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Systematic Review

A Systematic Literature Review and Analysis of Visual Pollution

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Abstract: Rapid urbanization has introduced new pollution challenges, with visual pollution becoming particularly prominent. This type of pollution affects both the visual environment and public psychology, impairing aesthetic appreciation. Visual pollution extends beyond outdoor advertising, manifesting in various forms across urban, roadway, and natural areas. Although many studies have identified and analyzed visual pollution, there is still a lack of comprehensive knowledge and awareness of this problem. Until now, visual pollution has never been a unified and complete concept, definition, and research methodology. To address this gap, our systematic literature review examined existing literature to further explore and understand visual pollution. We systematically reviewed research articles published between 2008 and 2023, utilizing three journal databases: Web of Science, Scopus, and Google Scholar. Ultimately, 52 articles met the review criteria. The results of the study showed the types and characteristics of visual pollutants, the locations where visual pollution occurs, the various factors contributing to visual pollution, and the methodologies employed to study visual pollution. This study enhances professionals' comprehension of visual pollution and its effects on the visual environment, equipping them to implement effective measures to reduce its impact and preserve visual quality in both urban and natural areas.

Keywords: visual pollution; visual pollution's impact; visual pollution's type and characteristic; visual pollution's location; visual pollution's factors; visual pollution's method

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1. Introduction

Pollution is a pervasive issue, continuously threatening human life and the natural environment. While pollution has existed as long as human history, its detrimental effects on the world are profound and ongoing. According to [1], pollution is defined as the accumulation of contaminants or other harmful substances that have negatively affected the environment and human health. Environmental pollution has long been recognized as one of the most significant threats to humanity, alongside other factors impacting human life quality. The general understanding of environmental pollution has traditionally been primarily associated with air, water, and noise pollution. Air pollution involves harmful particles and gases in the atmosphere, such as chemicals, particulates, and biological molecules [2]. It is the world's fourth-largest fatal health risk, causing 4.8 million premature deaths annually. The trends and threats associated with water pollution have worsened, significantly impacting regions such as Europe, China, India, South America, and Africa [3]. Furthermore, the continuous development of urbanization [4], economic growth [5], and transportation systems [6] have exacerbated noise pollution. This escalation is attributed to various anthropogenic sounds and activities, as well as poor urban design and chaotic construction practices, making noise pollution increasingly difficult to control, especially in urban areas.

However, modern environmental challenges have expanded this understanding to include visual pollution [7], a relatively recent phenomenon arising from rapid urban expansion, industrialization, exploration, and insufficient regulations. Visual pollution typically involves unappealing or obtrusive elements that negatively impact the visual quality of environments [8,9]. It includes limitations on the visibility of distant objects, the subjective effects of introducing built structures in scenic landscapes, and a more expansive definition encompassing other visual disturbances [10]. The impact of visual pollution can be exacerbated when the pollutant is mobile, as it tends to attract attention and reduce feelings of tranquility [11]. This results in numerous visual stimuli competing for people's attention, making it challenging for them to concentrate on their tasks [12]. Visual pollution affects more than just aesthetics; it is closely linked to the spatial configuration of objects and can significantly alter a space's character and visual harmony [12]. Hence, the aesthetic quality of the environment is crucial in determining the overall quality of life. Visual pollution has been shown to reduce people's enjoyment of public spaces and natural landscapes, leading to dissatisfaction and a lower quality of life.

Moreover, visual pollution can also harm mental health. The proliferation of advertisements, signs, and other visual distractions creates a chaotic atmosphere that makes it difficult to relax and feel at ease [13]. Exposure to visual pollution can trigger negative psychological responses, leading to adverse moods [14–16], such as anxiety, fear, insecurity, and lethargy. Consequently, this leads to mental fatigue and cognitive decline due to the constant sensory overload. The pervasive stress on the visual senses can precipitate a decline in mental health, which in turn impairs overall well-being and life satisfaction.

Visual pollution is particularly significant in densely populated commercial centers where outdoor advertisements (OAs) are prevalent, impacting the public's visual experience of the urban landscape [17]. These OAs have also proliferated along roads in various forms, not only obstructing the sightlines of motorists [18] but also damaging the visual aesthetics of the area [19]. Although OAs are intended to inform consumers about products and services that may enhance their daily lives, their pervasive nature in everyday environments can lead to various problematic effects, such as visual pollution. Additionally, the materials used for these advertisements often contribute to environmental degradation due to their non-biodegradable nature, exacerbating landfill issues [14]. Beyond urban settings, the natural landscape areas have also become subject to the impacts of visual pollution, especially some new landscape elements and natural phenomena that modify the overall view of the natural landscape environment [20].

