

A STUDY ON ADDRESSING VISUAL BLIGHT AND ITS RELATIONSHIP TO ENVIRONMENTAL IMPROVEMENT AND ENHANCING QUALITY OF LIFE IN AL-MUWAIH CITY

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Abstract

Urban visual pollution is often assessed as a perceptual or descriptive problem, while few studies trace community evidence through prioritisation to field implementation. This study developed and applied a mixed-methods assessment-to-implementation framework in Al-Muwayh City, Saudi Arabia. A literature-informed Arabic questionnaire translated six visual-pollution domains into 14 operational intervention domains and 64 Likert statements, alongside an exactly-five intervention question and three open-ended questions. Of 208 submissions, eight underage records and 40 adult exact straight-liners were excluded from the primary analysis, yielding 160 quality-screened adults. Internal consistency remained extremely high (Cronbach's alpha = 0.994; one-factor omega approximately 0.994), indicating substantial item redundancy. Parallel analysis retained one dominant general factor. Domain differences were statistically significant, Friedman chi-square (13) = 65.38, $p < 0.001$, but small in magnitude (Kendall's W = 0.031). Greenery (M = 3.514), visual coordination and local identity (M = 3.470), roads and street edges (M = 3.459), sidewalks (M = 3.411), visible waste (M = 3.402), and city entrances (M = 3.401) formed an overlapping high-priority cluster. Among 94 quality-screened adults who selected exactly five actions, improvement of the principal city entrances ranked first (66.0%), followed by increased greenery (47.9%), public-waste removal (46.8%), and construction-waste removal (45.7%). qualitative screening also emphasized roads, entrances, and greenery, but requires independent second-coder validation. Integrated evidence informed cleanup, infrastructure, landscaping, and entrance-identity interventions documented photographically. Photographs confirm physical implementation, not perceptual effectiveness; post-intervention surveys and repeated field audits remain necessary.

Keywords: Visual pollution; community-based assessment; urban design interventions; evidence-to-action planning; mixed-methods research; Saudi Arabia.

1. Introduction

Urban environmental quality is increasingly understood as extending beyond conventionally measured forms of pollution to include how people perceive, interpret, and experience the built environment. Cities are not only systems of buildings, infrastructure, and services; they are also continuously experienced visual landscapes whose spatial organisation influences comfort, orientation, behaviour, safety, and attachment to place. Within this broader understanding, visual pollution has emerged as an important but comparatively underdeveloped dimension of urban environmental degradation.

Visual pollution can be defined as the accumulation, absence, deterioration, or spatial arrangement of visible elements that disrupts visual coherence, reduces environmental legibility, generates perceptual overload, or weakens the aesthetic and functional quality of urban space (Nawaz and Wakil, 2022; Borowiak et al., 2024). It should therefore not be

reduced to a single unattractive object. Rather, it is a cumulative and relational condition produced through interactions among roads, sidewalks, buildings, vegetation, signs, lighting, waste, street furniture, and other visible components. Recent streetscape research shows that perceived attractiveness, calmness, safety, and disorder depend on the proportions, continuity, hierarchy, and coordination of these elements rather than on their isolated presence (**Ogawa et al., 2024**). Human- and computer-based assessments similarly indicate that visual complexity is shaped by the density, diversity, and overlap of streetscape features within the observer's field of view (**Florio et al., 2024**).

The literature identifies six recurrent domains of urban visual pollution: streetscape composition and greenery; signage and outdoor advertising; building façades and architectural appearance; lighting and the night-time environment; visible waste, litter, and construction and demolition debris; and urban furniture and small-scale street elements. These domains are analytically distinguishable but perceptually interdependent. A degraded urban corridor may simultaneously contain poor paving, façade inconsistency, informal signage, insufficient planting, exposed waste, and inadequate lighting, producing a combined effect greater than that of any one condition considered separately.

The significance of visual quality extends beyond aesthetic preference. Urban greenery, visual openness, and coherent spatial organisation can support environmental satisfaction, psychological restoration, and perceived quality of life (**de Souza et al., 2024; García-Martín et al., 2025**). In hot outdoor environments, vegetation and shading may also improve combined visual and thermal comfort (**Dong et al., 2025**). Coherent materials, colours, façades, gateways, and public-space elements can strengthen place identity and communicate care and continuity, whereas fragmented interventions and deteriorated edges may weaken the recognisability of the city (**Rezafar, 2023; Albrektsen, 2025**).

Visual order is also related to functional performance and safety. Streetscape characteristics have been associated with traffic-risk patterns, while poorly positioned or visually dominant roadside advertisements can compete with regulatory signs and other safety-critical information (**Yue, 2025; Yang et al., 2024; Sheykhfard et al., 2024**). Eye-tracking studies further demonstrate that dense and competing visual stimuli influence driver attention and observation behaviour (**Madleňák et al., 2024**). Lighting requires a similar balance: insufficient illumination may reduce visibility and perceived security, whereas excessive or poorly directed lighting may create glare, discomfort, and light pollution (**Pothukuchi, 2021; Liu et al., 2022**).

Maintenance-related conditions are equally important. Construction and demolition waste can generate persistent roadside and vacant-land degradation and may signal weak environmental control (**Seror and Portnov, 2018; Luu et al., 2021**). Façades can either mitigate or intensify visual degradation depending on their physical condition, materials, attachments, and relationship with the street (**Prieto and Pastén, 2024**), while urban furniture contributes positively only when its form, placement, and maintenance are coordinated with pedestrian movement and the surrounding public realm (**Grabiec et al., 2022**). Managing visual pollution therefore involves environmental quality, public safety, pedestrian experience, maintenance efficiency, local identity, and institutional coordination rather than superficial beautification alone.

Despite growing interest in urban visual quality, three important gaps remain. First, many studies examine isolated concerns—such as signage, lighting, façades, greenery, or waste—without assessing their cumulative interaction within the same urban environment. Second,

assessment methods remain fragmented across perception surveys, field audits, geographic information systems, street-view imagery, eye tracking, virtual environments, and computer vision (Farahani et al., 2023; Parmar and Jana, 2024). Although technological approaches can improve spatial coverage and consistency, they cannot replace context-specific knowledge of community priorities. Third, relatively few studies establish a traceable pathway from literature-based factor identification to local instrument development, community priority setting, spatially targeted intervention, and documented implementation. Participatory research has emphasised the value of community-informed mitigation (Churcher et al., 2024), while research in Saudi Arabia demonstrates the importance of context-sensitive visual assessment (Alharbi and Rangel-Buitrago, 2022). Nevertheless, integrated evidence-to-action applications remain limited, particularly in smaller cities.

Al-Muwayh City provides a suitable case for addressing these gaps. Its urban environment includes principal streets, residential neighbourhoods, commercial frontages, highway service roads, city entrances, vacant plots, and public-service areas. Within these settings, visual quality may be affected by construction debris, scattered waste, damaged containers, abandoned vehicles, informal posters, deteriorated sidewalks, weak road edges, inconsistent façades, inadequate planting, commercial signage, lighting deficiencies, and limited coordination of local identity elements. City entrances are especially important because they function as composite visual sequences involving approach roads, walls, paving, vegetation, lighting, signage, colours, local symbols, and the transition into the urban fabric. Professional observation alone, however, cannot determine which problems city users consider most urgent or which interventions they regard as most valuable.

