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The Impact of Façade Design on Visual Pollution
Case study: Peshawa-Qazi Street (100 m) in Erbil

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Abstract

Visual pollution refers to the negative impact of various environmental elements on the visual experience of individuals and the quality of the surroundings. This includes unsightly buildings and other man-made structures that disrupt natural beauty. The design of building facades plays a significant role in determining visual pollution. This study aimed to assess the impact of facade design on visual pollution by testing which facade design considerations most contribute to visual pollution in Peshawa-Qazi Street (100 m) in Erbil City. An online survey was conducted with 283 participants in six architectural departments within engineering colleges and other online engineering platforms in Erbil, Duhok, and Suleimani. Respondents included architectural students from the 3rd to 5th stage, academic staff, and professional architects. They rated the impact of individual facade elements, contextual integration, and other factors on visual pollution. A one-sample T-test was used to compare mean scores to a test value of (2.5). Results showed that all three categories of façade design considerations significantly increase visual pollution compared to the test value ($p < 0.05$). Considerations regarding the overall context of a facade had the most significant impact (mean of 1.93 higher than the test value), followed by other factors (mean of 1.79 higher) and individual elements (mean of 0.71 higher). To decrease visual pollution, it is recommended to the policymakers and municipalities to develop regulations, façade design guidelines and for architects to follow the principles of architectural form and composition regarding the integration of building facades with their surroundings, façade practical considerations, and refined composition of façade elements.

Keywords: Visual pollution, Façade design, Aesthetics, Context, Design principles, Built-Environment.

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1. Introduction

Visual pollution is an aesthetic issue and a growing concern in cities across the globe. It refers to the presence of undesirable and visually unappealing elements that disrupt the aesthetic harmony of urban areas. Architectural aesthetic problems such as unpleasing forms, shapes, and styles that create disordered environments have impacted city dwellers visually, mentally, and psychologically for centuries. The ancient Roman architect Vitruvius considered aesthetics one of architecture's main qualities in 15 BC, defining good architecture in terms of venustas (beauty), utilitas (utility), and firmitas (firmness). In contemporary interpretation, these correspond to form, function, and construction, with form representing the aesthetic aspects of buildings. Aesthetics constitutes an important architectural principle. Architects should consider this as the philosophical foundation for pleasing visual appearance, as shown in Fig. 1.

Visual pollution refers to disorderly elements in the environment that create an unaesthetic view and leaves an undesirable impression on individuals [13]. Since visual pollution affects the aesthetics of an environment, it can be defined as the effects of pollution that diminish the visual appeal of a built environment and affect one's ability to enjoy the view [25]. Visual pollution is caused by unsightly buildings or other man-made structures that disrupt the natural beauty of the built environment. The design of building facades plays a significant role in decreasing or increasing visual pollution, which contributes positively or negatively to the overall visual quality of the built environment.

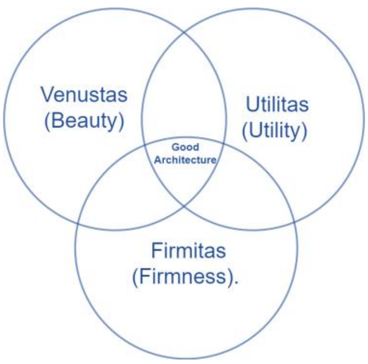

Fig. 1 The three branches of architecture Based on Vitruvius in Morgan [26].

According to the Cambridge Dictionary, a façade is the front of a building, especially a large or attractive building. It is the face of a building given special architectural treatment. Critical surfaces of façade design include functions, aesthetics, and void spaces [22]. The physical form of a building is characterized by the visual appearance of its façade, which connects to the unified architectural style along the Street or urban corridor. The façade of buildings should be designed according to the principles of design. Thus, the visual quality of a built environment can be evaluated through various design aspects such as repetition, scale, color, and texture [23]. The building's façade reflects its historical style and creates its identity [17]. Integrating the building with its context will enhance the visual appeal of the streetscape. Aesthetic appraisals depend partly on the degree to which a building appears compatible with its immediate context [24].

Erbil is one of the oldest continuously inhabited cities in the world, dating back to 6,000 years B.C. Now it faces a growing problem of visual pollution caused by poorly designed building facades, which negatively affects the city's architecture, resident satisfaction, mental health, tourism appeal, and investment. However, there is a lack of studies specifically focusing on this issue in the Kurdistan region, including considerations related to individual façade design, integration with context, and practical considerations of façade design. To address this gap, this study investigated the impact of building facade design on visual pollution in Erbil.

As a case study, the study employed a three-stage process, starting with photographic documentation of all building facades along a main 100-meter Street in Erbil. The Street was divided into six portions; photos were randomly selected to represent each portion and the overall street area. An online survey questionnaire was developed for architecture students and professionals to evaluate the visual appeal of the selected photographs and rate provided façade design considerations. Finally, statistical analysis of the collected survey data was performed using IBM (International Business Machines Corporation) SPSS (Statistical Package for the Social Science Statistics) Version 26 software to derive results. SPSS is an industry-standard software for survey-based research and quantitative analytics produced by IBM. We determined it would be the most appropriate choice for the computational analysis needs of this study in consultation with the statistician.

Overall, the study aimed to determine the influence of individual façade components, integration with the surrounding context, and other practical considerations related to façade design on visual pollution.

2. Literature Review

2.1. Façade design

In the study [7], researchers interviewed architects in the Netherlands to identify aspects that they consider essential in designing beautiful facades. They found that both intrinsic and extrinsic factors informed architects' preferences. Intrinsic factors are related to the inherent characteristics of the façade itself, such as composition, materials, and details. Extrinsic factors relate to how the façade is connected to external agents, such as context, humans, and intellectual intent, see Fig. 2.

