Architecture
Image Studies

Vol.7, Issue 1, pp.2847-2863, 2026
DOI: https://doi.org/10.62754/ais.v7i1.1335

https://journals.ap2.pt/index.php/ais/index

Measuring Visual Pollution in Individual Housing in Bou Saâda, Algeria: A Comparative Study of Four Urban Patterns Using the Analytic Hierarchy Process (AHP)

Ouggad Elhoucine[1], Nouibat Brahim[2]

Abstract

Visual pollution is an escalating urban-environmental challenge that has attracted growing scholarly attention in urban planning and built environment research, particularly in developing cities undergoing rapid and largely unregulated spatial transformation. This study measures the variation in visual pollution levels across four residential neighborhoods representing distinct urban patterns in the semi-arid context of Bou Saâda, Algeria: the Traditional Quarter (Ksar), the Colonial District (Le Plateau), the Modern Planned Settlement (110 Dwellings), and the Informal Settlement (Sidi Slimane). The Multi-Criteria Analytic Hierarchy Process (AHP) was applied following Saaty's protocol, complemented by a systematic field survey and in-depth expert interviews with specialists in urbanism and environmental planning.A comprehensive hierarchical evaluation framework was developed, comprising 30 criteria—10 shared across all patterns and 20 pattern-specific—alongside 275 indicators assessed on a 0–5 scale. The total observed visual pollution reached 1,975 points. Results revealed a pronounced divergence among the four patterns: the Informal Settlement ranked highest by a substantial margin (711 points, 36.00%), followed by the Traditional Quarter (439 points, 22.23%), the Planned Settlement (416 points, 21.06%), and the Colonial District (409 points, 20.71%). The absence of green spaces emerged as the most heavily weighted shared criterion (14.03%), followed by unfinished buildings (9.83%). Pearson correlation analysis further demonstrated that visual pollution operates as a tightly interconnected structural system, with correlation coefficients exceeding r = 0.80 in the majority of cases. The study concludes with a phased, evidence-based roadmap for improving visual landscape quality in comparable Algerian cities.

Keywords: *Visual Pollution, Analytic Hierarchy Process (AHP), Pearson Correlation Coefficient, Urban Patterns, Residential Environment, Urban Landscape Quality.*

Introduction

Over the past three decades, there has been a fundamental paradigm shift in how urban environmental quality is conceptualized and measured. Once regarded as a secondary aesthetic concern, it is now recognized as a multi-dimensional strategic indicator embedded within the core objectives of sustainable urban development frameworks. This shift reflects a broader transition from narrow architectural aesthetics toward a comprehensive approach that integrates residents' psychological well-being, socio-cultural identity, and the quality of the public space experience [1, 2, 3]. Within this expanded analytical framework, visual pollution has emerged as a complex urban-environmental issue attracting considerable research interest. In Anglo-Saxon scholarship, it is defined as the excessive visible accumulation of discordant elements in the built environment that disrupts urban landscape harmony and causes documented cognitive harm to users [4].

This challenge is particularly acute in developing cities experiencing rapid, unmanaged urban expansion, where escalating demographic pressures intersect with weak enforcement of planning legislation and limited resources for urban management [5, 6]. Field studies have documented the

[1] Mohamed boudiaf university, Urban Techniques Management Institute, 28000, M'Sila –Algeria, Laboratory of City Hydraulic Environment and Sustainable Development, University of M'Sila, Algeria, Email: houcine.ouggad@univ-msila.dz
[2] Mohamed Boudiaf University, 28000, M'sila-Algeria, Laboratory of City Hydraulic Environment and Sustainable Development, University of Msila, Algeria, Email: brahim.nouibat@univ-msila.dz

phenomenon of 'Hybrid Urbanism'—a condition in which successive historical urban layers (traditional, colonial, modern-planned, and informal) overlap to produce visually fragmented environments that lack morphological coherence [7, 8]. Environmental psychology research has further demonstrated that this fragmentation not only causes aesthetic harm but also erodes the community's sense of place attachment, contributing to spatial alienation [9, 10].

The city of Bou Saâda, located in M'Sila Province in central-eastern Algeria, constitutes a particularly instructive case for examining these intersecting dynamics. Its urban fabric encompasses four distinct typologies—organic traditional, classical colonial, modern planned, and unplanned informal—embedded within a demanding semi-arid climatic context [11]. The city has attracted growing scholarly attention: Diafat [12] documented the preservation challenges facing its heritage Ksar under the pressures of neglect and encroachment, while Metlah et al. [13] highlighted the striking thermal performance contrast between traditional and contemporary fabrics. At the residential scale, Kaourane et al. [14], employing a GIS-AHP methodology, demonstrated that the traditional fabric achieves the highest environmental suitability and socio-cultural cohesion scores (8.5/10). Nevertheless, the comparative visual pollution profile of Bou Saâda's four urban patterns remains an unaddressed research gap, which this study aims to fill.

Research Objectives

This study pursues five specific objectives:

• Establishing a comprehensive normative framework for measuring visual pollution in individual housing.

• To determine the relative weights of visual pollution criteria and establish scientific priority rankings using the Analytic Hierarchy Process (AHP).

• To conduct a rigorous quantitative comparative analysis of visual pollution across the four urban patterns.

• To derive phased, pattern-specific intervention recommendations applicable by urban planners and policy-makers.

• To map the structural inter-correlations among the 30 visual pollution criteria using Pearson's Correlation Coefficient, and to leverage these findings in developing integrated intervention packages that address interconnected criteria concurrently.

Literature Review

The Concept of Visual Pollution: Definition and Dimensions

Definitional approaches to visual pollution vary considerably across disciplines. Environmental psychology frames it as 'any visible human intervention that produces a negative deviation from users' aesthetic expectations' [15], whereas urban planning scholarship favors a functional definition centered on 'the excessive accumulation of discordant visual elements that degrade built environment quality and undermine its aesthetic legibility' [4]. Nasar [16] distinguishes between two overlapping dimensions: objective pollution—observable and quantitatively measurable (e.g., signage density, rates of unfinished construction, chromatic dissonance)—and subjective pollution, which is tied to culturally shaped individual and collective aesthetic perception. Portella [4] adds a third dimension: technical pollution, generated by visible infrastructure such as exposed wiring, utility poles, and service equipment.

