & Burn, J. F. (2021). The nature effect in motion: visual exposure to environmental scenes impacts cognitive load and human gait kinematics. *National Center for Biotechnology Information, 8*(1). doi:10.1098/rsos.201100
Carmona, M. (2021). *Public Places Urban Spaces: The Dimensions of Urban Design* (3 ed.). New York: Routledge. doi:10.4324/9781315158457
Chen, T., Hui, E. C., & Wu, J. e. (2019). Identifying urban spatial structure and urban vibrancy in highly dense cities using georeferenced social media data. *Habitat International, 89*. doi:10.1016/j.habitatint.2019.102005
Chmielewski, S. (2021). Towards Managing Visual Pollution: A 3D Isovist and Voxel Approach to Advertisement Billboard Visual Impact Assessment. *ISPRS International Journal of Geo-Information, 10*(10). doi:10.3390/ijgi10100656
Council on Environmental Quality (1970). *"Scenic-Beauty Issues in Public Policy Making," in Environmental Aesthetics.* New York: Cambridge University Press.
Cvetković, M., Momčilović – Petronijević, A., & Ćurčić, A. (2018). VISUAL POLLUTION OF URBAN AREAS AS ONE OF THE MAIN ISSUES OF THE 21ST CENTURY. *26th International Conference Ecological Truth & Environmental Research.* Bor Lake, Bor, Serbia.
DaiDung. (2023). *WIND POWER FOR GREEN CITY*. Retrieved from https://daidung.com/en/wind-power-for-green-city/
El-Ghonaimy, I. H. (2019). Visual pollution phenomena and sensitivity of residences in heritage city centers Case of: Old district of Manama city, Kingdom of Bahrain. *Journal of Contemporary Urban Affairs, 1*(3), 175-190.
Foley, J. A., Bayraktar, I., & Hyare, H. e. (2020). Impaired spatial processing in visual perception, imagery and art-making following parieto-occipital infarcts. *Cortex, 126*, 355-367. doi:10.1016/j.cortex.2020.01.023
Gao, H., Abu Bakar, S., & Maulan, S. e. (2023). Identifying visual quality of rural road landscape character by using public preference and heatmap analysis in Sabak Bernam, Malaysia. *Land, 12*(7). doi:10.3390/land12071440
Gao, H., Abu Bakar, S., & Maulan, S. e. (Eds.). (2024). A Systematic Literature Review and Analysis of Visual Pollution. *Land, 13*(7). doi:10.3390/land13070994
Garrison, W. L. (1959). *Spatial Structure of the Economy: I,".* Annals of the Association of American Geographers.
Guo, Y., Tang, J., Liu, H., & al., e. (2024). Identifying up-to-date urban land-use patterns with visual and semantic features based on multisource geospatial data. *Sustainable Cities and Society, 101*. doi:10.1016/j.scs.2024.105184
Gupta, A., Padsala, M., & Jani, D. e. (2024). From Above and Beyond: Decoding Urban Aesthetics with the Visual Pollution Index. doi:10.1007/978-3-031-56388-1_13
Helbich, M., Burov, A., & Dimitrova, D. (2024). Sleep problems mediate the association between outdoor nighttime light and symptoms of depression and anxiety: A cross-sectional, multi-city study in Bulgaria. *Environmental Research, 263*(1). doi:10.1016/j.envres.2024.119897
Hillier, B., & Hanson, J. (1984). *The Social Logic of Space.* Cambridge university press.
Horton, F. E., & Reynolds, D. R. (2016). Effects of Urban Spatial Structure on Individual Behavior. *Economic Geography, 47*(1), 36-48.
Ishikawa, A. (2023). A review of effects of visual environmental factors on interpersonal cognition and behavior: Focusing on brightness, color, and depth. *Journal of Environmental Engineering, 87*(802), 797-808. doi:10.3130/aije.87.797
Jacobs, J. (1961). *The Death and Life of Great American Cities New York, NY, USA.* New York, NY, USA: Random House.
Jana, M. K., & De, T. (2015). Visual pollution can have a deep degrading effect on urban and suburban

community: A study in few places of Bengal, India, with special reference to unorganized billboards. *European Scientific Journal, 11*, 1-14.

Jayasinghe, P. A., Derrible, S., & Kattan, L. (2023). Interdependencies between Urban Transport, Water, and Solid Waste Infrastructure Systems. *Infrastructures, 8*(4). doi:10.3390/infrastructures8040076

Jensen, C. U., Panduro, T. E., & Lundhede, T. H. (2014). The vindication of Don Quixote: The impact of noise and visual pollution from wind turbines. *Land Economics*, 668-682.

Kamičaitytė-Virbašienė, J., Godienė, G., & Kavoliūnas, G. (2016). Methodology of visual pollution assessment for natural landscapes. *Journal of Sustainable Architecture and Civil Engineering, 12*, 80-88.

Kirchhoff, T., Ramisch, K., & Feucht, T. e. (2022). Visual evaluations of wind turbines: Judgments of scenic beauty or of moral desirability? *Landscape and Urban Planning, 226*. doi:10.1016/j.landurbplan.2022.104509

Korkou, M., Tarigan, A., & Hanslin, H. M. (2023). The multifunctionality concept in urban green infrastructure planning: A systematic literature review. *Urban Forestry & Urban Greening, 85*. doi:10.1016/j.ufug.2023.127975

Kühn, S., & Gallinat, J. (2024). Environmental neuroscience unravels the pathway from the physical environment to mental health. *Nature Mental Health, 2*(3), 263-266. doi:10.1038/s44220-023-00137-6

Liu, Y., Chen, X., & Liu, D. (2020). How Does Urban Spatial Structure Affect Economic Growth? Evidence from Landsat Data in China. *Journal of Economic Issues, 54*(3), 798-812. doi:10.1080/00213624.2020.1787062

Lynch, K. (1960). *The Image of The City.* Cambridge: M.I.T. Press.