In another study [3], researchers investigated the aesthetic preferences of people in Poland for building façade compositions. They found that people preferred more regular compositions over less regular ones. They also found that irregular compositions elicited stronger negative reactions than positive reactions from people. Researchers explored aesthetic preferences for the visual quality of urban landscapes in high-rise buildings in Shiraz, Iran. They found that people preferred high-rise buildings with irregular, distinctive traits over those with regular, primary traits. They suggested that architects consider public preferences for complexity, asymmetry, and variety when designing high-rise buildings [1]. See Fig. 3.

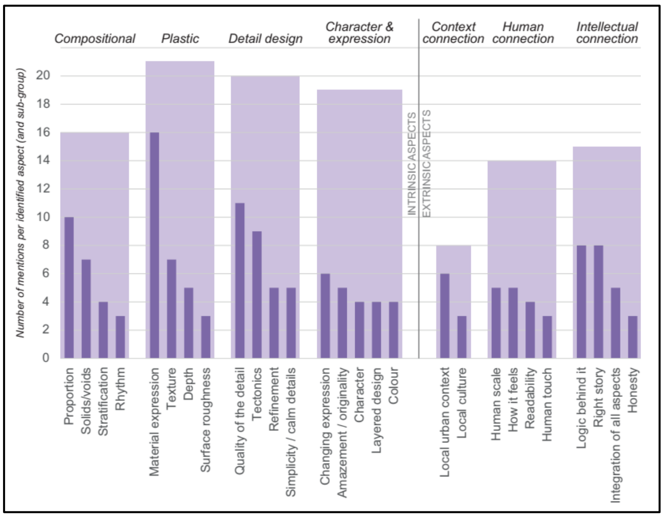

Fig. 2 Factors and sub-factors used in the study of [7].

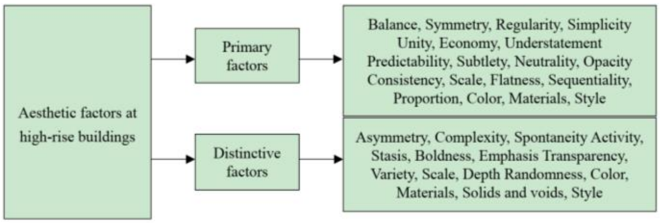

Fig. 3 Aesthetic factors and sub-factors used in the study [1].

Researchers assessed the visual quality of Nigeria's Covenant University Senate building façade through public perception [2]. They found that façade height and shape were the most preferred elements, highlighting the need for architects to understand public aesthetic preferences.

The visual aspects of historical building facades analyzed in Kuala Lumpur, Malaysia, and their influence on façade image. They found that architectural style and color most influenced the historical façade image. Style, material, and shape positively affected the facades' visual richness and historical character. Inconsistent color negatively impacted the façade image. Colors like pink, yellow, and blue weaken historical characters [12]. The researcher examined the visual properties and problems affecting the facades of shophouses in Georgetown, Penang, in a study [16]. They found that the unique visual characteristics of shophouse facades have developed over time. While some principles are resilient, shape and color are fragile and easily distorted. Recommendations included protecting facades by removing visual problems, working on heritage values, and passing supportive regulations.

2.2. Visual pollution

The researchers in the study [5] examined visual pollution and poor façade design along the Al-Madina Al-Munawara corridor in Amman, Jordan. They found that the lack of a unified architectural language, haphazard use of materials, colors, and window types, and inconsistency with neighboring buildings were the main problems with façade design along the corridor. They concluded that the rapid development of the corridor without clear guidelines on materials, colors, and design harmony with context had led to visual chaos, a loss of identity, and massive visual pollution. The Researchers analyzed visual pollution in the old district of Manama, Bahrain [18]. They found that the most common problems with façade design in Manama were mismatched colors, using marble as the primary material, simple shapes, and different heights between adjacent buildings. They concluded that poor regulation and disregard for neighboring buildings were the main factors causing visual pollution from facades in Jeddah. In the study [19] researchers examined visual pollution and its impact on architectural facades in Algeria. Focusing on a case study of collective housing in Batna, the authors analyzed how user modifications to building exteriors distorted the original design intent. Through photographic comparison and survey data, they found that additions like air conditioners, antennas, and enclosed balconies created dual meanings that polluted the visual image. The study showed how unregulated changes degraded aesthetic values like proportion, rhythm, and balance. It provided evidence that visual pollution generated disharmony and suggested involving users in the design process to limit future infringement. Overall, this was an insightful study of how uncontrolled visual pollution degraded architectural meaning. In the study [11], researchers examined visual pollution indicators along the Bab Al-Hussein commercial street in Al-Hilla City, Iraq. They found gaps in regulatory implementation and aesthetic sensitivity to be critical factors. Recommendations included raising public awareness and encouraging research to reduce visual pollution impacts.

Visual pollution caused by poor façade design in Jeddah, Saudi Arabia, was investigated by the researchers [6]. They found that the most common problems with façade design in Jeddah were mismatched colors, the use of marble as the primary material, simple shapes, and different heights between adjacent buildings. They concluded that poor regulation and disregard for neighboring buildings were the main factors causing visual pollution from facades in Jeddah. Other researchers [20], examined visual pollution in two city squares in Tehran: Enghelab Square and Vanak Square. They found that Vanak Square had a higher visual quality than Enghelab Square based on strengths like green spaces. The analysis suggested an “invasive” approach for visually enhancing Vanak Square but a more “conservative” one for Enghelab. In another study [4], researchers investigated visual pollution along a historic shopping street in Kuala Lumpur, Malaysia. They found that higher visual pollution generally increased unpleasantness ratings. However, tolerance was higher than expected, with a 25% unpleasant rating. The analysis found that gender, education level, and the location of the residential influenced reactions. Males and rural residents were more sensitive to visual pollution.