A study [21] has categorized visual pollution as two sides: one with tangible things that are specific objects or elements of the visual landscape that people can notice, and another one with intangible things mostly related to emotions, e.g., happiness, fear, or stress. This form of pollution not only degrades natural and built environments but also diminishes their aesthetic and potentially functional value and impacts human mental health. Therefore, understanding and addressing visual pollution is crucial to preserving urban and natural environments' visual integrity and aesthetic value and safeguarding human mental health and well-being.

The significance of visual pollution was first recognized in the mid-20th century. During that time, as automobile transportation improved and developed and car tourism increased in the United States, people became increasingly aware of the negative impacts of roadside OAs on the visual landscape [22]. Nowadays, urban environments are flooded with numerous OAs. This widespread presence often results in a cluttered and disorderly appearance, obstructing views and leading to disorientation among city dwellers [15,23]. Visual pollution has been linked to the growing number of OAs [24]. This view is supported by [25], who mentions that excessive OA contributes significantly to visual pollution, considering that more than seven OAs in a view can be problematic. Furthermore, visual pollution is said to occur when the ratio of the obstructed view to the visible view volume exceeds 4%, specifically due to OAs [26]. Frequent placement of OAs in public spaces and their long-distance visibility make them a major source of visual pollution.

While OAs are widely regarded as a significant source of visual pollution, their role is controversial. OAs are considered an effective form of communication that efficiently convey messages across diverse societies [27] and provide economic benefits by enhancing marketing efforts [28]. A study [24] has concluded that the four characteristics of OA—visibility, media effectiveness, local presence, and tangible response—define them as an effective tool for communication and a medium for information for the general public. It has also been argued that while OAs contribute to spatial disorder within urban environments, this chaos may render otherwise predictable or orderly urban spaces more intriguing [29]. Indeed, artistic advertisements can become tourist attractions, offering unique symbols and identities that may elevate locations to landmark status, as seen with New York's Times Square and Tokyo's Ginza district.

As research on visual pollution continues, the recognition of visual pollution has become more comprehensive and is not limited to OA. Visual pollution includes any material or object that causes discomfort for the visual senses [17,30]. This discomfort can stem from landscape components that are out of harmony with the surroundings [15,31,32], challenging integration into the environment. Visual pollution has been described as the loss of attractiveness and distortion of vision, resulting in diminished human perception of attractive components in all surroundings [33]. Additionally, visual pollution can result from neglect and poor management of both natural and man-made landscapes, leading to diminished area appeal [34]. It is characterized by an unregulated and disorganized diversity of colors, shapes, lights, and materials, resulting in unsightly urban environments [35].

Despite its significance, there has never been a unified and complete concept and definition of visual pollution. It is regarded as a complex phenomenon dependent on the surrounding environment and the psychology of the individual affected [36]. Unlike traditional forms of pollution, such as air and water, which have been extensively studied and defined, visual pollution presents unique challenges due to its subjective impact on environmental aesthetics and quality [31]. Although scholars have continued to explore visual pollution, visual pollution remains an under-understood and under-researched form of pollution [30]. Therefore, our review aims to systematically review the existing literature to explore and understand further visual pollution. The following section of the results presents the types and characteristics of visual pollutants, the locations where visual pollution exists, the various factors contributing to visual pollution, and the methodologies employed to study visual pollution. Understanding these factors is essential for preventing and mitigating visual pollution, thereby enhancing the visual comfort of public environments.

2. Materials and Methods

This systematic literature review utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. PRISMA offers a standardized methodology for screening and extracting literature, ensuring all relevant studies are appropriately included and appraised. This systematic literature review process was organized around precise keyword selection, well-defined inclusion and exclusion criteria, and comprehensive literature screening and selection. Subsequent stages included detailed data collection and analysis, culminating in systematically exploring the field.

2.1. Keyword Selection

In conducting this systematic literature review, keywords were strategically categorized into two primary components to cover all relevant aspects of visual pollution: visual pollution and investigations. First of all, the keyword "visual pollution or contamination" can be defined as two distinct but related concepts: visual disturbance and visual blight. These words describe disruptions that negatively impact the visual environment, potentially degrading its aesthetic quality and comfort. Secondly, "visual pollutants" and "visual contaminants" refer to the primary objects within the human environment that cause visual discomfort and contribute to the manifestation of visual pollution (Ahmed et al., 2019) [31]. Thirdly, the investigation component sought to clarify the range of topics covered by visual pollution studies by identifying the type, location, factor, and method involved. Finally, the keywords

for this systematic literature review are summarized as follows: "visual pollution" OR "visual contamination" OR "visual disturbance" OR "visual blight" AND "visual pollutants" OR "visual contaminants" AND "type" OR "location" OR "factor" OR "method".