Accordingly, this study adopted an applied assessment-to-implementation approach. Six literature-derived domains were translated into fourteen locally relevant assessment dimensions and evaluated through community ratings, intervention selections, open-ended responses, and place-based references. Quantitative and qualitative findings were integrated to identify priority problems, actions, and indicative intervention locations. Following the analysis, selected priorities were implemented in Al-Muwayh City and documented using before-and-after field photographs.

The study addresses three research questions, (1) Which visual-improvement dimensions, interventions, and locations receive the highest community priority in Al-Muwayh City, (2) How do quantitative ratings, intervention selections, and qualitative place-based responses complement one another in identifying priority actions, (3) How can the resulting community evidence be translated into spatially targeted and photographically documented urban interventions. By linking literature-derived evidence, locally adapted community assessment, spatial prioritisation, and field implementation, the study contributes an evidence-based framework for moving from the diagnosis of visual degradation to coordinated and observable urban improvement. Its principal contribution lies not only in identifying community priorities, but also in demonstrating how these priorities can inform practical action in a smaller-city context.

2. Materials and Methods

2.1. Study Design and Study Area

This study employed an applied mixed-methods case-study design to assess visual-improvement needs and translate community-derived evidence into implemented urban interventions in Al-Muwayh City. The design integrated quantitative perception assessment, intervention selection, qualitative responses, spatially referenced community knowledge, and

photographic documentation. This combination enabled the study to move beyond the identification of visual problems toward the prioritisation, implementation, and documentation of corrective urban actions.

Al-Muwayh City was selected because its urban structure includes several contrasting environments within a relatively compact settlement. The study covered principal streets, residential neighbourhoods, commercial frontages, city entrances and approach corridors, highway service roads, public-service areas, and vacant or peripheral land. These environments contain interacting visual elements related to road condition, sidewalks, building façades, planting, lighting, signage, waste-management infrastructure, abandoned objects, and local-identity features. Particular attention was given to the city entrances and highway-facing corridors because they function as composite visual sequences linking roads, walls, paving, vegetation, lighting, signs, and symbolic urban elements. The regional location of Al-Muwayh City and the principal urban environments included in the study are presented in **Figure 1**.

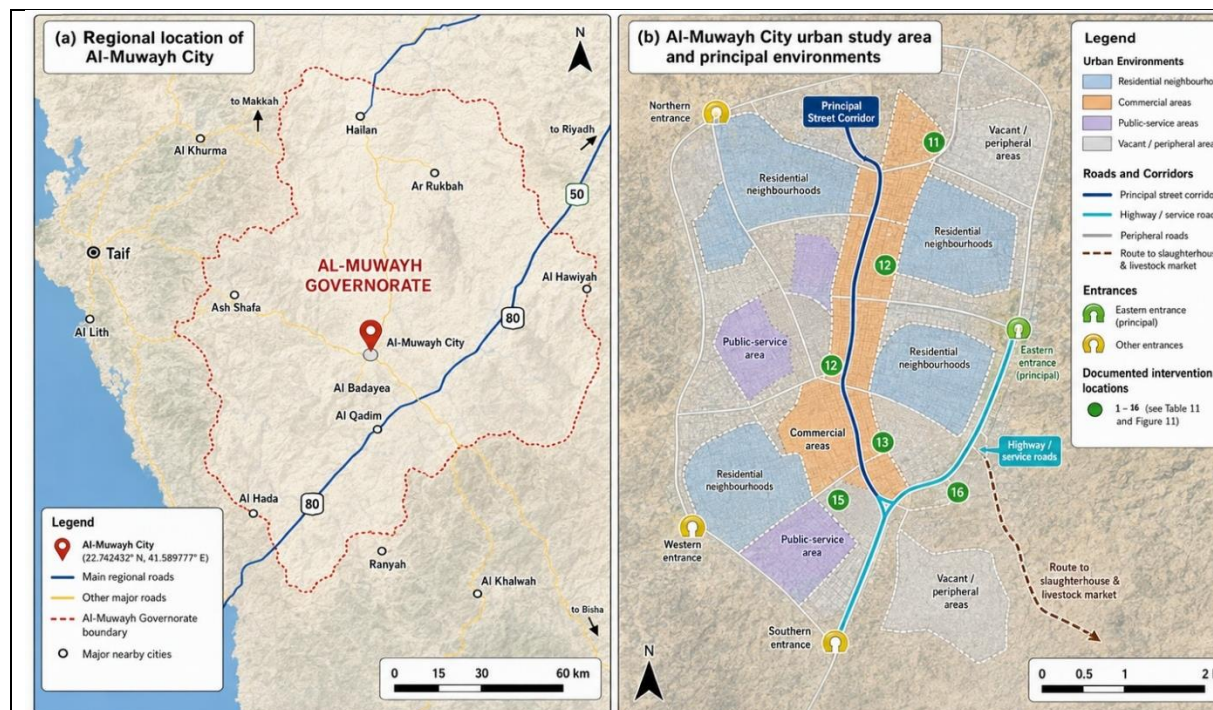
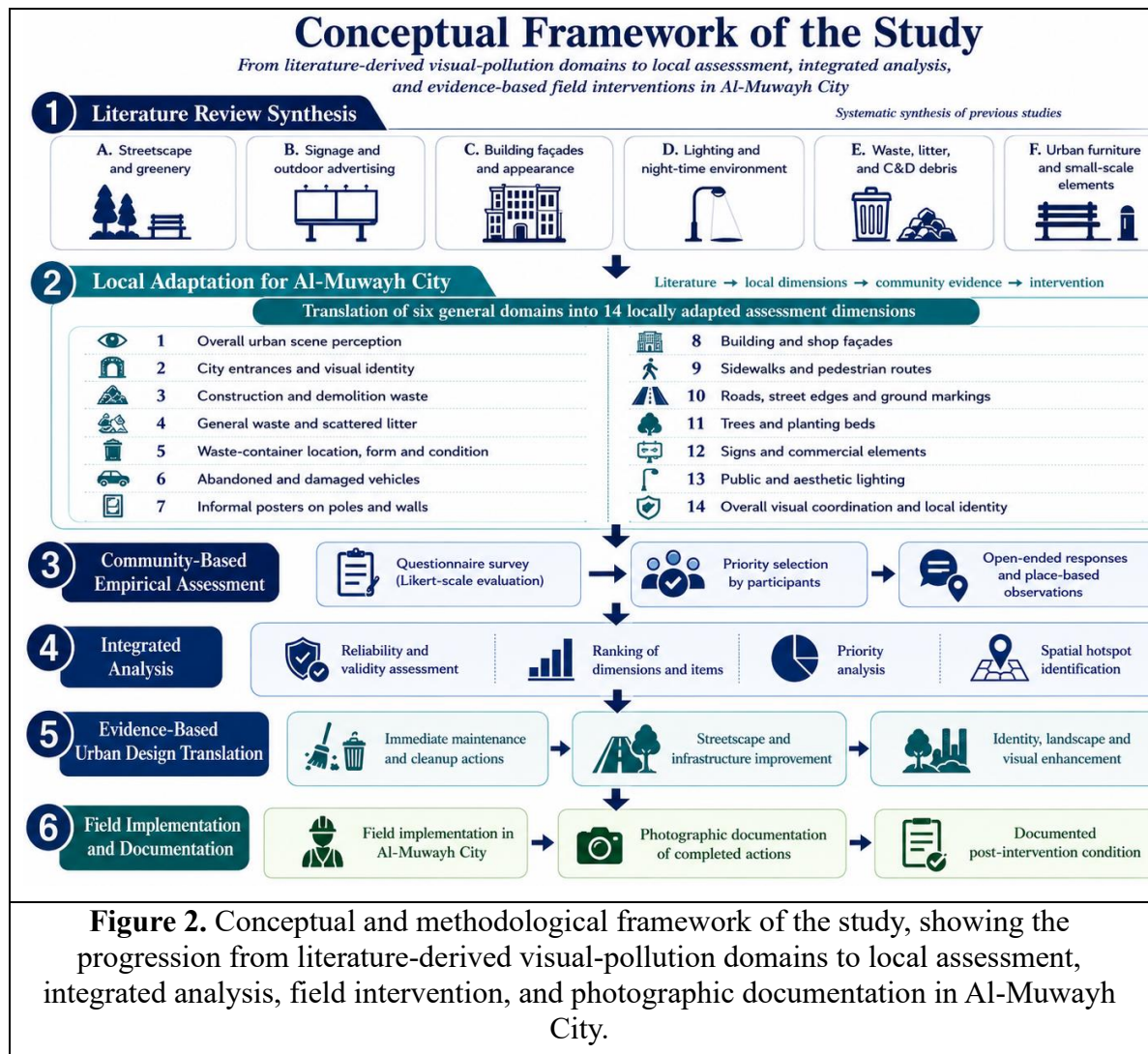