In their study [8], researchers analyzed the visual impact of architectural forms and aesthetic judgment by examining library buildings. The authors surveyed college students online, rating 16 library images on aesthetic appeal and expected functionality. Results found a very strong correlation between aesthetic appeal and expected reading comfort. Analysis of visual judgment parameters ranked color as most influential, followed by materials, composition, and shape. Architecture students favored shape and composition more, while non-architecture students preferred color intensity and material variety. The study concluded that inherent aesthetic perception order hardly varies with design training. Overall, the survey method effectively identified visual parameters impacting the aesthetic judgment of public buildings. While limited to one building type and student sample, creating a judgment index and relation of appeal to functionality offered significant implications for façade design.

Researchers analyzed visual pollution from commercial banners on building facades, comparing Alexandria, Egypt, and Moscow [9]. In Alexandria, despite governmental efforts, businesses violate laws by installing massive, chaotic banners on historic buildings. In Moscow, 2012 regulations sharply reduced advertising and required coordinated shop signage matching facades. He concluded that visual pollution harms aesthetics and psychology. Comparing the two cities showed that Moscow’s strict implementation of banner regulations improved aesthetics, while the lack of regulations in Alexandria caused visual chaos. The paper highlighted how enforcing clear limits on commercial building banners benefits urban visual harmony.

Researchers examined an integrated approach to studying street lighting, façade lighting, and light pollution in the study [10]. They concluded that an integrated system enables optimized street and façade lighting to control light pollution. In another one [15], researchers used a lens model to examine differences in how architects versus laypeople aesthetically evaluate building facades. Architects and laypeople rated their emotional reactions to photos of office buildings, and physical façade features were scored. Results found low agreement between groups on pleasure and overall aesthetic ratings. Each person experiences unique physical sensations that are associated with pleasure and arousal. These cues can vary greatly from one individual to another group, clarifying affective bases for their aesthetic divergence. The quantitative approach provided empirical evidence that differing emotional responses to façade elements underlie aesthetic disagreement between architects and non-architects. Mapping these routes from features to emotions to overall judgments elucidated the roots of their divergent aesthetic assessments. In Table 1, we summarized factors and results from previous studies.

Table 1. Factors and results from previous studies (Author).

Source	Factors used	Conclusion
[7]	Proportion, rhythm, balance, texture, material qualities of the façade, detail, character, color, context, and scale.	- They found that both intrinsic and extrinsic factors informed architects’ preferences. - Comparison of outcomes against previous literature results
[2]	Shape, Color, and window openings.	- Façade shape and height are perceived as the most interesting - Designers need to be equipped with the perception of building design elements
[6]	Color, material, shape and height	- Different neighborhoods in Jeddah have different manifestations of visual pollution. - The al-Hendaweyyah neighborhood is a slum area with significant visual pollution.
[27]	Advertisements, Color, lighting, cleanliness, and visual complexity.	- Vanak Square has a better position than Enghelab Square regarding visual pollution. - The study has offered eight prioritization strategies for the squares.
[19]	Proportion, rhythm, balance air conditioners and antennas.	It provides a framework to assess visual pollution on building facades, demonstrating how uncontrolled user additions can degrade original design intent and aesthetic quality. It recommends solutions to mitigate this through inclusive design and planning for façade evolution.

[1]	Scale, Materials, Color, Balance, Unity, Variety, Proportion, Emphasis.	They found that people preferred high-rise buildings with irregular, distinctive traits over those with regular, primary traits. They suggested that architects consider public preferences for complexity, asymmetry, and variety when designing high-rise buildings.
[8]	Shape/geometry, windows, doors, Color, Materials, patterns and textures.	The study identified several built-form characteristics that impact aesthetic judgment, which could inform the architectural design to improve visual appeal for the intended users. It also demonstrated methods to quantify aesthetic perceptions.
[16]	Shape, color, texture, symmetry, repetition, scale, proportion, rhythm, hierarchy.	The study performed an analytical examination of shophouse façade architecture, identified threats from various visual problems, analyzed their impact, and provided recommendations focused on preserving the unique façade typology.
[9]	Banner types and locations	the article analyzes and compares causes of visual pollution from building banners and signage in Egypt and Russia, finding better enforcement of regulations in Moscow and improving aesthetics. It recommends that Egypt implement bans and rules more strictly to reduce visual pollution.
[12]	Style, Shape, Decoration, Materials, Color, Texture and Dimensions	The study demonstrated that architectural style, material, shape, and color consistency, are key visual façade elements influencing the historical image of an area. This highlights their importance in façade design and restoration.
[15]	Articulation, materials, shape, ornamentation.	The research demonstrates that architects and laypersons rely on divergent physical attributes to make aesthetic evaluations of buildings, despite some shared principles. This helps elucidate the basis for their disagreements.
[10]	Façade lighting	The study demonstrates an integrated design approach to optimize street and façade lighting while minimizing light pollution. The proposed analysis methods allow appropriate lighting contributions from each source.

2.3. Research questions

To investigate the impacts of façade design on visual pollution in Erbil, the following research questions were raised.

Which of the following façade design considerations contribute most to visual pollution in Erbil city:

1. Considerations of Individual façade Design.
2. Considerations of façade design in relevance to its context.
3. Other considerations related to façade design (practical considerations).