Image 01: Individual residential units suffering from visual pollution

A substantial body of environmental psychology research, building on Ulrich's foundational work [17], confirms that sustained exposure to visual pollution diminishes psychological well-being and elevates levels of stress and chronic cognitive fatigue [18, 19]. Wilson and Kelling's influential 'Broken Windows' theory [20] established a social dimension, linking visible urban degradation to the erosion of informal social control and increased crime. At the economic

level, hedonic pricing studies have documented a direct relationship between visual landscape quality and both property values and investment attractiveness [21, 22].

Visual Pollution in Oasis Cities: Contextual Specificity

Oasis cities are subject to three interacting pressure systems. First, the climatic-physical dimension: extreme heat and sand-laden winds accelerate facade and material deterioration at a rate seldom observed in temperate urban environments [11, 23]. Second, the demographic-urban dimension: continuous rural-to-urban migration fuels rapid informal construction that outpaces planning capacity [24, 25]. Third, the heritage-identity dimension: a persistent tension exists between imported architectural modernism and the logic of authentic oasis architectural traditions [26, 27]. The convergence of these pressures produces a characteristic gradient of visual pollution intensity that varies significantly across urban typologies.

Image 2: Unplanned slum housing

In the Algerian context, Nouibat [28] examined the social dimensions of housing problems in Bou Saâda's 270-unit residential district, while Diafat [12] revealed the extinction risks confronting the city's heritage Ksar. Cross-city comparisons in Arab oasis contexts indicate that traditional organic fabrics exhibit greater resilience to visual pollution than standardized planned neighborhoods, owing to the natural harmony that emerges from deeply rooted cultural and material identity [26].

Integration of AHP, GIS, and Pearson Correlation in Urban Landscape Quality Assessment

Saaty [22] developed the Analytic Hierarchy Process (AHP) as a structured mathematical framework for complex multi-criteria decision-making. The method decomposes a problem into successive hierarchical levels and employs pairwise comparisons using a preference scale (1–9) to convert qualitative expert judgments into quantifiable values, the reliability of which is verified through the Consistency Ratio (CR) [29]. AHP has been extensively applied to urban environmental quality assessment [30, 31].

The full methodological potential of AHP is realized when it is integrated with Geographic Information Systems (GIS) and Pearson's Correlation Coefficient within a unified assessment framework. AHP establishes the relative weights of pollution criteria through systematic pairwise comparisons [1, 29]. GIS translates these weights into spatial representations by digitizing neighborhood boundaries, georeferencing field observations, and generating graduated thematic maps that enable clear visual comparisons across urban patterns—an approach whose effectiveness in residential suitability assessment and intervention site selection has been demonstrated by Al-Shalabi et al. [32] and confirmed in the Bou Saâda context by Kaourane et al. [14]. Pearson's Correlation Coefficient, in turn, exposes the structural interconnection network among criteria, demonstrating that visual pollution does not arise from independent variables but from an intertwined system that demands bundled rather than criterion-by-criterion intervention [33, 34]. Taken together, GIS answers 'Where is the pollution located?' AHP clarifies 'What are its principal drivers?', and Pearson reveals 'How do these drivers interrelate?'— enabling urban planners to design sustainable, evidence-prioritized intervention strategies.

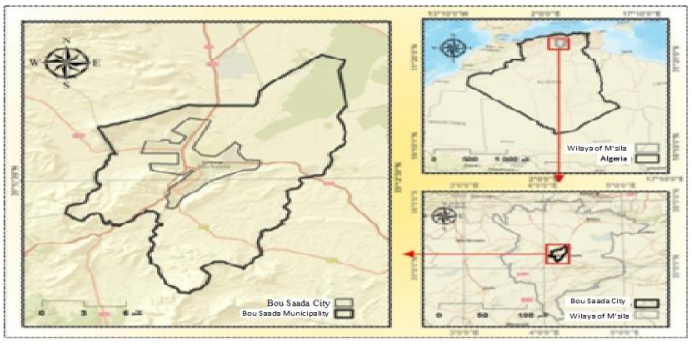


Figure 01: BouSaada City Location

Study Area

Bou Saâda is situated in M'Sila Province, Algeria (35°12′N, 4°11′E), and functions as a significant urban center in the country's central semi-arid region. The city experiences a semi-arid continental climate characterized by hot, dry summers

with temperatures frequently exceeding 40°C, cold winters, and mean annual precipitation of 200–300 mm.

Four neighborhoods were selected to represent the primary individual residential typologies in Bou Saâda:

• **Ksar Bou Saâda:** A historic organic traditional fabric reflecting authentic architectural identity through local materials and winding alleyways.

• **Le Plateau District:** A French colonial fabric with a regular grid layout and European-style buildings dating to the nineteenth century.

• **110-Housing Subdivision:** A modern planned neighborhood embodying contemporary urbanism through a geometric street grid and organized infrastructure.

• **Sidi Slimane District:** An informal settlement that developed without prior planning and suffers from the absence of urban standards and basic infrastructure.