Figure 1. Regional location of Al-Muwayh City and the principal urban environments, corridors, entrances, and documented intervention locations included in the study.

The research followed a sequential assessment-to-implementation process. First, six visual-pollution domains identified through the literature review were adapted into fourteen locally relevant assessment dimensions. An Arabic-language questionnaire was then administered to residents and other adult city users familiar with Al-Muwayh. The resulting quantitative ratings, intervention selections, open-ended responses, and place-based references were analysed jointly to identify priority dimensions, actions, and indicative locations for field verification. Based on this integrated analysis, selected interventions were implemented and documented using before-and-after field photographs. The complete progression from literature synthesis and local instrument adaptation to community assessment, integrated analysis, field implementation, and documentation is summarised in Figure 2.



2.2. Instrument Development and Data Collection

A focused narrative review of 23 relevant sources informed the conceptual scope of the instrument. Cross-cutting evidence addressed definitions, urban visual-quality assessment, perception, identity, and assessment methods (Nawaz and Wakil, 2022; Borowiak et al., 2024; Ogawa et al., 2024; Florio et al., 2024; Farahani et al., 2023; Parmar and Jana, 2024; Alharbi and Rangel-Buitrago, 2022; Rezafar, 2023; Albrektsen, 2025). The six domain groups were then informed by studies of streetscape composition and greenery (de Souza et al., 2024; García-Martín et al., 2025; Dong et al., 2025); signage and traffic-related visual distraction (Churcher et al., 2024; Madleňák et al., 2024; Sheykhfard et al., 2024; Yang et al., 2024; Yue, 2025); building façades (Prieto and Pastén, 2024); public lighting (Pothukuchi, 2021; Liu et al., 2022); visible waste and construction debris (Seror and Portnov, 2018; Luu et al., 2021); and urban furniture (Grabiec et al., 2022).

The assessment instrument was developed through a literature-informed and context-sensitive process. Six recurrent visual-pollution domains provided the conceptual foundation: streetscape composition and greenery; signage and outdoor advertising; building façades; public lighting and the night-time environment; waste and construction and demolition debris;

and urban furniture and small-scale street elements. These domains were translated into 14 locally actionable dimensions based on their observability in Al-Muwayh, relevance to perceived visual quality, association with feasible municipal or design responses, and conceptual traceability to the reviewed literature. The detailed mapping between the six literature-derived domains and the fourteen locally adapted dimensions is presented in Supplementary **Table S1**.

The initial item pool comprised 98 Likert-scale statements. Semantically overlapping, repetitive, or weakly differentiated items were removed or consolidated to reduce respondent burden while preserving coverage of all fourteen dimensions. This refinement produced a final instrument containing 64 statements. The complete item-reduction procedure, item distribution across dimensions, and item-to-dimension coding structure are reported in Supplementary **Tables S2 and S3**. The retained items assessed both the perceived visual effect of existing urban conditions and the perceived need for corrective intervention.

The Arabic-language questionnaire consisted of four components. The first collected participant characteristics, including age, relationship with Al-Muwayh, duration of residence or regular city use, and the urban environment most frequently used. The second included the 64 assessment statements, rated on a five-point scale from 1, indicating no perceived effect or intervention need, to 5, indicating a very high perceived effect or intervention need. The third presented sixteen predefined urban-improvement actions and instructed participants to select the five actions they considered most urgent. The fourth contained three open-ended questions addressing the location most in need of improvement, the principal source of visual degradation, and suggested urban-improvement actions.

The target population included residents, employees, business owners, visitors, and road users familiar with Al-Muwayh City. Because no complete sampling frame was available, a non-probability voluntary-response strategy was adopted. The web-based questionnaire was administered between 7 and 26 June 2026 and yielded 208 completed responses. No missing or out-of-range values were identified in the 64 core statements; therefore, no statistical imputation was required. The complete instrument-development procedure, literature-based domain synthesis, full Arabic questionnaire, and English translation prepared for publication are provided in the Supplementary Material. The English version is presented for transparency and international accessibility and was not used as a separate data-collection instrument.

2.3. Quantitative, Qualitative, and Spatial Analysis

Data analysis was conducted using Python 3.13. The raw survey file was preserved unchanged and a separate analysis-ready dataset was created. Screening covered age eligibility, completeness, response-range validity, full-record duplication, within-respondent variability, and compliance with the intervention-selection instruction. Eight respondents reporting an age below 18 years were excluded before substantive analysis, yielding 200 eligible adults. Exact straight-lining was defined as selection of the same response category across all 64 quantitative items, corresponding to zero within-respondent variance. Forty adult records met this criterion and were excluded from the primary analysis, producing a quality-screened sample of 160. A stricter threshold of within-person SD ≤ 0.25 produced a sensitivity sample of 141 adults but was not used as the primary exclusion rule because low variability may represent a genuinely consistent opinion. All decisions were retained as respondent-level quality flags with explicit exclusion reasons.

Participant characteristics were summarised using frequencies and percentages. Item- and domain-level responses were described using means, standard deviations, medians, interquartile ranges, response distributions, the proportion with a domain score of at least 4, and nonparametric bootstrap 95% confidence intervals based on 2,000 resamples. Means were reported alongside distributional statistics because each domain contained multiple related ordinal items.

For participant i , the score for dimension d was calculated as the arithmetic mean of the retained items assigned to that dimension:

$D_{id} = \frac{1}{k_d} \sum_{j=1}^{k_d} x_{ijd}$	(1)
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where D_{id} is the score of participants i for dimension d , x_{ijd} is the response to item j within dimension d , and k_d is the number of retained items within the dimension. An overall visual-improvement assessment score was calculated as the participant's mean across all 64 statements. Higher scores represented a greater perceived visual effect, a stronger perceived need for intervention, or both.

Internal consistency was evaluated using Cronbach's alpha, standardised alpha, approximate one-factor McDonald's omega, corrected item-total correlations, alpha if item deleted, and mean inter-item correlations. Structural diagnostics included the Kaiser-Meyer-Olkin measure, Bartlett's test of sphericity, correlation-matrix eigenvalues, inter-domain correlations, and a 500-permutation parallel analysis. These procedures were interpreted diagnostically: very high coefficients were treated as potential evidence of item redundancy, and the theoretically defined groups were not assumed to be independent latent constructs.