M.A.S., M., Ahmed Osman, I., & Yakubu Aminu, D. e. (2021). Visual Pollution Manifestations Negative Impacts on The People of Saudi Arabia. *International Journal of Advanced and Applied Sciences, 8*(9), 94-101.

Mandeli, K. (2019). Public space and the challenge of urban transformation in cities of emerging economies: Jeddah case study. *Cities, 95*. doi:10.1016/j.cities.2019.102409

Moulay, A., Ujang, N., & Said, I. (2018). Legibility of neighborhood parks as a predicator for enhanced social interaction towards social sustainability. *Cities, 61*, 58-64.

Nami, P., Jahanbakhsh, P., & Fathalipour, A. (2015). The Role and Heterogeneity of Visual Pollution on the Quality of Urban Landscape Using GIS; Case Study: Historical Garden in City of Maraqeh. *Open Journal of Geology, 6*(1), 20-29. doi:10.4236/ojg.2016.61003

Nia, H. A. (2019). Visual pollution phenomena and sensitivity of residences in heritage city centers Case of: Old district of Manama city, Kingdom of Bahrain. *Journal of Contemporary Urban Affairs, 3*(1), 175-190.

Ortiz-Peregrina, S., Ortiz, C., & Casares-López, M. e. (2023). The Relationship between Anxiety, Visual Function, and Symptomatology in University Students. *Journal of clinical medicine, 12*(20). doi:10.3390/jcm12206595

Portella, A. (2014). User's Perception and Cognition of the Built Environment. In *Visual Pollution* (p. 35). London: Routledge. doi:10.4324/9781315547954

Rachman, S., Coughtrey, A., & Shafran, R. e. (2014). Visual Contamination. In *Oxford Guide to the Treatment of Mental Contamination* (pp. 155-158). doi:10.1093/med:psych/9780198727248.003.0010

Ramadan, S., Al-Ikhsan, A., & Ladianto, A. J. (2023). The presence of signage in the control of visual pollution in urban areas: A case study in the M.T Haryono street corridor, Kendari City, Indonesia. *IOP Conference Series: Earth and Environmental Science.* doi:10.1088/1755-1315/1263/1/012009

Rangel-Buitrago, N., Galgani, F., & Neal, W. J. (2023). Politics maybe… visual pollution: No! *Marine Pollution Bulletin, 197*. doi:10.1016/j.marpolbul.2023.115711

Rodrigues, P. F., & Pandeirada, J. N. (2018). When visual stimulation of the surrounding environment affects children's cognitive performance. *Journal of Experimental Child Psychology, 176*, 140-149. doi:10.1016/j.jecp.2018.07.014

Sadeghpoor, F., Ranjbar, E., & Esmaeilinasab, M. e. (2024). Streets and Stress: A Pilot Study on How Quality and Design of Streets Impacts on Urban Stress. *HERD: Health Environments Research &*

Design Journal, 17(1), 224-248. doi:10.1177/19375867231200584

Samavati, S., & Desmet, P. M. (2022). *Happy Public Spaces: A Guide with 20 Ingredients to Design for Urban Happiness. Delft: Delft University of.* Delft University of Technology.

Scenic America. (2022, March 31). *Visual Pollution and the Preservation of Aesthetic Places*. Retrieved from https://www.scenic.org/2022/03/31/visual-pollution-and-the-preservation-of-aesthetic-places/

Shatwan, A. M. (2021). Visual Pollution and the Architecture of Façade Design: A Case Study in Jeddah. *Umm Al-Qura University Journal of Engineering & Architecture*.

Sinha, S. (2024). Visual Pollution: The Critical Need For Environmental And Social Awareness. *International Journal of Creative Research Thoughts (IJCRT), 12*(8).

Skenteris, K., Mirasgedis, S., & Tourkolias, C. (2019). Implementing hedonic pricing models for valuing the visual impact of wind farms in Greece. *Economic Analysis and Policy, 64*, 248-258. doi:10.1016/j.eap.2019.09.004

Szczepańska, M., Wilkaniec, A., & Škamlová, L. (2019). Visual pollution in natural and landscape protected areas: Case studies from Poland and Slovakia. *Quaestiones Geographicae, 38*, 133-149.

Urban furniture: identity of the city. (2022). Retrieved from Initube: https://initube.es/en/urban-furniture-identity-of-the-city/

Zaeimdar, M., Khalilnezhad Sarab, F., & Rafati, M. (2024). Investigation of the relation between visual pollution and citizenry health in the city of Tehran (case study: municipality districts No.1 & 12 of Tehran). *Anthropogenic Pollution*.

Zhang, C., Chen, Y., & Dewancker, B. J. (2024). Emotional Landscapes in Urban Design: Analyzing Color Emotional Responses of the Elderly to Community Outdoor Spaces in Yi Jie Qu 10.3390/buildings14030793 Buildings. *Buildings, 14*(3). doi:10.3390/buildings14030793

Zhang, D., Jin, X., & Wang, L. e. (2023). Form and color visual perception in green exercise: Positive effects on attention, mood, and self-esteem. *Journal of Environmental Psychology, 88*. doi:10.1016/j.jenvp.2023.102028

Živković, J. (2019). Urban Form and Function. In *Climate Action* (pp. 1-10). Encyclopedia of the UN Sustainable Development Goals. Springer, Cham. doi:10.1007/978-3-319-71063-1_78-1