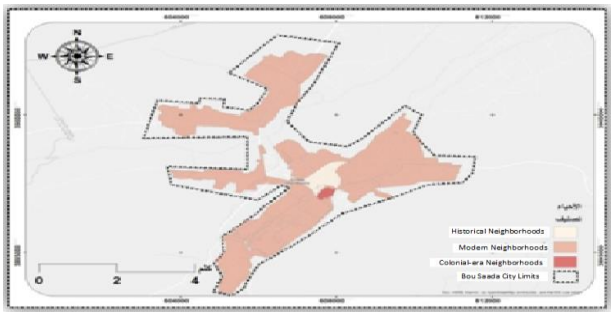


Figure 02: Spatial Distribution of the Four Study Neighborhoods within the Urban Fabric of Bou Saâda

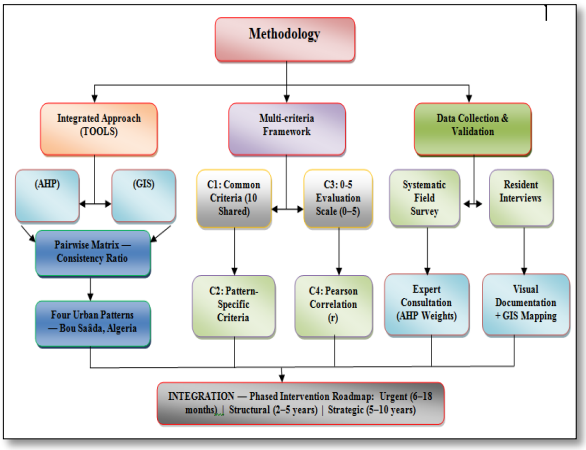
Research Methodology

Data Collection Instruments

Four primary instruments were employed to ensure comprehensive data collection:

• **Systematic Field Survey:** A structured program of observation and photography documented visual pollution elements across all four neighborhoods.

• **Expert Interview Forms:** Semi-structured interviews were conducted with specialists in urbanism, architecture, and urban planning to elicit relative criterion weights using the Saaty Scale (1–9).



• **Resident Questionnaire:** A survey instrument was administered to a representative sample of inhabitants across the four districts to capture subjective perceptions of visual pollution and its community impacts.

• **Geographic Information Systems (GIS):** GIS served multiple functions—digitizing neighborhood boundaries, georeferencing field observations, integrating spatial datasets, and producing graduated thematic maps that enable visual comparison of relative pollution levels across the four urban fabrics [32].

4.2- Criteria and Indicators Framework

A hierarchical analytical framework was designed comprising 30 criteria—10 shared across all four urban patterns and 20 pattern-specific (5 per pattern)—and 275 granular indicators. Each indicator was assessed using a six-point severity scale (0–5), as detailed in Table 1.

Table 1: Visual Pollution Indicator Evaluation Scale

Score	Level	Percentage (%)	Description
0	Excellent	0%	Pollution is absent.
1	Very Light	< 10%	Negligible pollution with minimal impact.
2	Light	10–25%	Limited pollution that is readily manageable.
3	Moderate	25–50%	Noticeable pollution affecting visual comfort.
4	High	50–75%	Severe pollution requiring corrective intervention.
5	Catastrophic	> 75%	Extreme pollution that obscures urban identity.

Analytic Hierarchy Process (AHP)

The AHP procedure follows Saaty's established protocol (1980, 2008) [1, 29], adapted for neighborhood-level housing evaluation. The process comprises four sequential steps:

- **Step 1 —** Hierarchical Structure: The problem is decomposed into five levels: (i) goal (visual pollution assessment); (ii) main criteria; (iii) sub-criteria; (iv) specific assessment indicators; and (v) alternatives (the four neighborhoods).
- **Step 2 —** Weight Derivation: Criterion weights were extracted through 45 pairwise comparisons for shared criteria and 27 for pattern-specific criteria, employing the Saaty Scale (1–9). Comparative judgments drew on three integrated sources: expert opinion, a systematic literature review, and contextual analysis of Bou Saâda's local urban conditions. Relative weights were calculated using the eigenvalue method.
- **Step 3 —** Consistency Verification: The Consistency Ratio (CR) was computed for each comparison matrix. A strict threshold of CR < 0.10, as established in AHP literature [1], was maintained throughout; all matrices achieved CR values below 0.05, confirming high levels of judgment stability and validating the derived weights.

Pearson Correlation Coefficient

The methodological framework was augmented by the Pearson Correlation Coefficient (r) as a complementary statistical instrument. This measure quantifies the strength and direction of linear relationships between two continuous quantitative variables, ranging from −1 (perfect negative correlation) to +1 (perfect positive correlation), with 0 indicating the absence of a linear relationship [35]. It is computed as:

$$r = [n \cdot \Sigma(xy) - \Sigma x \cdot \Sigma y] / \sqrt{\{[n \cdot \Sigma x^2 - (\Sigma x)^2] \cdot [n \cdot \Sigma y^2 - (\Sigma y)^2]\}}$$

where n = 4 (the number of urban patterns) and x, y represent the values of the two criteria being compared across each pattern [36]. The coefficient was applied across all 30 criteria (10 shared + 20 pattern-specific) to map the full network of structural inter-correlations and identify hidden 'degradation chains' that transcend individual pattern boundaries [4]. This analysis yielded a central finding: visual pollution in Bou Saâda is not the product of independent variables but of a tightly interconnected structural system, with coefficients exceeding r = 0.80 in the majority of cases.

Results

AHP Weights of Shared Visual Pollution Criteria

Integrated Table 2 presents the complete quantitative distribution of theoretical AHP weights and field values for all 30 criteria and 275 indicators across the four urban patterns, disaggregated by shared and pattern-specific criteria.

Table 2: Theoretical AHP Weights and Field Values of Visual Pollution across the Four Urban Patterns

Rank	Criterion	No. of Indicators	Theoretical Weight AHP %	Traditional Quarter	Colonial District	Planned Settlement	Informal Settlement	Total	Field %	Gap
Shared Criteria										
1	Absence & Deterioration of Green Spaces	20	14.03	63	51	65	90	269	13.62	−0.41
2	Waste Accumulation & Open Space Decay	16	11.90	48	33	35	68	184	9.32	−2.58
3	Unfinished Buildings	21	9.83	44	42	54	98	238	12.05	+2.22