Differences among the fourteen repeated domain scores were assessed using Friedman's test, with Kendall's W as the effect-size measure. Where appropriate, pairwise Wilcoxon signed-rank tests were evaluated using Holm correction. Robustness was examined by comparing domain estimates and Spearman rank correlations across the eligible-adult sample ($n=200$), the primary quality-screened sample ($n=160$), and the stricter low-variance sensitivity sample ($n=141$).

$$I_{im} = \begin{cases} 1 & \text{if participant } i \text{ selected intervention } m \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

The selection percentage for intervention m was calculated as:

$$P_m = \frac{1}{N} \sum_{i=1}^N I_{im} \times 100 \quad (3)$$

Because the questionnaire instructed respondents to select exactly five actions but did not technically enforce this limit, the primary intervention analysis was restricted to quality-screened adults who selected exactly five options ($n=94$). Selection frequencies and percentages were calculated using this valid subset, preventing participants who selected many options from contributing disproportionate weight.

The three open-ended questions were subjected to a structured deductive-inductive content-analysis procedure. The fourteen intervention domains informed the initial codebook, while additional codes captured locally specific problems, locations, maintenance concerns, and

proposals. Arabic spelling variants were standardised and a response could receive more than one theme.

Place references in the open-ended responses were standardised descriptively. Because participants supplied narrative names for streets, entrances, corridors, and service areas rather than geographic coordinates, the mapped locations were interpreted as approximate planning references, not geocoded observations or statistically validated hotspots.

Finally, dimension scores, intervention selections, qualitative themes, and spatial concentrations were interpreted jointly. They were not merged into a single weighted numerical index because each evidence stream represented a different aspect of community need. Convergence across the four sources was used to identify immediate actions, strategically important interventions, and the locations in which implementation was most strongly supported.

2.4. Translation into Field Interventions

The field interventions were selected through the integrated interpretation of dimension scores, intervention rankings, open-ended responses, and frequently mentioned locations. Actions supported by multiple evidence sources and feasible for implementation at identifiable sites were prioritised. Following completion of the analysis, selected interventions were implemented in Al-Muwayh City, including waste and construction-debris removal, treatment of waste-container surroundings, removal of abandoned vehicles and informal posters, rehabilitation of road edges and pedestrian areas, landscape enhancement, and improvement of city entrances and visual-identity elements.

Before-and-after photographs were taken from comparable viewpoints to document the original conditions and the completed physical improvements. These photographs were used as evidence of field implementation and visible environmental change, but not as evidence of changes in community perception, which would require a separate post-intervention assessment.

Participation was voluntary, and the questionnaire introduction informed respondents that their anonymous responses would be used for research concerning improvement of Al-Muwayh's urban visual environment. No names, contact details, identification numbers, exact addresses, or other directly identifying information were collected. Eight records reporting an age below 18 years were identified during eligibility screening and excluded before all substantive analyses.

3. Results

3.1. Participant Characteristics and Response Quality

A total of 208 questionnaire responses were received. Eight underage records were excluded before substantive analysis, leaving 200 eligible adults. Forty adult records exhibited exact straight-lining across all 64 quantitative items and were excluded from the primary analysis. The resulting primary analytical sample comprised 160 respondents. No quantitative item values were missing, no out-of-range responses were found, and no fully duplicated records were detected.

The primary sample remained strongly familiar with Al-Muwayh City. Residents accounted for 119 participants (74.4%), and 118 (73.8%) had lived in or regularly used the city for more than ten years. Participants aged 31-45 years comprised 100 respondents (62.5%), while principal streets were the most frequently used environment for 65 (40.6%). These

characteristics support local familiarity but do not establish statistical representativeness of all city users.

Across the complete dataset, 41 records (19.7%) exhibited exact straight-lining, including 40 eligible adults. Removing the adult straight-liners reduced the primary sample to 160. A stricter low-variance rule produced a sensitivity sample of 141. The rank order of the fourteen domains was identical between the eligible-adult and primary samples (Spearman $\rho = 1.000$) and nearly identical under the stricter rule ($\rho = 0.996$), demonstrating that cleaning changed score levels but not the substantive priority pattern.

Only 118 of the 208 submissions selected exactly five interventions. After eligibility and quality screening, 94 respondents both entered the primary sample and followed the exactly-five instruction. This valid subset was used for the primary intervention ranking. Detailed screening and compliance flags are reported in the Supplementary Material.

Table 1. Participant characteristics and response-quality indicators

Indicator	Result
Initial responses received	208
Under-18 responses excluded	8
Eligible-adult sample	200
Adult exact straight-liners excluded	40
Primary quality-screened sample	160
Residents of Al-Muwayh City	119 (74.4%)
Residence or regular city use >10 years	118 (73.8%)
Participants aged 31-45 years	100 (62.5%)
Principal streets as most-used environment	65 (40.6%)
Exactly-five selections in primary sample	94 (58.8%)
Rank sensitivity	$\rho = 1.000$; strict $\rho = 0.996$

3.2. Reliability and Dimensionality Diagnostics

In the primary sample, the 64-item instrument produced Cronbach's $\alpha = 0.994$, standardised $\alpha = 0.994$, and approximate one-factor McDonald's $\omega = 0.994$. The mean inter-item correlation was 0.716. Although these values indicate highly consistent responding, their magnitude is better interpreted as evidence of extensive semantic overlap and a strong general response tendency than as exceptional proof of multidimensional validity.

The Pearson-based Kaiser-Meyer-Olkin measure was 0.966, and Bartlett's test was significant, $\chi^2(2016) = 16,577.33$, $p < 0.001$. The first eigenvalue was 46.34 and accounted for 72.4% of item variance. In the 500-permutation parallel analysis, only the first observed eigenvalue exceeded its 95th-percentile random benchmark; the second observed eigenvalue (2.31) was below the corresponding random benchmark (2.49).

Inter-domain correlations were also high (median = 0.828; range = 0.629-0.922). Accordingly, the fourteen groups were retained as literature- and content-defined intervention domains

nested within a broad perceived need for urban visual improvement, not as fourteen empirically independent latent constructs. Detailed reliability and structural diagnostics are provided in the Supplementary Material.

3.3. Dimension-Level Results

The overall 64-item visual-improvement assessment score in the primary sample was 3.333 (bootstrap 95% CI: 3.146-3.516). Domain scores differed statistically, Friedman chi-square(13) = 65.38, $p < 0.001$, but Kendall's $W = 0.031$ indicated a very small effect. Nineteen of 91 Holm-adjusted pairwise comparisons were significant, primarily contrasting the highest-scoring domains with general perception, commercial signs, or building facades.

As shown in Figure 3, greenery and planting beds had the highest mean ($M=3.514$, 95% CI: 3.316-3.705), followed by visual coordination and local identity ($M=3.470$, 95% CI: 3.259-3.677) and roads, street edges, and markings ($M=3.459$, 95% CI: 3.256-3.651). Sidewalks ($M=3.411$), visible waste ($M=3.402$), and city entrances ($M=3.401$) followed closely. Their substantially overlapping confidence intervals indicate a high-priority cluster rather than a sharply separated league table.