2.2. Inclusion and Exclusion Criteria

The inclusion criteria for this study are as follows: (i) the subject of the article must be concerned with visual pollution, (ii) the article must have been published within the time frame from 2008 to 2023, and (iii) the article must be published in a peer-reviewed English-language scientific journal, including research papers, review papers, and conference papers.

The exclusion criteria for this study are as follows: (i) articles that are not relevant to the topic of visual pollution, (ii) book chapters, literature reviews, MSc and Ph.D. thesis, and government reports, and (iii) duplicate articles.

2.3. Literature Screening and Selection

Three databases—Web of Science, Scopus, and Google Scholar—were used to retrieve the initial pool of literature for this systematic literature review, shown in Table 1. Initially, a total of 15,300 articles were gathered. These articles were first filtered according to the inclusion and exclusion criteria detailed in Section 2.2, and 978 articles were finally selected. Subsequent screening removed 33 duplicates. After a detailed review of the full texts of these peer-reviewed journal articles, 52 articles (42 research papers, 9 conference papers, and 1 review paper) ultimately met all the specified requirements for inclusion in this study, as depicted in Figure 1.

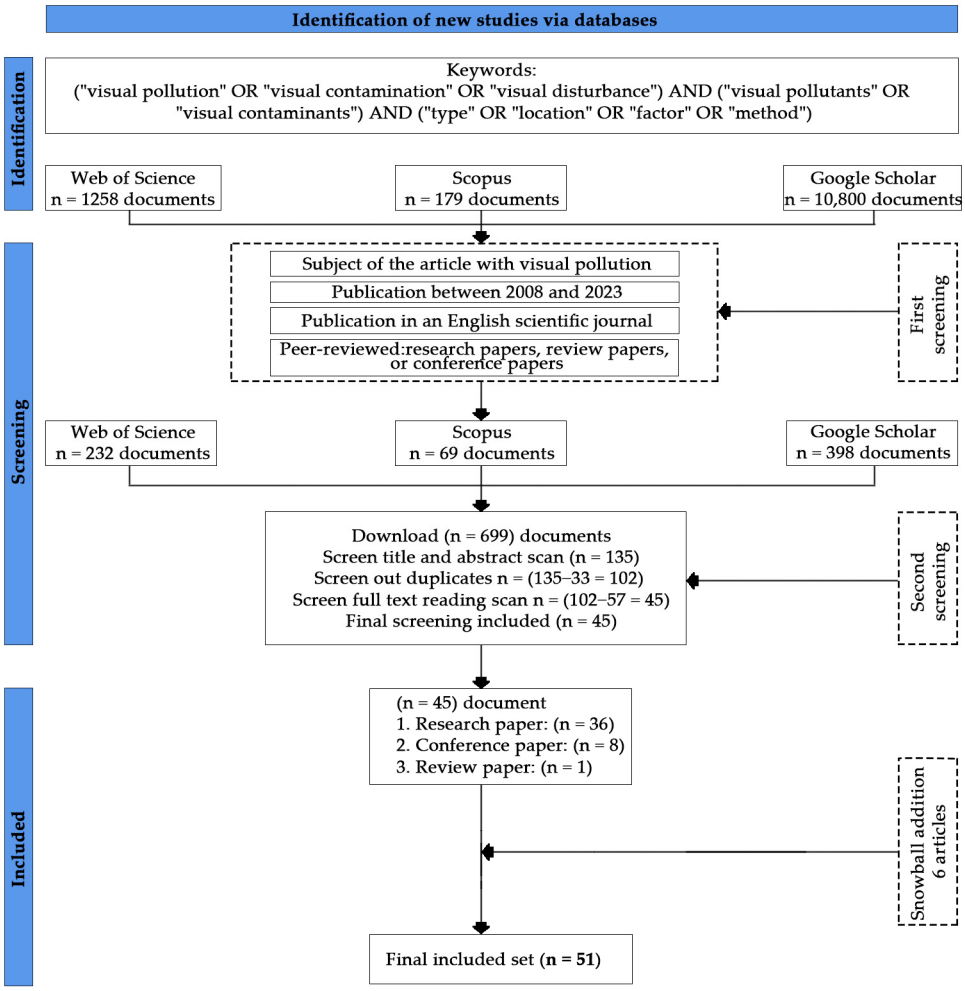

Figure 1. The PRISMA Flowchart describing the literature screening process for systematic search reviews.