4	Chaotic Technical Installations	14	9.57	43	41	40	65	189	9.57	0.00
5	Façade & Color Deterioration	15	9.06	40	43	40	62	185	9.37	+0.31
6	Infrastructure Network Disorder	14	8.35	38	26	27	64	155	7.85	−0.50
7	Advertising & Commercial Encroachment	14	6.99	32	40	32	53	157	7.95	+0.96
8	Chaotic Walls & Barriers	8	5.16	25	20	18	38	101	5.11	−0.05
9	Lighting Deficiencies	7	4.46	19	21	18	28	86	4.35	−0.11
10	Traffic Congestion & Parking Disorder	9	3.49	10	14	17	31	72	3.65	+0.16
Shared Subtotal		138	83.02	362	331	346	597	1,636	82.84	−0.18
Pattern-Specific Criteria — Traditional Quarter (Ksar)										
1	Decay of Traditional Materials (Clay, Gypsum…)	9	1.10	22	—	—	—	22	1.11	+0.01
2	Distortion of Heritage Alleys & Public Spaces	8	0.86	18	—	—	—	18	0.91	+0.05
3	Encroachments on Organic Traditional Fabric	7	0.77	17	—	—	—	17	0.86	+0.09
4	Loss of Authentic Architectural Elements (Mashrabiyas, Arches…)	6	0.63	12	—	—	—	12	0.61	−0.02
5	Incongruous Additions	5	0.53	8	—	—	—	8	0.41	−0.12

	Using Discordant Modern Materials									
Traditional Subtotal		**35**	**3.90**	**77**	**—**	**—**	**—**	**77**	**3.90**	**—**
Pattern-Specific Criteria — Colonial District (Le Plateau)										
1	Commercial Conversion of Ground Floors	8	1.17	—	25	—	—	25	1.27	+0.10
2	Alteration of Classical European Façades	7	0.92	—	19	—	—	19	0.96	+0.04
3	Chaotic Commercial Signage Discordant with Architectural Style	6	0.74	—	15	—	—	15	0.76	+0.02
4	Deterioration of Colonial Pavements & Urban Elements	6	0.61	—	11	—	—	11	0.56	−0.05
5	Exposed Service Utility Disorder (AC Units, Satellite Dishes…)	5	0.51	—	8	—	—	8	0.41	−0.10
Colonial Subtotal		**32**	**3.95**	**—**	**78**	**—**	**—**	**78**	**3.95**	**—**
Pattern-Specific Criteria — Planned Settlement (110 Dwellings)										
1	Individual Violations Breaking Architectural Uniformity	8	1.10	—	—	22	—	22	1.11	+0.01
2	Appropriation of Green Spaces for Private Use	7	0.85	—	—	16	—	16	0.81	−0.04
3	Chaotic Unauthorized Floor Additions	6	0.68	—	—	14	—	14	0.71	+0.03
4	Heterogeneity of	5	0.54	—	—	10	—	10	0.51	−0.03

	Finishing Materials & Façade Colors									
5	Deterioration of Shared Facilities & Communal Spaces	4	0.38	—	—	8	—	8	0.41	+0.03
Planned Subtotal		**30**	**3.54**	**—**	**—**	**70**	**—**	**70**	**3.54**	**—**
Pattern-Specific Criteria — Informal Settlement (Sidi Slimane)										
1	Absence of Sewage Networks in Public Space	10	1.58	—	—	—	30	30	1.52	−0.06
2	Accumulation of Debris & Building Materials in Public Space	9	1.27	—	—	—	26	26	1.32	+0.05
3	Irregular Building Lines & Absence of Mandatory Setbacks	8	1.08	—	—	—	21	21	1.06	−0.02
4	Dissonance of Building Forms & Absence of Aesthetic Standards	7	0.95	—	—	—	20	20	1.01	+0.06
5	Absence of Urban Equipment (Lighting, Street Furniture …)	6	0.88	—	—	—	17	17	0.86	−0.02
Informal Subtotal		**40**	**5.77**	**—**	**—**	**—**	**114**	**114**	**5.77**	**—**
Specific Subtotal (All Patterns)		**137**	**17.16**	**77**	**78**	**70**	**114**	**339**	**17.16**	**—**
Grand Total (Shared + Specific)		**275**	**100**	**439**	**409**	**416**	**711**	**1,975**	**100**	**—**

Methodological Note: *The gap in pattern-specific criteria is computed at the individual criterion level rather than at the subtotal level, as internal balancing between positive and negative gaps eliminates their net mathematical effect. The shared criteria gap (−0.18) represents the only value with*

full comparative validity, as it draws on a unified and independent computational reference for both columns.

Overall Comparative Results

Table 3 summarizes the integrated visual pollution results across the four residential patterns, presenting both quantitative totals and qualitative characterizations of degradation in each.

Table 3: Overall Visual Pollution Results across the Four Residential Patterns

Rank	Urban Pattern	Shared Pollution	Specific Pollution	Total	Value/5	Percentage (%)	Qualitative Character
1	Informal Settlement	597	114	711	4.17	36.00	Comprehensive Disorder
2	Traditional Quarter	362	77	439	2.80	22.23	Decay and Loss
3	Planned Settlement	346	70	416	3.21	21.06	Individual Encroachments
4	Colonial District	331	78	409	3.16	20.71	Distortion and Transformation
Total	—	1,636	339	1,975	2.66	100%	—

Note: *The Value/5 score is calculated relative to the number of indicators applicable to each specific pattern, making it a measure of qualitative pollution intensity rather than aggregate volume.*

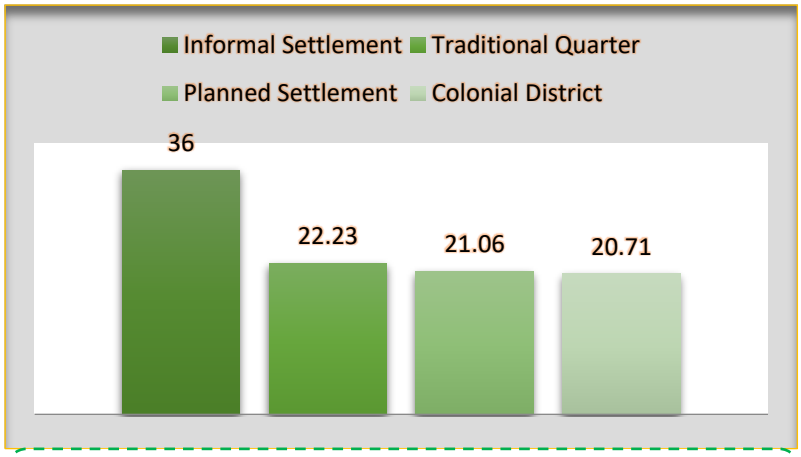


Figure 03: Overall Visual Pollution Results across the Four Residential Patterns

Source: Prepared by the authors.