Commercial signs ($M=3.178$), building facades ($M=3.200$), informal posters and stickers ($M=3.234$), and overall urban-scene perception ($M=3.127$) occupied the lower end of the relative ordering. These results should not be interpreted as evidence that those issues are unimportant; the narrow score range and small Kendall's W show that the practical differences among many domains were modest.

Sensitivity analysis confirmed the stability of the domain ordering. Spearman's ρ was 1.000 between the eligible-adult ($n=200$) and primary ($n=160$) rankings and 0.996 between the eligible-adult and strict low-variance ($n=141$) rankings. Thus, response-quality screening affected absolute means and reliability estimates but did not materially alter the relative priority pattern.

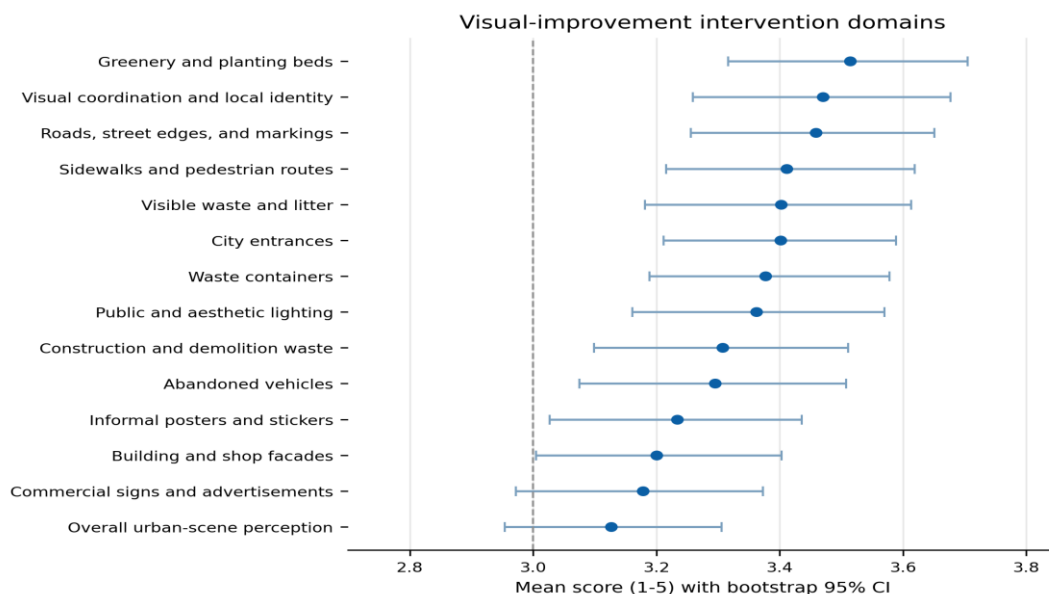


Figure 3. Mean scores and bootstrap 95% confidence intervals for the fourteen visual-improvement intervention domains in the primary quality-screened sample ($n=160$).

3.4. Community Intervention Priorities

Community priorities were assessed using the 94 quality-screened adults who selected exactly five interventions. As shown in Figure 4, improvement of the general appearance of the principal city entrances ranked first, selected by 62 respondents (66.0%).

Increasing greenery and green spaces followed with 45 selections (47.9%), removal of public waste and litter with 44 (46.8%), and removal of construction and demolition waste with 43 (45.7%). Rehabilitation of sidewalks and pedestrian paths ranked fifth with 36 selections (38.3%). The results combine a highly visible gateway intervention with environmental cleanup, landscape expansion, and pedestrian-infrastructure rehabilitation.

The next priority tier included public and aesthetic lighting (34.0%), overall visual identity (31.9%), waste-container locations and appearance (31.9%), and entrance enhancement using symbols and aesthetic elements (28.7%). Regulation of commercial signs and advertisements received the lowest direct selection rate (5.3%).

Because the online form did not enforce the exactly-five instruction, responses containing fewer or more than five selections were not included in the primary frequency denominator. This instrument-design limitation should be considered when interpreting direct selection rates.

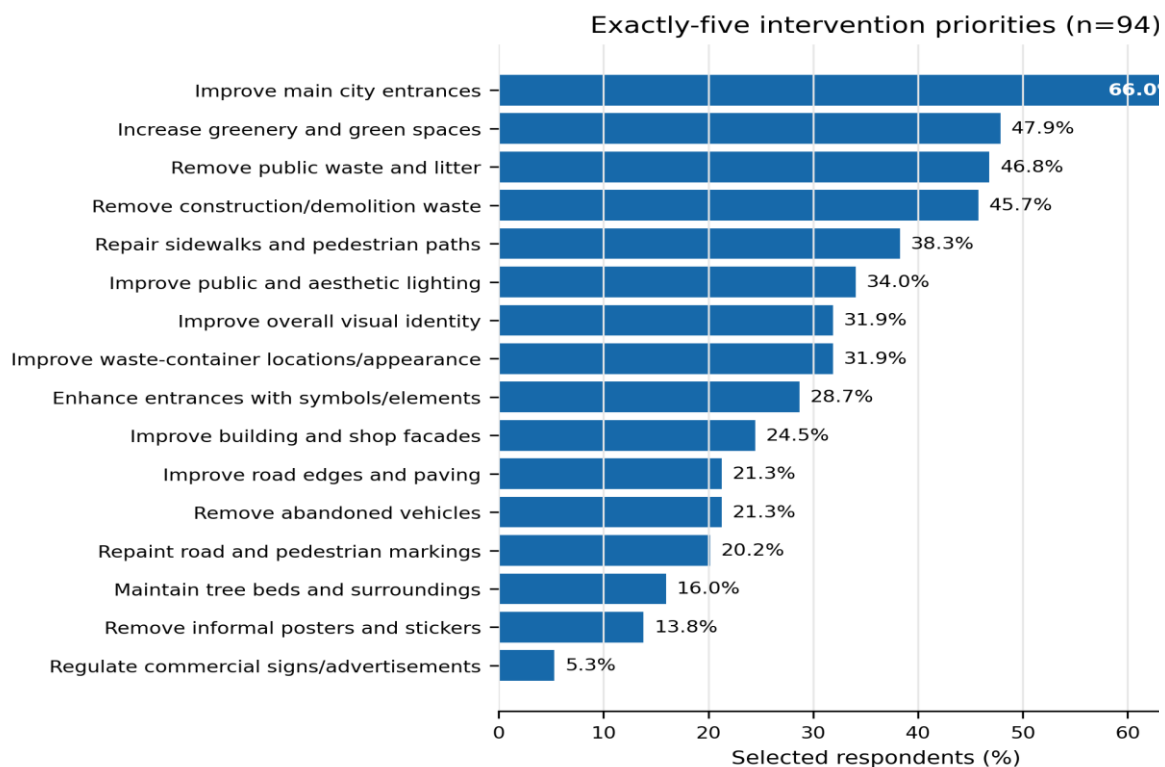


Figure 4. Community intervention priorities among quality-screened adults who followed the exactly-five instruction (n=94).