2.4. Research hypotheses

Based on the research questions, the following hypotheses were developed:

1. Null Hypothesis (H0): There is no significant difference in the contribution to visual pollution between considerations of individual façade design, considerations of façade design in relevance to its context, and other considerations related to façade design.
2. Alternative Hypothesis (Ha): There is a significant difference in the contribution to visual pollution between at least one of the three types of façade design considerations.

The research will thoroughly examine the three considerations mentioned in the research question to test the hypotheses.

3. Materials and Methods

3.1. Study design and participants

This quantitative study utilized an online survey to assess perceptions of how façade design impacts visual pollution.

A structured questionnaire was developed consisting of 45 factors measured on a 5-point Likert scale from “strongly disagree” to “strongly agree. Responses from participants were collected using a Likert scale survey questionnaire and then analyzed using IBM SPSS Statistics software by assigning numerical codes, with higher scores indicating a more significant contribution to visual pollution. Factors were grouped into three categories:

- Individual façade design considerations (17 factors)
- Contextual integration of facades (17 factors)
- Other practical façade considerations (11 factors)

This study method is based on previous studies:

The study [7] interviewed architects about aesthetic façade preferences. [14] employed a similar questionnaire methodology to survey architects’ façade design priorities and evaluate outcomes. Furthermore, a survey was informed by foundational insights on architects’ aesthetic judgments provided by [18] regarding differences from public perceptions. Finally, [5] examined poor façade design as a contributor to visual pollution. The 283 participants were architectural students from the 3rd, 4th, and 5th stages (66.4%) (choosing the last three stages because they have more experience in principles of design), academic staff, and professional architects (33.4%) Fig. 4. 29% of respondents were males, and 71% were females Fig. 5.

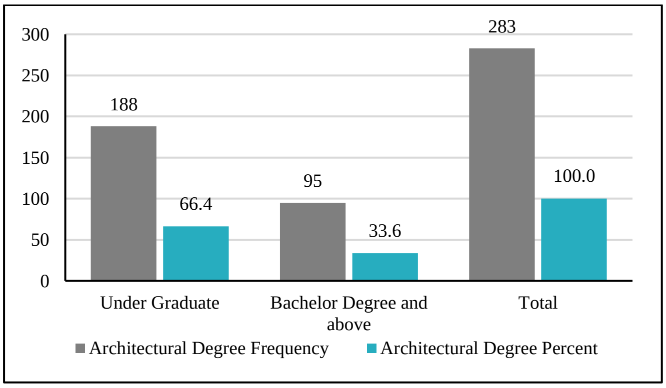

Fig. 4 Respondents’ qualification frequency and percent.

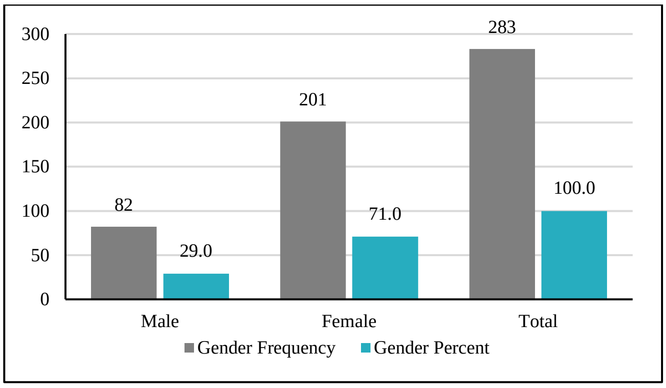

Fig. 5 Respondents' gender frequency and percent.

3.1. Study area

Erbil is the capital of the Kurdistan Region – Iraq. The area examined in Erbil city was Peshawa Qazi Street (100 m street), with an 8.22-kilometer-long commercial street (mixed-used) configured in a ring shape. The author conducted photographic documentation of all building facades along Peshawa Qazi Street. The road is divided into six portions depending on the urban density, Fig. 6.

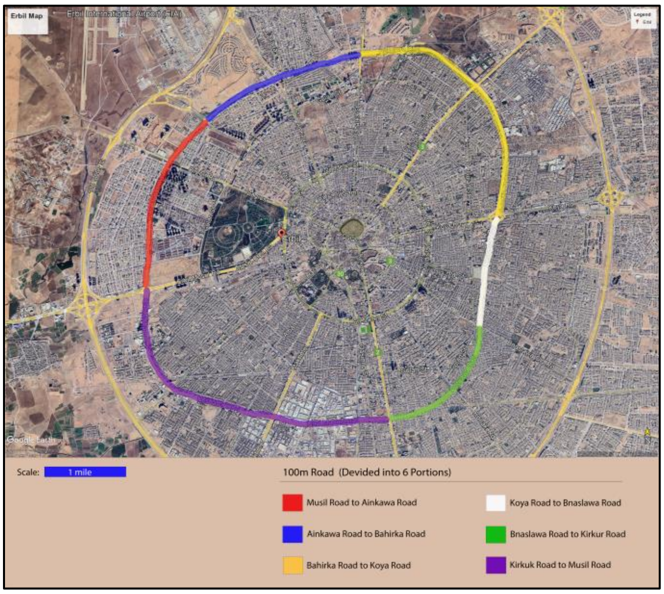

Fig. 6 Satellite image of Erbil indicating the case study street (100 m) (Google Map).

3.2. Survey questionnaire

The online survey questionnaire consisted of four sections. The first collected demographic data, including gender, age, and architectural education level. The second section showed photos and questions about individual façade design considerations. The third section showed façade photos and questions related to the contextual integration of façade design considerations. The fourth section included photos and questions of other façade considerations. The photos were selected randomly using Python software from 176 photos. There were 8 sample photos for the individual facade section (Fig 7), 8 photos for contextual integration (Fig 8), and 10 photos for the other considerations (Fig 9). Respondents reviewed the provided photos and rated the relevant facade design considerations and their impact on visual pollution according to their preferences. All the photos used in the questionnaire can be found in the appendix of this paper in high resolution.