Pearson Correlation Analysis

Table 4 presents the Pearson correlation analysis for all 30 visual pollution criteria across the four urban patterns. The results reveal a structurally dense network of inter-criterion relationships, with coefficients consistently exceeding r = 0.80. For each criterion, the table identifies the highest pair wise correlation and the urban phenomenon it diagnoses.

Table 4: Pearson Correlation Analysis of Visual Pollution Criteria (30 Criteria)

I. Shared Criteria (Cross-Pattern)

Rank	Criterion	Weight (%)	Highest Correlation With	r	Diagnosed Phenomenon
1	**Absence of Green Spaces**	14.03	Unfinished Buildings	0.962	Dual Abandonment: building neglect and green space neglect reinforce each other simultaneously.

2	**Waste & Space Degradation**	11.90	Chaotic Technical Equipment	0.891	Compound Disorder: absent waste management and absent equipment oversight share a common systemic origin.
3	**Unfinished Buildings**	9.83	Street Elements	0.976	Neglect Vortex: stalled construction generates neglected public space, which further weakens street maintenance.
4	**Chaotic Technical Equipment**	9.57	Infrastructure Network Disorder	0.967	Visual Chaos System: concealed networks and exposed equipment represent two manifestations of a single technical crisis.
5	**Façade & Color Deterioration**	9.06	Advertising & Commercial Encroachment	0.967	Visual Alliance: deteriorated façades and disorderly advertising mutually reinforce and amplify each other.
6	**Infrastructure Network Disorder**	8.35	Traffic & Parking Disorder	0.921	Network-Mobility Coupling: utility disruption and traffic disorder jointly produce cumulative visual pollution.
7	**Advertising & Commercial Encroachment**	6.99	Façade Deterioration	0.967	Commercial Façade Infringement: ground floors are converted into excessive advertising spaces that erase original character.
8	**Chaotic Walls & Barriers**	5.16	Absence of Green Spaces	0.889	Enclosure of Shared Space: expansionist fencing absorbs sidewalks and green areas, converting them to private use.
9	**Lighting Deficiencies**	4.46	Traffic & Parking Disorder	0.912	Nocturnal Public Space Crisis: defective lighting and parking disorder are twin symptoms of public space failure after dark.
10	**Traffic & Parking Disorder**	3.49	Waste Degradation	0.878	Vicious Cycle: unregulated vehicle spread reinforces spatial disorder and compounds illegal waste disposal.

II. Traditional Quarter

Rank	Criterion	Weight (%)	Highest Correlation With	r	Diagnosed Phenomenon
1	**Decay of Traditional Materials**	28.14	Distortion of Heritage Alleys	0.924	Material Failure Precedes Spatial Distortion: erosion of mud and plaster disfigures alley walls and irregularly narrows pathways.
2	**Distortion of Heritage Alleys**	22.03	Loss of Architectural Elements	0.911	Accelerating Degradation Loop: alley deterioration hastens the loss of its architectural features, and vice versa.
3	**Encroachments on Traditional Fabric**	19.87	Discordant Modern Materials	0.934	Material Language Violation: encroachment replaces indigenous materials with elements alien to the fabric's identity.

4	**Loss of Authentic Architectural Elements**	16.29	Incongruous Additions	0.912	Pseudo-Compensation: the removal of a mashrabiya yields not an empty space but a plastic window that intensifies visual dissonance.
5	**Incongruous Modern Additions**	13.67	All Four Criteria	0.934	Visual Summation of Degradation: all forms of encroachment and deterioration ultimately manifest as material and chromatic dissonance.

III. Colonial District

Rank	Criterion	Weight (%)	Highest Correlation With	r	Diagnosed Phenomenon
1	**Commercial Conversion of Ground Floors**	29.56	Chaotic Commercial Signage	0.948	Commerce–Advertising–Disorder Chain: ground floor conversion necessitates signage, which in turn attracts disorderly service equipment.
2	**Alteration of Classical Façades**	23.41	Chaotic Commercial Signage	0.934	Advertising-Painted Façades: layers of plastic signage erase the mass and original detailing of classical façades.
3	**Chaotic Commercial Signage**	18.73	All Four Criteria	≥ 0.878	Visual Amplification Effect: signage acts as a multiplier that intensifies all other forms of transformation and degradation.
4	**Deterioration of Colonial Pavements & Elements**	15.42	Chaotic Service Utilities	0.867	Comprehensive Character Erosion: façades degrade above while pavements deteriorate below in a synchronized loss of historic identity.
5	**Exposed Service Utility Disorder**	12.88	Commercial Conversion	0.912	Commercial Externalities: commercial activity drives the installation of air-conditioning units and exposed cabling that layer visual disorder.

IV. Planned Settlement

Rank	Criterion	Weight (%)	Highest Correlation With	r	Diagnosed Phenomenon

1	**Individual Violations Breaking Architectural Uniformity**	31.02	Closure of Green Spaces	0.956	Horizontal and Vertical Infringement: violations extend horizontally into shared space and vertically through unauthorized floor additions.
2	**Appropriation of Green Spaces for Private Use**	23.87	Shared Facility Degradation	0.923	Tragedy of the Commons: the privatization of shared space removes the collective incentive for facility maintenance.
3	**Unauthorized Floor Additions**	19.34	Heterogeneity of Finishing Materials	0.945	Accumulated Violations Register: each unauthorized floor introduces new materials, turning the façade into a visual record of cumulative infractions.
4	**Heterogeneity of Finishing Materials & Colors**	15.16	All Four Criteria	0.921	Final Visual Translation: every form of infringement ultimately manifests as material and chromatic dissonance on the façade.
5	**Shared Facility Degradation**	10.61	Appropriation of Green Spaces	0.923	Concurrent Privatization and Neglect: space appropriation and facility degradation are parallel and mutually reinforcing processes of communal breakdown.