3.5. Preliminary Qualitative Themes and Indicative Locations

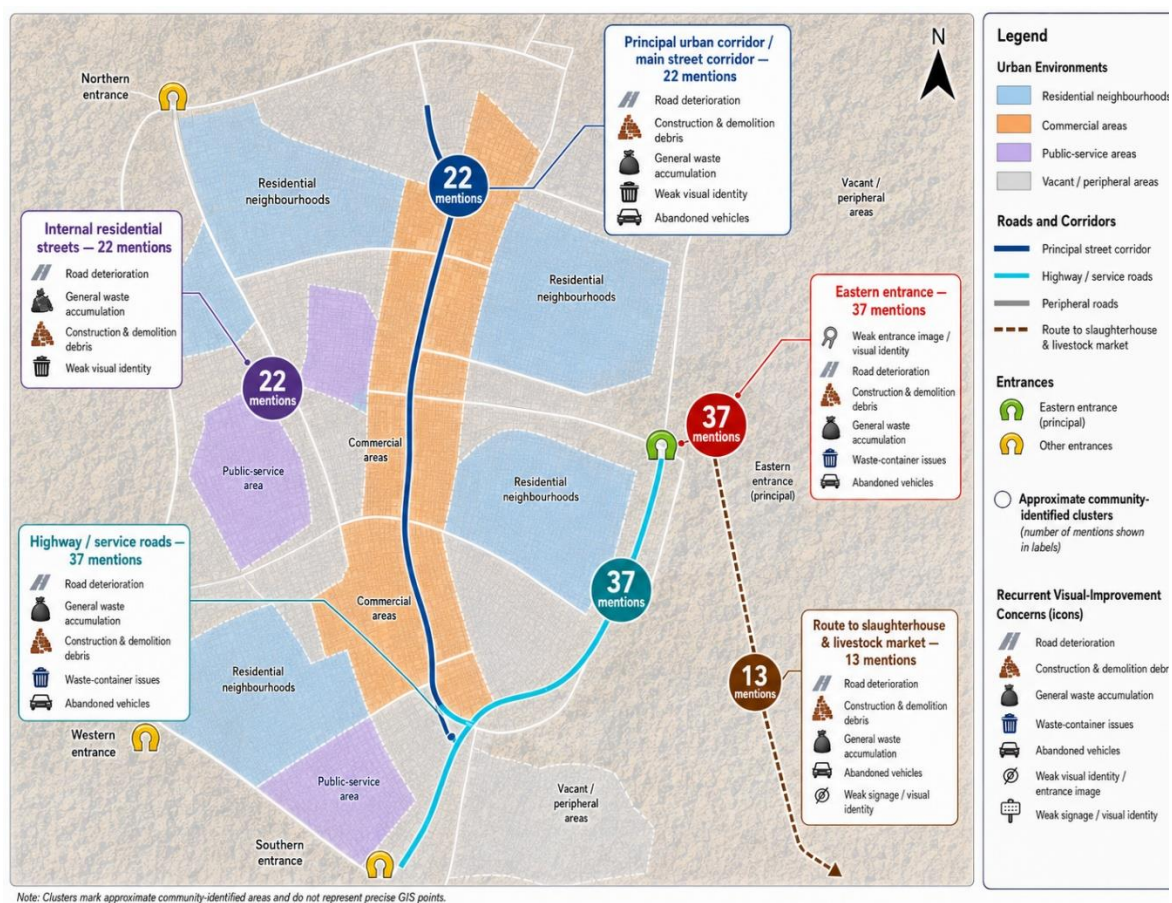
The open-ended fields were screened using a reproducible keyword-assisted thematic procedure within the primary sample (n=160).

Roads, paving, and street edges were the leading preliminary theme in reported locations (69 respondents; 43.1%) and perceived causes (55; 34.4%). Entrance and highway-frontage

locations were identified by 39 respondents (24.4%), while facade-related causes appeared in 19 responses (11.9%) and entrance-related causes in 15 (9.4%).

Road, paving, and street-edge rehabilitation also dominated the preliminary proposal coding (61 respondents; 38.1%), followed by greenery and landscaping (27; 16.9%), entrance and highway-frontage improvement (14; 8.8%), and waste and cleanliness measures (11; 6.9%). These findings broadly complement the quantitative priority cluster but remain subject to codebook refinement and independent recoding.

Nonresponse affected 23.8% of location answers, 24.4% of main-cause answers, and 27.5% of proposals; a further 19-21% were classified as other or unclear in the preliminary screen. Figure 5 should therefore be read as an indicative planning map derived from narrative references and field interpretation, not as a validated GIS hotspot analysis.



3.5.Implemented Urban-Improvement Actions

The final intervention programme was derived through the combined interpretation of dimension-level scores, community priority selections, open-ended responses, and recurrent location clusters. Actions supported by more than one evidence stream and considered feasible at identifiable sites were prioritised for field implementation. The completed interventions were organised into three complementary groups.

The first group comprised immediate cleanup and maintenance actions. These included the removal of general waste and construction or demolition debris, cleaning of waste-container surroundings, removal of abandoned vehicles, and elimination of informal posters from public elements. These actions addressed recurrent concerns associated with neglected sites, vacant land, road edges, and visually exposed public areas.

The second group focused on streetscape and infrastructure improvement. Selected road edges, paved areas, sidewalks, and pedestrian environments were rehabilitated or reorganised, particularly in locations repeatedly identified through the qualitative and spatial analyses. The third group addressed city entrances, landscaping, and visual identity through entrance enhancement, planting and tree-bed maintenance, landscape treatment, and the improvement of selected identity-related urban elements.

As illustrated in **Figure 6**, the photographic pairs document a selection of implemented actions across these intervention groups, showing the conditions observed before implementation and the visible physical changes following completion. The photographs therefore provide evidence that the interventions were implemented and that site-level environmental conditions changed. A more focused example is presented in **Figure 7**, which highlights the transformation of the principal city entrance as a flagship intervention. This example is particularly important because entrance enhancement emerged as one of the strongest priorities in the community-based assessment and was also reinforced by the qualitative and spatial results. The entrance project combined gateway identity treatment, landscape improvement, and associated corridor enhancement, thereby representing the clearest integration of environmental improvement and place identity.

These photographic records should not, however, be interpreted as evidence of improved public perception or satisfaction, because no post-intervention community survey was conducted. The complete links between evidence sources, implemented actions, locations, and photographic records are provided in **Supplementary Table S9**.

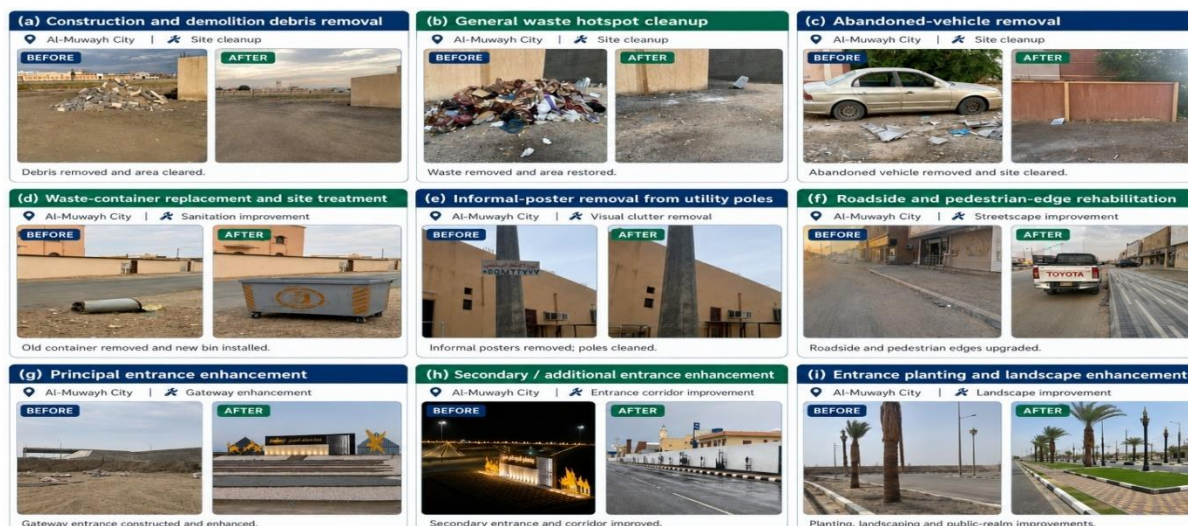


Figure 6. Selected before-and-after photographic documentation of implemented urban-improvement actions in Al-Muwayh City: (a) construction and demolition debris removal; (b) general-waste hotspot cleanup; (c) abandoned-vehicle removal; (d) waste-container replacement and site treatment; (e) informal-poster removal; (f) roadside and pedestrian-edge rehabilitation; (g) principal entrance enhancement; (h) secondary entrance and