Fig. 7 Photos related to individual façades design (Author).

Fig. 8 Photos related to façades design in relevance to their context (Author).

Fig. 9 Photos related to other façades design considerations (Author).

The relationship between the rating and visual pollution is explained in Fig. 10.

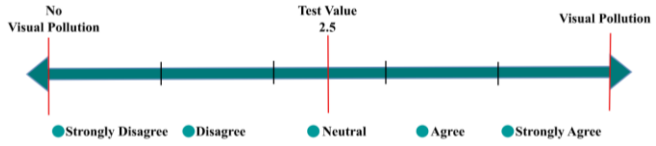

Fig. 10 Relationship between survey rating and visual pollution (Author).

3.3. Sample size

A statistician was consulted before data collection to determine the appropriate sample size for achieving sufficient statistical power. Based on the statistician's recommendations, a sample size calculation was performed using standard criteria for questionnaire surveys. With a total population of 850 potential respondents, using sample size calculation, 5 % margin of error and 95 % confidence level, the minimum required sample size is 265 respondents, we collected 283 complete responses to represent the total population, this reflects approximately 33.3 % of the total population size.

3.4. Data analysis

Data was analyzed using IBM SPSS Statistics 26. Statistics, including means, t-value, p-value, and standard deviations. A one-sample t-test was conducted for each category to compare mean scores to a test value of 2.5, representing a neutral impact on visual pollution.

4. Results and discussion

4.1. Reliabilities

Table 2 shows the internal consistency reliability of the study according to George and Mallery [21].

Table 2. Reliability of the study.

Façade Design Considerations	Cronbach's Alpha	No. of Items	Internal Consistency Reliability
Individual façade design	0.956	17	Excellent
Façade in relevance to the context	0.885	17	Good
Other Façade considerations	0.843	11	Good

4.2. Consideration of individual façade design

Table 3 shows all individual facade design considerations had mean scores higher than the test value of 2.5 ($p < 0.05$), indicating they all contribute to increasing visual pollution.

The elements with the highest mean scores were variety ($M = 3.54$), scale ($M = 3.50$), and proportion ($M = 3.47$). These factors play the most significant role in visual pollution when considered individually.

Articulation, style, character, color, balance, details, unity, contrast, materials and textures, rhythm, and emphasis had means in the range of (3.01 to 3.37). These still contribute noticeably to visual pollution.

Harmony repetition and doors and windows had the lowest means from (2.88 to 2.95). Though still significant, these individual elements have less impact.

At the end of factors (Ind) is used in the individual categories and (Con) in contextual categories for distinguishing.

Table 3. Individual façade design statistical analysis (Author).

Individual Façade Considerations	N	Mean	Std. Deviation	t-Value	P-Value
ArticulationInd	283	3.37	1.220	12.006	0.000
DetailsInd	283	3.18	1.445	7.876	0.000
MaterialandTextureInd	283	3.11	1.330	7.665	0.000
StyleInd	283	3.37	1.421	10.267	0.000
CharacterInd	283	3.32	1.406	9.827	0.000
ColorInd	283	3.32	1.225	11.231	0.000
DoorsandWindowsInd	283	2.88	1.373	4.653	0.000
BalanceInd	283	3.30	1.184	11.325	0.000
ContrastInd	283	3.17	1.212	9.340	0.000
UnityInd	283	3.18	1.202	9.474	0.000
ScaleInd	283	3.50	1.256	13.419	0.000
ProportionInd	283	3.47	1.230	13.268	0.000
RhythmInd	283	3.08	1.283	7.575	0.000
VarietyInd	283	3.54	1.241	14.107	0.000
RepetitionInd	283	2.90	1.423	4.740	0.000
HarmonyInd	283	2.95	1.285	5.900	0.000
EmphasisInd	283	3.01	1.437	5.938	0.000

Figure 11 shows the impact of each factor related to individual façade design considerations with the highest t-Values from Variety (14.107) to the Doors and Windows (4.653). This implies that these design factors significantly impact and are important regarding façade design.

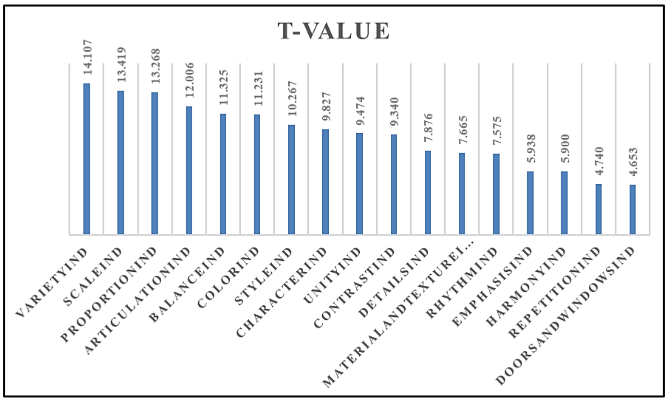

Fig. 11 The t-value of the individual façade design considerations from the highest to the lowest impact (Author).

4.3. Considerations of façades design in relevance to their context

Table 4. shows all contextual facade factors had mean scores significantly higher than 2.5 ($p < 0.05$), indicating they significantly contribute to increased visual pollution.

The elements with the highest means were scale ($M = 4.64$), variety ($M = 4.64$), style ($M = 4.62$), and proportion ($M = 4.62$). This implies a need for more cohesion between a building and its surroundings, which plays the most significant role in visual pollution.

Details, color, character, articulation, balance, materials and texture, emphasis, and harmony had means in the (4.40-4.55) range. While still significant contributors, these are slightly less impactful than scale, variety, etc., when considering the context.