V. Informal Settlement

Rank	Criterion	Weight (%)	Highest Correlation With	r	Diagnosed Phenomenon
1	**Absence of Sewage Networks**	27.43	Debris Accumulation	0.967	Total Planning Vacuum: spaces unable to manage wastewater automatically become repositories for waste and construction debris.
2	**Debris & Building Material Accumulation**	21.98	Absence of Urban Equipment	0.934	Negative Spatial Definition: public space is defined by what is absent; the resulting void is filled with debris.
3	**Irregular Building Lines**	18.76	Dissonant Building Forms	0.978	Morphological Absence of Control: the lack of mandatory setbacks leads directly to comprehensive volumetric and formal dissonance.
4	**Dissonant Building Forms**	16.54	All Four Criteria	0.934	Aggregate Criterion: aesthetic dissonance is the ultimate visual

					expression of cumulative planning failure in this pattern.
5	**Absence of Urban Equipment**	15.29	Debris Accumulation	0.934	The Chaos Triad: (absent sewage) + (absent lighting and street furniture) + (debris) = an acutely fragile urban environment.

Discussion

The findings of this study make a substantial contribution to the theoretical and empirical understanding of visual pollution in the Algerian urban context, advancing beyond existing international approaches in both methodological scope and analytical depth. The ten shared criteria account for 82.84% of the total observed visual pollution (1,636 of 1,975 points), while pattern-specific criteria contribute only 17.16%. This distribution demonstrates that visual pollution in Bou Saâda is not an incidental phenomenon but a structurally embedded condition rooted in both urbanization mechanisms and inhabitant behavior. The urban landscape crisis consequently transcends the specificities of individual patterns to reflect a systemic urban governance failure, necessitating diagnostic and interventionist approaches that differ substantially from those prevalent in classical literature.

Among the shared criteria, 'Absence of Green Spaces' leads with 269 points. Notably, the field volume of 'Unfinished Buildings' (12.05%) substantially exceeds its theoretical AHP weight (9.83%), demonstrating that this phenomenon is considerably more prevalent than expert estimations suggest. Conversely, the field volume for 'Waste Accumulation and Open Space Decay' (9.32%) falls below its theoretical weight (11.90%), indicating a relative overestimation in expert judgment. The criterion of 'Chaotic Technical Installations' exhibits perfect alignment between theoretical weight and field value (9.57% in both cases), attesting to the precision of expert judgment for this specific dimension. At the pattern-specific level, the Informal Settlement records the highest specific pollution (114 points, 5.77%), reflecting the systemic and interlocked nature of its degradation, which demands urgent, bundled intervention. Collectively, these findings underscore the necessity of combining AHP with systematic field monitoring in any sustainable assessment framework, in order to avoid misallocating resources toward criteria that may be overestimated in expert-only evaluations.

The cross-pattern comparison reveals simultaneous quantitative and qualitative divergence. The Informal Settlement leads with 711 points (36.00%) and a qualitative intensity of 4.17/5, embodying what may aptly be termed 'Comprehensive Disorder'—a condition that reflects not merely the absence of aesthetic regulation but a multi-level systemic planning failure encompassing infrastructure, urban morphology, and social behavior within a single interlocked system requiring urgent intervention. The remaining three patterns converge in their aggregate percentages (20.71%–22.23%), yet their qualitative scores reveal meaningful distinctions: the Planned Settlement (3.21/5) surpasses the Colonial District (3.16/5) despite near-identical totals, confirming that qualitative pollution intensity does not correlate linearly with quantitative volume and that both metrics must be employed in tandem to avoid systematic misclassification.

Pearson correlation results confirm that visual pollution does not stem from independent causal factors but from a tightly structured system of inter-criterion dependencies. This system reaches its peak in the Informal Settlement, where the average correlation coefficient of $r = 0.941$ represents the highest value recorded across the entire study. The 'Dual Abandonment' phenomenon ($r = 0.962$ between absent green spaces and unfinished buildings) and the 'Neglect Vortex' ($r = 0.976$ between unfinished buildings and street elements) demonstrate that targeted intervention in a single high-correlation criterion generates automatic improvement in its structurally linked variable—offering urban planners a strategic multiplier that maximizes intervention impact at reduced cost. In contrast, the 'Pseudo-Compensation' phenomenon identified in the Traditional Quarter ($r = 0.912$ between the loss of authentic architectural elements and the introduction of incongruous additions) reveals that the removal of heritage elements does not produce a neutral vacancy but rather triggers their replacement with purely functional substitutes that exacerbate visual dissonance rather than mitigating it.

Recommendations and Intervention Strategies

The following recommendations are grounded in the quantitative and correlational evidence derived from this study. They are structured across three temporal horizons within which urban, planning, and social dimensions converge into an integrated intervention framework—explicitly rejecting

the fragmented criterion-by-criterion approach that correlational analysis has proven to be methodologically insufficient.

Urgent Interventions (Short-Term: (6–18 Months)

Urban Dimension

It is recommended that Law 08-15 be enforced through the imposition of legally binding construction completion deadlines, supported by effective administrative and financial pressure mechanisms including permit suspension and progressive financial penalties. Concurrently, an emergency program for the rehabilitation of degraded public green spaces should be launched in coordination between municipal authorities and the provincial environmental directorate.

• **Informal Settlement:** Emergency extension of sewage networks and rehabilitation of the most severely degraded public spaces, given their role as the primary driver of the pattern's integrated pollution system.

• **Traditional Quarter:** Removal of visually incongruous informal additions from alley façades, and temporary restoration of deteriorated roofs and boundary walls using traditional materials pending the launch of the structural heritage program.