corridor improvement; and (i) entrance planting and landscape enhancement. The photographs document completed physical actions and visible site-level changes but do not independently demonstrate changes in community perception or long-term intervention effectiveness.

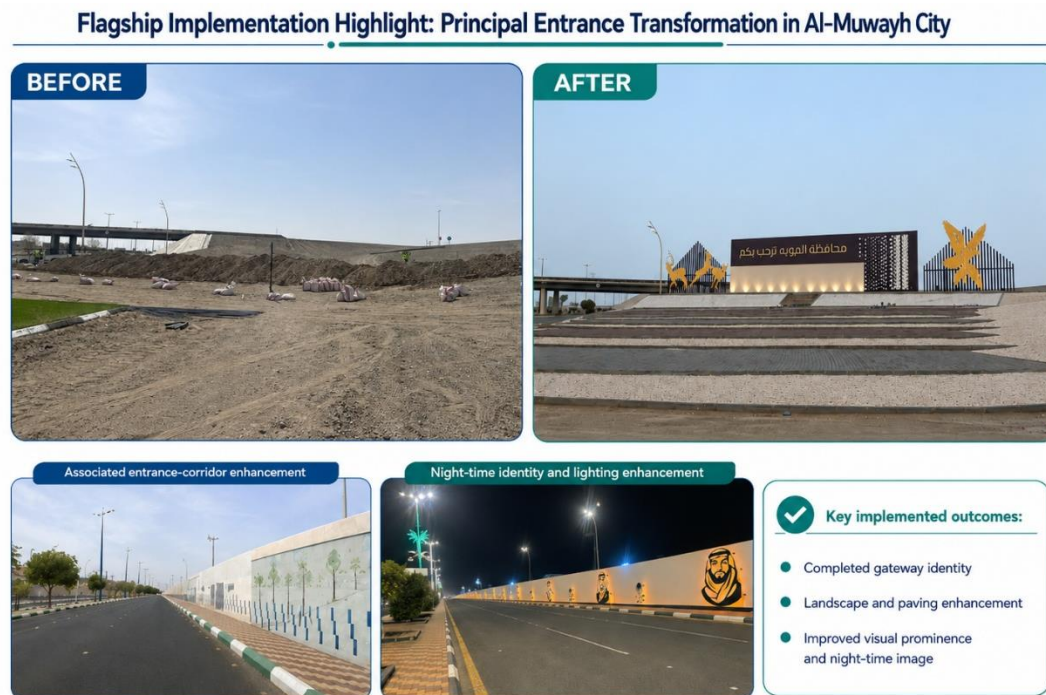


Figure 7. Focused photographic documentation of the principal entrance transformation and associated corridor enhancement in Al-Muwayh City.

4. Discussion

4.1. Interpretation of the Principal Findings

This study demonstrates that visual pollution in Al-Muwayh City is not perceived as a single isolated problem, but as a cumulative condition produced by the interaction of streetscape deficiencies, environmental neglect, infrastructure deterioration, limited greenery, and weak visual coordination. The relatively narrow range of scores across the fourteen operational dimensions supports this interpretation. Although some dimensions ranked higher than others, the findings indicate a broad need for coordinated improvement rather than reliance on one stand-alone beautification project. This is consistent with the growing view that urban visual quality is shaped by the combined condition of roads, public spaces, façades, signage, vegetation, waste management, lighting, and small-scale urban elements (Nawaz and Wakil, 2022; Borowiak et al., 2024).

Trees and planting beds received the highest dimension-level assessment, while visual coordination, local identity, road conditions, and pedestrian environments also appeared prominently. These results suggest that participants associated visual improvement not only with the removal of unattractive elements, but also with the addition and maintenance of positive environmental features. Green infrastructure may therefore serve both an aesthetic and a spatial-organisational function by reducing visual dryness, improving continuity between built and open areas, and strengthening the perceived quality of entrances and streets (Florio et al., 2024; Dong et al., 2025).

However, the exactly-five results placed improvement of the principal city entrances above all other interventions. This finding reflects the symbolic and strategic importance of arrival environments. Entrances are highly visible spaces that shape first impressions, communicate local identity, and concentrate several urban components within a limited area, including roads, lighting, landscaping, paving, signage, and gateway structures. The prominence of entrance improvement was complemented by preliminary narrative references to entrances and highway frontage.

Road and asphalt deterioration emerged as the most recurrent problem in the qualitative responses. This indicates that residents did not separate visual quality from functional urban performance. Damaged roads, incomplete paving, deteriorated edges, and discontinuous sidewalks were understood simultaneously as infrastructure defects and sources of visual disorder. The integrated interpretation of these findings is summarised in **Table 3**.

Table 3. Integrated evidence-to-action synthesis for visual-improvement planning in Al-Muwayh City

Evidence stream	Principal finding	Planning interpretation	Implemented or recommended response
Dimension-level assessment	Greenery, visual identity, roads, sidewalks, visible waste, and entrances formed an overlapping high-priority cluster.	Visual-improvement needs are multidimensional and extend across the city	Coordinated landscape, streetscape, maintenance, and identity programmes
Exactly-five intervention priorities	Principal city entrances ranked first	Entrances represent highly visible and symbolically important intervention sites	Principal entrance and associated corridor enhancement
Open-ended problem responses	Road, asphalt, and street-edge deterioration was the most recurrent concern	Functional infrastructure deterioration contributes directly to perceived visual disorder	Road-edge, paving, sidewalk, and pedestrian-route rehabilitation
Preliminary open-ended proposals	Road rehabilitation, greenery, cleaning, maintenance, and entrance improvement dominated recommendations	Participants favoured practical and maintainable actions rather than isolated decorative treatments	Phased packages combining cleanup, infrastructure repair, landscaping, and monitoring
Indicative place references	Narrative references emphasised roads, entrances/highway frontage, and other recurrent locations.	Place references guide field verification but do not constitute validated GIS hotspots.	Targeted interventions at entrances, service roads, residential

			streets, and exposed peripheral locations
Photographic documentation	Multiple physical interventions were completed and recorded	Implementation can be verified visually, but perceptual effectiveness remains unmeasured	Repeat field audits, maintenance monitoring, and post-intervention community assessment

4.2. Convergence and Complementarity of Evidence

The four evidence streams did not produce identical rankings, but their differences are analytically useful rather than contradictory. Dimension-level ratings measured the perceived importance and intervention need associated with broad components of the urban environment. By contrast, the exact-five question required participants to select a limited number of actions, thereby revealing priorities under an implicit resource constraint. Open-ended responses explained why certain issues were considered important, while location-based responses identified where intervention should be concentrated.