Doors/windows, rhythm, contrast, and unity had means between (4.07-4.36). Though significant, these elements have a lower influence than other contextual factors.

Repetition had the lowest means (3.99) among contextual elements, but still over the test value.

Table 4. Contextual façade design considerations statistical analysis (Author).

Façade with context Considerations	N	Mean	Std. Deviation	t-Value	P-Value
ArticulationCon	283	4.53	0.946	36.158	0.000
DetailsCon	283	4.55	0.867	39.876	0.000
MaterialsandTextureCon	283	4.41	0.939	34.281	0.000
StyleCon	283	4.62	0.818	43.655	0.000
CharacterCon	283	4.55	0.829	41.603	0.000
ColorCon	283	4.55	0.785	44.018	0.000
DoorsandWindowsCon	283	4.36	0.970	32.316	0.000
BalanceCon	283	4.50	0.932	36.147	0.000
ContrastCon	283	4.25	0.833	35.430	0.000
UnityCon	283	4.07	0.796	33.203	0.000
ScaleCon	283	4.64	0.649	55.510	0.000
ProportionCon	283	4.62	0.707	50.436	0.000
RhythmCon	283	4.34	0.815	37.911	0.000
VarietyCon	283	4.64	0.676	53.314	0.000
RepetitionCon	283	3.99	0.797	31.451	0.000
HarmonyCon	283	4.40	0.930	34.358	0.000
EmphasisCon	283	4.41	0.880	36.505	0.000

Figure 12 shows the impact of each factor related to contextual façade design considerations with the highest t-Values from Scale (55.510) to the Repetition (31.451). This explained that these design factors significantly impact and are important regarding façade design.

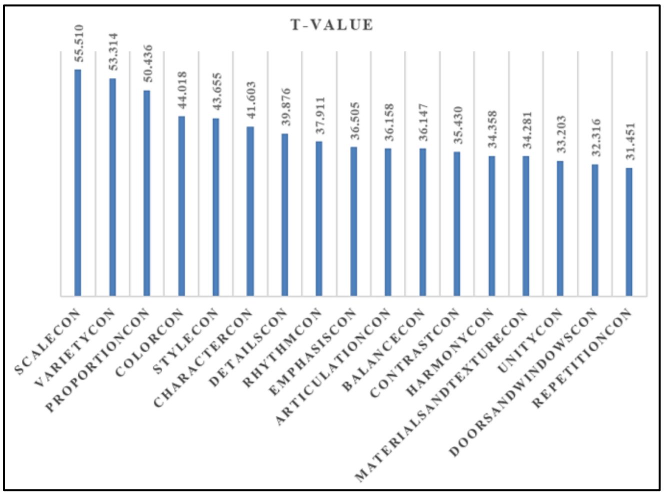

Fig. 12 The t-value of the contextual façade design considerations from the highest to the lowest impact (Author).

4.4. Other façade design considerations

Table 5. shows the mean scores for all the facade elements (maintenance, durability, etc.) are significantly higher than the test means of 2.5 ($p < 0.05$).

The highest mean scores are for signage (4.58), billboards (4.50), serviceability (4.47) and maintenance (4.46). These specific elements contribute the most to visual pollution from the factors examined.

Durability, quality of construction and lighting still rated as contributors but have slightly lower means in the (4.21-4.39) range.

Changings, cell towers and wires also have means above (4), indicating they contribute substantially.

Dishes/Antennas have the lowest means out of the factors with (3.8) but are still above the test mean.

Table 5. Other façade design considerations statistical analysis (Author).

Other Façade Considerations	N	Mean	Std. Deviation	t-Value	P-Value
Maintenance	283	4.46	1.011	32.600	0.000
Durability	283	4.39	1.090	29.096	0.000
Qualityoffaçadeconstruction	283	4.33	1.015	30.353	0.000
Changings	283	4.19	1.076	26.497	0.000
Lighting	283	4.21	1.279	22.519	0.000
Signage	283	4.58	0.860	40.724	0.000
Billboards	283	4.50	0.935	35.937	0.000
Wires	283	4.14	1.095	25.208	0.000
CellTower	283	4.19	1.232	23.096	0.000
Dishes/Antennas	283	3.80	1.196	18.262	0.000
Serviceability	283	4.47	0.923	35.826	0.000

Figure 13 shows the impact of each factor related to other façade design considerations with the highest t-Values from Signage (40.724) to the Dishes/Antennas (18.262). This explains that other factors significantly impact façade design aesthetics.

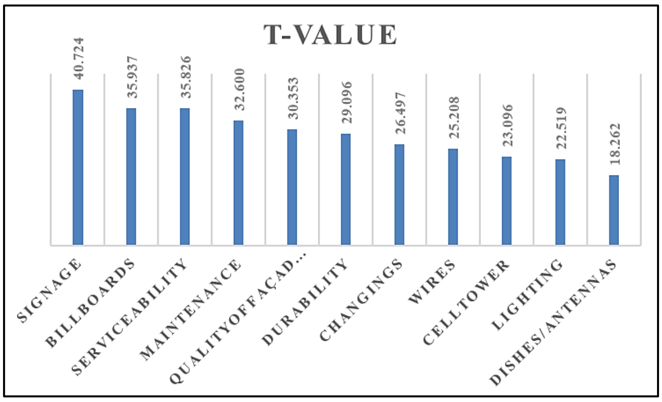

Fig. 13 The t-value of the contextual façade design considerations from the highest to the lowest impact (Author).

4.5. Overall of the three groups of facade considerations

Based on the additional one-sample t-test results comparing the overall mean scores for the three categories of facade design considerations to the test value of 2.5, here are some key points:

The mean in Fig. 14. The difference between all three categories and the test value is statistically significant, with p-values of 0.000.