• **Planned Settlement:** Urgent field monitoring of individual violations that breach architectural uniformity, and immediate suspension of ongoing unauthorized construction activities.

• **Colonial District:** Removal of the most visually prominent discordant commercial signage, and interim regulation of ground-floor commercial activities.

Planning Dimension

GIS-based maps of pollution intensity should be operationalized to direct intervention resources toward the most affected zones according to quantitative priority. A standardized field monitoring protocol for visual pollution should be developed and made applicable by municipal technical services.

Social Dimension

Intensive awareness campaigns targeting residents through accessible visual communication should be launched, articulating the aesthetic, economic, and psychological costs of visual pollution. Community reporting mechanisms through digital platforms should be activated to engage residents in ongoing monitoring, alongside educational programs targeting youth to foster a culture of shared responsibility for urban aesthetics.

Structural Interventions (Medium-Term: (2–5 Years)

Urban Dimension

• **Informal Settlement:** Implementation of a phased urban restructuring project regulating building setbacks, unifying volumes and materials through a simplified construction guide calibrated to the socio-economic conditions of the resident population, accompanied by a comprehensive program equipping public spaces with lighting and street furniture.

• **Traditional Quarter:** Launch of an integrated heritage revitalization program comprising a mandatory guide for traditional construction materials supported by accessible loans, professional training for craftspeople in heritage restoration techniques, and a master plan protecting alleyways from individual encroachment.

• **Planned Settlement:** Revision of subdivision plans (POS) to incorporate binding visual specifications for finishing materials and façade colors; recovery of appropriated green spaces; and rehabilitation of deteriorated shared facilities.

• **Colonial District:** Introduction of a commercial licensing system conditional on compliance with strict visual standards; mandatory replacement of discordant signage with unified alternatives; and rehabilitation of pavements and urban elements according to a cohesive material and color scheme that restores the district's historic visual identity.

Planning Dimension

A digital visual pollution observatory should be established and updated periodically based on the methodology developed in this study. Visual landscape quality indicators should be integrated into

Strategic Environmental Assessment (SEA) reports accompanying urban development projects. Intervention priorities should be aligned with the highest-correlation criteria identified by the Pearson analysis, as addressing these generates cascading improvements across structurally linked variables.

Social Dimension

Elected neighborhood committees should be established within each urban pattern to monitor violations and oversee rehabilitation programs. Neighborhood compacts binding residents, the municipality, and developers to mutual obligations regarding urban landscape quality should be formalized. Community participation in design and implementation phases should be institutionalized to ensure the long-term sustainability of outcomes.

Comprehensive Strategy (Long-Term: (5–10 Years)

Urban Dimension

• **Informal Settlement:** Full urban restructuring within a national program integrating infrastructure provision and aesthetic standards, with flexible building guidelines that incentivize incremental compliance among low-income residents.

• **Traditional Quarter:** Inscription within a nationally protected urban heritage framework, with a dedicated architectural guide specifying permissible color schemes, finishing materials, and façade configurations as a mandatory reference document for all building and restoration permits.

• **Planned Settlement:** Comprehensive revision of zoning regulations and joint-ownership contracts to incorporate explicit aesthetic obligations, with an incentive system rewarding owners who maintain architectural uniformity.

• **Colonial District:** Mandatory Visual Impact Assessment (VIA) for all new commercial or residential projects; inclusion of the district in heritage tourism itineraries to raise community awareness of its architectural value and encourage self-sustaining maintenance.

Planning Dimension

Visual landscape quality standards should be incorporated into official urban planning documents as mandatory requirements rather than advisory guidelines. Visual pollution indicators should be formally recognized alongside air and noise pollution as official sustainable urban development metrics, institutionalizing their status as full environmental and urban policy concerns.

Social Dimension

Integrated socio-urban rehabilitation programs should be launched that treat visual pollution as a symptom of deeper structural challenges including poverty, unemployment, and weak place attachment. Residential support programs should be linked to façade and shared space quality benchmarks, acknowledging that visual pollution cannot be effectively addressed in isolation from the inadequate housing conditions and economic precarity that generate and perpetuate it.

Table 5: Summary of Intervention Strategies by Urban Pattern

Level	Time Horizon	Informal Settlement	Traditional Quarter	Planned Settlement	Colonial District
Urgent	**6–18 Months**	Sewage extension + public space rehabilitation	Temporary alley restoration	Halt unauthorized construction	Remove prominent discordant signage
Structural	**2–5 Years**	Building line regulation + street furniture	Heritage revitalization program	POS revision + green space recovery	Conditional licensing + pavement rehabilitation
Strategic	**5–10 Years**	Comprehensive restructuring	National heritage protection	Ownership contract revision	Heritage tourism + VIA requirement

Conclusion

This study developed a comprehensive measurement framework for visual pollution in individual residential housing in Bou Saâda, employing a tripartite methodological integration of the Analytic

Hierarchy Process (AHP), Geographic Information Systems (GIS), and Pearson's Correlation Coefficient across 275 indicators, 30 criteria, and four distinct urban patterns. The results establish that visual pollution in Bou Saâda is a structurally systemic phenomenon rather than a localized or incidental one. The dominance of shared criteria—accounting for 82.84% of total observed pollution—demonstrates that the urban landscape crisis is not confined to any single pattern but reflects a broader urban governance failure that transcends typological boundaries.

Pearson correlation analysis revealed that visual pollution operates as a tightly interconnected structural network, achieving its highest overall correlation in the Informal Settlement (average r = 0.941) and its highest individual pairwise coefficient between unfinished buildings and street elements (r = 0.976). These findings carry direct strategic implications: interventions targeting high-correlation criteria produce cascading improvements across structurally linked variables, effectively multiplying intervention impact.