For example, trees and planting beds received the highest dimension mean, whereas city entrances ranked first in the forced intervention selection. This difference suggests that greenery was viewed as a widespread city-level need, while entrance improvement was perceived as a more visible, focused, and immediately actionable project. Similarly, road-related dimensions were among the highest-rated, but the qualitative responses provided greater detail about potholes, deteriorated asphalt, unfinished edges, and damaged pedestrian areas. The qualitative findings therefore clarified the specific physical conditions underlying the numerical assessments.

The stability of the domain ordering across the eligible-adult, primary, and strict sensitivity samples strengthens confidence in the relative priority pattern. The intervention analysis, however, was intentionally restricted to the 94 quality-screened adults who followed the exactly-five instruction; results from noncompliant selection patterns were not treated as equivalent evidence.

The place references added an indicative spatial layer, but they were narrative and non-geocoded. They are useful for directing field verification toward entrances, service roads, corridors, and residential streets, yet they should not be described as statistically validated hotspots until independent coding and coordinate-based verification are completed.

Accordingly, the contribution of the mixed-methods approach lies in the complementarity of the evidence: quantitative scores established the breadth of perceived need, forced selections clarified relative priorities, qualitative responses explained underlying concerns, and spatial references directed those priorities towards implementable locations.

4.3. Evidence-to-Action Translation and Planning Implications

The study translated the combined evidence into three complementary intervention levels. The first level consisted of immediate cleanup and maintenance actions, including waste and debris removal, treatment of waste-container surroundings, removal of abandoned vehicles, and elimination of informal posters. These actions generally require limited design development and can produce rapid and visible improvements. However, their effects may be temporary without regular inspection, enforcement, and recurring municipal maintenance.

The second level focused on streetscape and infrastructure rehabilitation. Road edges, sidewalks, paved areas, pedestrian routes, and exposed frontages require more than superficial visual treatment because their physical condition affects movement, accessibility, safety, and spatial order. The prominence of road-related concerns indicates that visual-improvement programmes should be integrated with engineering and public-works planning. Road resurfacing should therefore be coordinated with edge treatment, markings, drainage, sidewalks, lighting, and landscape elements rather than implemented as an isolated technical activity.

The third level addressed entrances, landscape, and visual identity. These interventions require greater design coordination but offer the strongest potential for improving arrival experience and place recognition. As shown in **Figure 6**, the implemented programme included actions across cleanup, container treatment, poster removal, streetscape rehabilitation, landscaping, and entrance enhancement. **Figure 7** presents the principal entrance transformation as the flagship implementation example. This intervention is particularly significant because it responded simultaneously to the highest forced priority, recurrent qualitative concerns about entrances, and the spatial concentration of responses around arrival corridors.

The principal entrance project combined gateway construction, landscape and paving treatment, associated corridor improvement, lighting, and visual-identity elements. Its value therefore lies not only in the gateway structure itself but in the coordinated treatment of the surrounding environment. This supports the evidence-to-action logic presented in **Table 3**, in which interventions supported by multiple evidence streams received stronger implementation justification.

For municipal planning, the findings support a phased sequence: (1) immediate cleanup and repair, (2) priority-corridor rehabilitation, (3) entrance and public-realm enhancement, (4) landscape and identity consolidation, and (5) continuous monitoring.

This sequence balances early visible outcomes with longer-term structural improvement. It also reduces the risk of investing in decorative elements before resolving waste, road, sidewalk, and maintenance deficiencies. This planning framework was developed specifically for Al-Muwayh City; its applicability to other cities requires independent testing and adaptation to their local urban, institutional, and community contexts.

4.4. Study Limitations and Future Monitoring

Several limitations should guide interpretation of the findings. First, the questionnaire was distributed electronically using a non-probability sampling approach. The final sample therefore reflects the views of participating adults and should not be treated as statistically representative of every resident or city user. The sample was also dominated by residents and long-term users, which strengthened local familiarity but may have underrepresented visitors and occasional road users.

Second, the study was cross-sectional and relied on self-reported perceptions. Exact straight-lining affected 40 eligible-adult records and was handled through exclusion from the primary analysis plus sensitivity checks; rapid-completion screening was impossible because response-duration data were unavailable. The extremely high reliability coefficients and inter-domain correlations indicate extensive item redundancy. The fourteen groups should therefore be interpreted as related operational planning domains within a broad general assessment, not as independent psychological constructs.

Third, the online form did not technically enforce selection of exactly five interventions, leaving 94 quality-screened respondents for the primary priority analysis. Spatial locations were derived from participant descriptions and represent approximate planning references rather than geocoded or surveyed hotspots.

Finally, before-and-after photographs verify physical implementation and visible site-level change but do not establish long-term effectiveness, maintenance quality, or improved community perception. Some photographic pairs also differed in viewpoint, lighting conditions, or time of day. Future evaluation should combine georeferenced repeat photography, structured field audits, maintenance indicators, and a post-intervention questionnaire. Repeated measurement of the fourteen dimensions would allow assessment of whether perceived intervention need decreases after implementation, while monitoring road condition, waste recurrence, planting survival, lighting functionality, and gateway maintenance would provide a more objective basis for evaluating programme sustainability.

5. Conclusion

This study developed and applied an evidence-based approach for identifying, prioritising, and translating visual-improvement needs into implementable urban actions in Al-Muwayh City. By integrating a literature-informed questionnaire with quantitative assessment, intervention prioritisation, open-ended responses, approximate spatial clustering, and photographic documentation, the study moved beyond descriptive diagnosis towards an applied assessment-to-implementation framework.

The findings showed that visual pollution in Al-Muwayh cannot be addressed through isolated beautification measures. Greenery, visual coordination and local identity, roads and street edges, sidewalks, visible waste, and city entrances formed an overlapping high-priority cluster. Domain differences were statistically detectable but small, so the evidence supports priority tiers rather than a precise ranking. Among quality-screened adults who followed the exactly-five instruction, improvement of the principal city entrances ranked first, while preliminary open-ended coding emphasised roads, entrances, and greenery. These qualitative and place-based findings require independent validation before stronger thematic or hotspot claims are made.

The study's principal applied contribution lies in the translation of this combined evidence into three intervention levels: immediate cleanup and maintenance, streetscape and infrastructure rehabilitation, and entrance, landscape, and visual-identity enhancement. Several actions were subsequently implemented and documented, including debris and waste removal, abandoned-vehicle removal, waste-container treatment, poster removal, roadside and pedestrian-edge rehabilitation, landscaping, and entrance enhancement. The principal entrance transformation represented the strongest flagship example because it combined gateway identity, paving, landscape treatment, lighting, and corridor improvement within a single coordinated intervention.

The photographic records confirm that the selected physical actions were completed and that visible site-level conditions changed. Nevertheless, they do not establish improved public perception, satisfaction, or long-term effectiveness. Future evaluation should therefore include a post-intervention community survey, repeated georeferenced photography, structured field audits, and maintenance indicators. Overall, the study demonstrates that community evidence can provide a practical basis for prioritising limited municipal resources and developing phased, location-specific, and maintainable urban-improvement programmes in Al-Muwayh

City. The transferability of this approach to other urban contexts requires independent validation and adaptation to local conditions.

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