The contextual considerations have the highest mean difference of (1.938).

The other considerations have a mean difference of (1.796).

The individual considerations have the lowest mean difference of (0.713).

The t-value in Fig. 15. represents how much the mean score differs from the test value of 2.5. The larger the t-value, the greater the impact on visual pollution.

For contextual considerations, the t-value of 65.469 is very high, indicating a large impact on visual pollution.

Other considerations had the next highest t-value of 45.170. They had a significant influence on perceived visual pollution.

Individual elements had the smallest t-value of 11.998. However, it contributes to increased pollution to a minor degree compared to contextual and other factors.

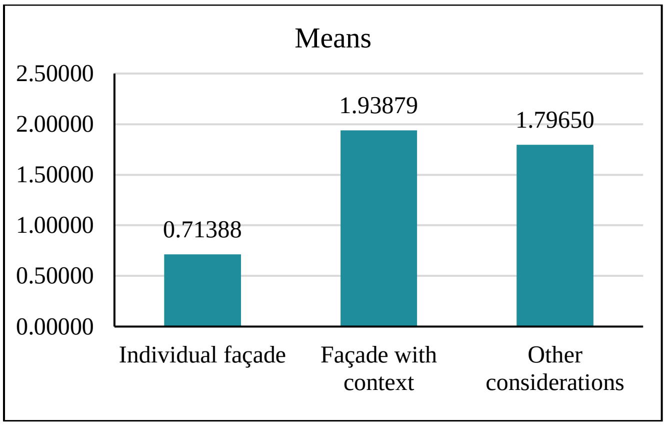

Fig. 14 The mean difference between the three groups of considerations overall (Author).

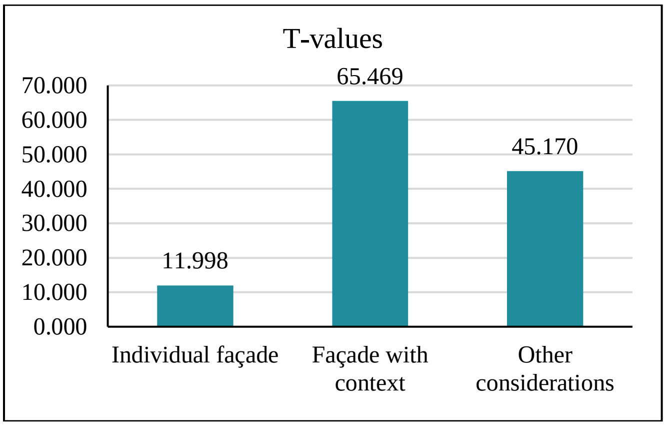

Fig. 15 T-value difference between the overall three groups of considerations (Author).

5. Conclusion and recommendations

5.1. Conclusion

This study aimed to determine the impact of facade design on visual pollution through testing which facade design considerations most contribute to visual pollution in Peshawa-Qazi Street (100 m Street) in Erbil City. It provides clear evidence that facade design significantly influences perceptions of visual pollution in the urban environment. According to survey respondents and statistical analysis, all three major categories of design considerations examined, individual facade elements, contextual integration, and other practical factors contribute significantly to increased visual pollution. A one-sample T-test was used to compare mean scores to a test value of (2.5).

The considerations related to contextual integration of the facade design had the most significant impact on perceived visual pollution, with an overall mean of 4.45 (1.93 points higher than the test value of 2.5) and a t-value of 65.469 ($p<0.001$).

The most impactful contextual factors were lack of cohesion in scale (Mean = 4.64, S.D. = 0.649), variety (Mean = 4.64, S.D. = 0.676), style (Mean = 4.62, S.D. = 0.818), and proportion (Mean = 4.62, S.D. = 0.707) and all factors in this category have a significant impact on visual pollution. This indicates that the mismatch integration between buildings and their surroundings significantly increases perceived visual pollution.

The other facade design considerations (practical) of maintenance, durability, quality of construction, changing facades, lighting, signage, billboards, wires, cell towers, dishes/antennas, and serviceability had a significant impact on perceived visual pollution, with an overall mean score of 4.29 (1.79 points higher than the test value of 2.5) and a t-value of 45.170 ($p < 0.001$). Specifically, signage had the highest mean at 4.58 (S.D. = 0.86), followed by billboards at 4.50 (S.D. = 0.93), serviceability at 4.47 (S.D. = 0.92), and maintenance at 4.46 (S.D. = 1.01), and all factors in this category have a significant impact on visual pollution. This indicates that issues with a building's practical considerations significantly impact visual pollution.

The considerations related to individual elements of the building façade also significantly impacted perceived visual pollution, though lower than contextual and practical factors. The overall mean was 3.21 (0.71 points higher than the test value of 2.5), with a t-value of 11.998 ($p < 0.001$).

The most impactful individual elements were lack of variety (Mean = 3.54, S.D. = 1.241), mismatch in scale (Mean = 3.50, S.D. = 1.256), and poor proportional relationships (Mean = 3.47, S.D. = 1.230), and all factors in this category have a significant impact on visual pollution. It is clear that the lack of individual facade features, compared to the building itself, increases perceived pollution.

The findings provide clear quantitative evidence rejecting the null hypothesis of no significant differences between categories' contributions to visual pollution. All three types significantly increased visual pollution, with contextual relationships having the most significant impact, followed by other factors and individual elements.

Considerations related to contextual integration had the highest impact, with a mean score of (1.94) points higher than the test value, with a t-value of (65.469). This accounted for approximately (43.6%) of the total increase in perceived visual pollution.