The study makes a dual scholarly contribution. Theoretically, it expands the conceptual framework of visual pollution assessment to encompass 30 criteria and 275 indicators that accommodate the diversity of Algerian urban typologies, moving beyond the classical aesthetic metrics that have dominated the literature. Practically, it provides a replicable, transferable assessment tool applicable to comparable Algerian and North African cities, accompanied by a phased, evidence-based intervention framework grounded in both quantitative measurement and structural correlation analysis.

Several directions for future research remain open. The spatial representation component could be extended to three-dimensional GIS modeling to capture the temporal evolution of visual pollution. The evaluation framework could be expanded to incorporate residents' sensory perceptions through large-scale survey instruments, complementing objective field measurements with subjective landscape assessments. Finally, longitudinal studies tracking intervention outcomes over time would provide valuable evidence for refining the phased recommendations proposed here.

References

[1] K. Lynch, The Image of the City. Cambridge, MA: MIT Press, 1960.
[2] M. Carmona, T. Heath, T. Oc, and S. Tiesdell, Public Places, Urban Spaces: The Dimensions of Urban Design. Oxford: Architectural Press, 2010.
[3] J. C. Nagle, "Visual Pollution," Notre Dame Law Review, vol. 84, no. 1, pp. 1–70, 2009.
[4] A. Portella, Visual Pollution: Advertising, Signage and Environmental Quality. Farnham: Ashgate Publishing, Ltd., 2014.
[5] S. Chmielewski, "The color of the city: Measuring visual pollution by outdoor advertising," Applied Geography, vol. 124, p. 102302, 2020.
[6] D. Yilmaz and A. Sagsoz, "In the Context of Visual Pollution: Effects of Advertisements on the Built Environment," Scientific Research and Essays, vol. 6, no. 14, pp. 2992–3000, 2011.
[7] J. L. Nasar, The Evaluative Image of the City. Thousand Oaks, CA: Sage Publications, 1998.
[8] R. Kaplan and S. Kaplan, The Experience of Nature: A Psychological Perspective. Cambridge: Cambridge University Press, 1989.
[9] R. S. Ulrich, "View through a window may influence recovery from surgery," Science, vol. 224, no. 4647, pp. 420–421, 1984.
[10] C. Ellard, Places of the Heart: The Psychogeography of Everyday Life. Bellevue Literary Press, 2015.
[11] J. Q. Wilson and G. L. Kelling, "Broken Windows: The police and neighborhood safety," The Atlantic Monthly, vol. 249, no. 3, pp. 29–38, 1982.
[12] A. Bendjelid, J. C. Brulé, and F. Jacques, Villes et Territoires en Algérie. Oran: CRASC, 2004.
[13] A. Diafat, "Preservation Challenges of the Traditional Ksar of Bou Saâda," Journal of Heritage Conservation, vol. 4, no. 2, pp. 45–58, 2015.
[14] M. Metlah et al., "Thermal Performance Comparison Between Traditional and Contemporary Urban Fabrics: Case of Bou Saâda," Int. Journal of Sustainable Dev., vol. 16, no. 5, pp. 891–902, 2021.
[15] A. Kaourane et al., "A GIS-AHP Integrated Approach for Assessing Environmental Suitability in Bou Saâda," IJCESEN, 2024 (In Press).
[16] [16] M. Dahli, L'habitat informel en Algérie: Entre contraintes et opportunités. Éditions Universitaires Européennes, 2012.
[17] S. Madani and A. Diafat, "The impact of urbanization on the identity of oasis cities," in Proceedings of SUST, 2010, pp. 215–230.
[18] D. Boussaa, "The Algiers Casbah: Conservation and management in a world heritage site," Journal of Architectural Conservation, vol. 20, no. 1, pp. 63–81, 2014.
[19] B. Nouibat, "Socio-spatial analysis of contemporary housing in Algerian mid-sized cities," M'sila University Research Journal, vol. 7, no. 1, pp. 14–29, 2018.

[20] H. Fathy, Natural Energy and Vernacular Architecture. Chicago: University of Chicago Press, 1986.
[21] H. M. Taleb and S. Sharples, "Developing sustainable residential buildings in Saudi Arabia," Applied Energy, vol. 88, no. 1, pp. 383–391, 2011.
[22] T. L. Saaty, "Decision making with the analytic hierarchy process," Int. Journal of Services Sciences, vol. 1, no. 1, pp. 83–98, 2008.
[23] T. L. Saaty, The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. New York: McGraw-Hill, 1980.
[24] I. B. Huang, J. Keisler, and I. Linkov, "Multi-criteria decision analysis in environmental sciences," Science of the Total Environment, vol. 409, no. 19, pp. 3578–3594, 2011.
[25] A. Mardani et al., "Multiple criteria decision-making techniques and their applications," Economic Research, vol. 28, no. 1, pp. 516–571, 2015.
[26] M. A. Al-Shalabi et al., "GIS based multicriteria approaches to housing site selection," in CGIV Proceedings, 2006, pp. 170–177.
[27] S. Al-Otaibi and M. Al-Qahtani, "The Impact of Urban Aesthetic on Quality of Life," JAUES, vol. 26, no. 2, pp. 12–24, 2019 (In Arabic).
[28] A. E. Stamps, Psychology and the Aesthetics of the Built Environment. Kluwer Academic Publishers, 2000.
[29] M. D. Velarde, G. Fry, and M. Tveit, "Health effects of viewing landscapes," Urban Forestry & Urban Greening, vol. 6, no. 4, pp. 199–212, 2007.
[30] C. Y. Jim and W. Y. Chen, "Impact of urban environmental elements on residential housing prices," Landscape and Urban Planning, vol. 78, no. 4, pp. 422–434, 2006.
[31] J. Cohen, Statistical Power Analysis for the Behavioral Sciences. Routledge, 2013.
[32] Al-Shalabi et al., "GIS based multicriteria approaches…," CGIV, 2006 —
[33] K. Pearson, "Notes on regression and inheritance," Proc. Royal Society, vol. 58, pp. 240–242, 1895
[34] D. Freedman, R. Pisani, and R. Purves, Statistics, 4th ed. W.W. Norton, 2007.