Other practical considerations had the next biggest impact, with a mean of 1.80 points above the test value and a t-value of (45.170). This category contributed around (40.4%) of the increase in pollution.

Individual facade elements had the smallest but still have significant impact, with a mean of (0.71) points higher and a T-value of (11.998). They accounted for about (16%) of the increased perception of visual pollution.

In conclusion, this study provides clear quantitative evidence that lack of contextual integration and practical considerations regarding building facades are the primary causes of increased perceived visual pollution along Peshawa-Qazi Street.

Based on the mean scores, around 84% of the increase in visual pollution perception can be attributed to contextual and practical considerations. This implies that the primary cause of visual pollution is the absence of regulations and guidelines from policymakers and municipalities. Additionally, architects share some responsibility for the remaining 16% increase in pollution as they design unappealing facades.

5.2. Recommendations

1. Policymakers and municipalities should establish guidelines and regulations for the design of facades, considering context, practicality, and individual elements for both new and existing buildings.
2. Architects and designers should adhere to best practices for facade design. This includes principles of design and composition, durable materials, concealment of service items, and contextual integration.
3. To reduce visual pollution, regulations should be implemented for signage and billboard design, including dimensions, positions, colors, fonts, and materials. This will prevent visual chaos and ensure that facade elements are not hidden or obscured.
4. Building owners and landlords should regularly inspect and maintain facades to prevent deterioration. This includes cleaning, repairing cracks, replacing broken elements, and applying new paint coatings when faded.
5. Educational campaigns can increase public awareness about the impact of building facades on visual pollution, resident satisfaction, mental health, tourism, and investment.

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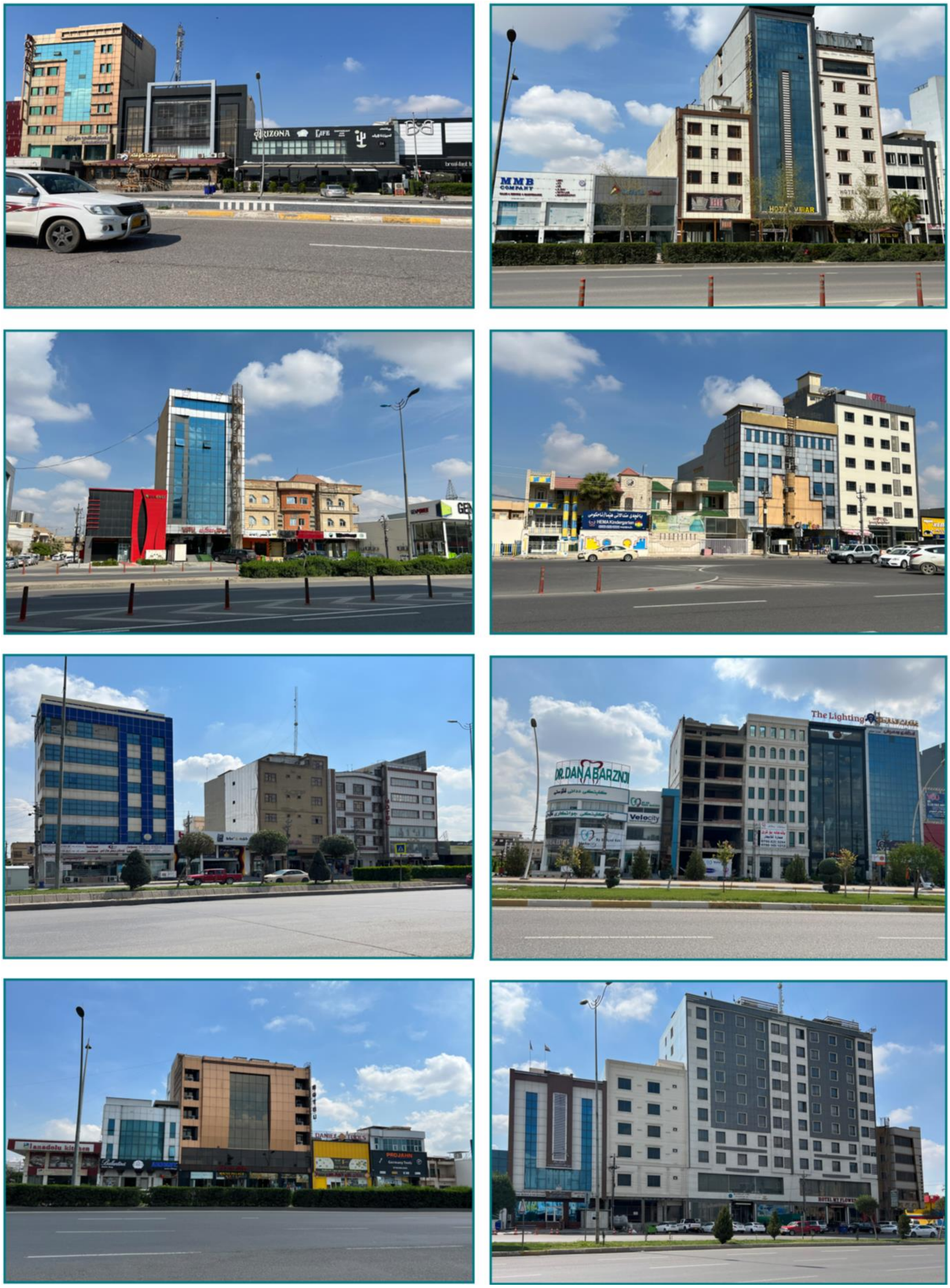
Appendix

1. Photos related to individual façade design considerations.

2. Photos related to the considerations for buildings façade design in relevant to their context.



3. Photos related to other façade design considerations.