Table 1. Database search strategy.

Database	Search Terms
Web of Science	"visual pollution" OR "visual contamination" OR "visual disturbance" OR "visual blight" AND "visual pollutants" OR "visual contaminants"
Scopus	"visual pollution" OR "visual contamination"
Google Scholar	"visual pollution" OR "visual contamination" AND "type" OR "location" OR "factor" OR "method"

2.4. Data Collection

In this study, a detailed examination and systematic review of the selected articles were performed to assess critical aspects of visual pollution. Relevant data extracted from these articles were organized in a Microsoft Excel spreadsheet (2020) to facilitate analysis and ensure systematic data handling. The recorded data included several detailed elements crucial for a thorough understanding of visual pollution, such as types of visual pollutants, the locations where visual pollution exists, the various factors contributing to visual pollution, and the methodologies employed to study visual pollution. The data collected in this study are presented in detail in Appendix A, Table A1.

2.5. Data Analysis

This study synthesizes the data presented in Table A1 of Appendix A, aiming to enhance the connections between existing literature. In order to fully comprehend the concept of visual pollution, it is essential to gain an understanding of various dimensions (Figure 2). Firstly, visual pollution arises through the presence of visual pollutants. Understanding the character and role of these visual pollutants could provide an overview of visual pollution. Next, the locations of these pollutants and the factors contributing to their prevalence at these sites were analyzed to provide a deeper understanding of visual pollution. Furthermore, a summary of the existing methods of identifying and measuring visual pollution was conducted, enriching the understanding of effective monitoring and management strategies. Generally speaking, this information is pivotal in effectively grasping the complexities involved in managing visual pollution.

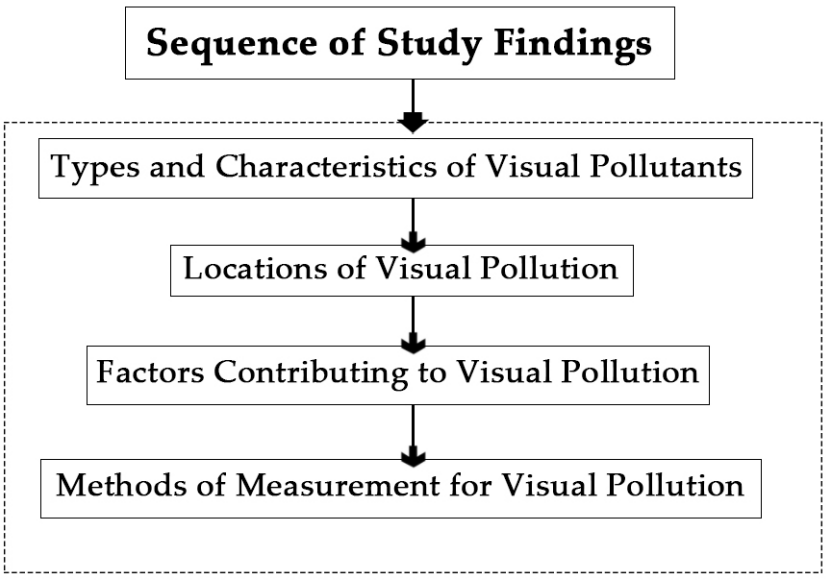

Figure 2. Sequence of study findings.

3. Results

A comprehensive count and review of the 52 articles selected for analysis revealed that these articles were published between 2008 and 2023. As shown in Figure 3, there has been a significant increase, especially after 2015. From 2019 to 2023 (July 2019, April 2020, June 2021, May 2022, August 2023), 30 articles were published, representing more than half of the articles selected. Moreover, these articles were sourced from 46 different journals. Notably, three articles were published in the IOP Conference Series: Earth and Environmental Science, three in the ISPRS International Journal of Geo-Information, and two in Land, with the remaining articles distributed across various other journals. Geographically, the regions of interest in these articles include Asia, Europe, Africa, and North America, with a predominant focus on Asia and Europe. The largest number of articles pertain to Asia, particularly the Middle East, South Asia, and Southeast Asia. Specific regions and countries studied include:

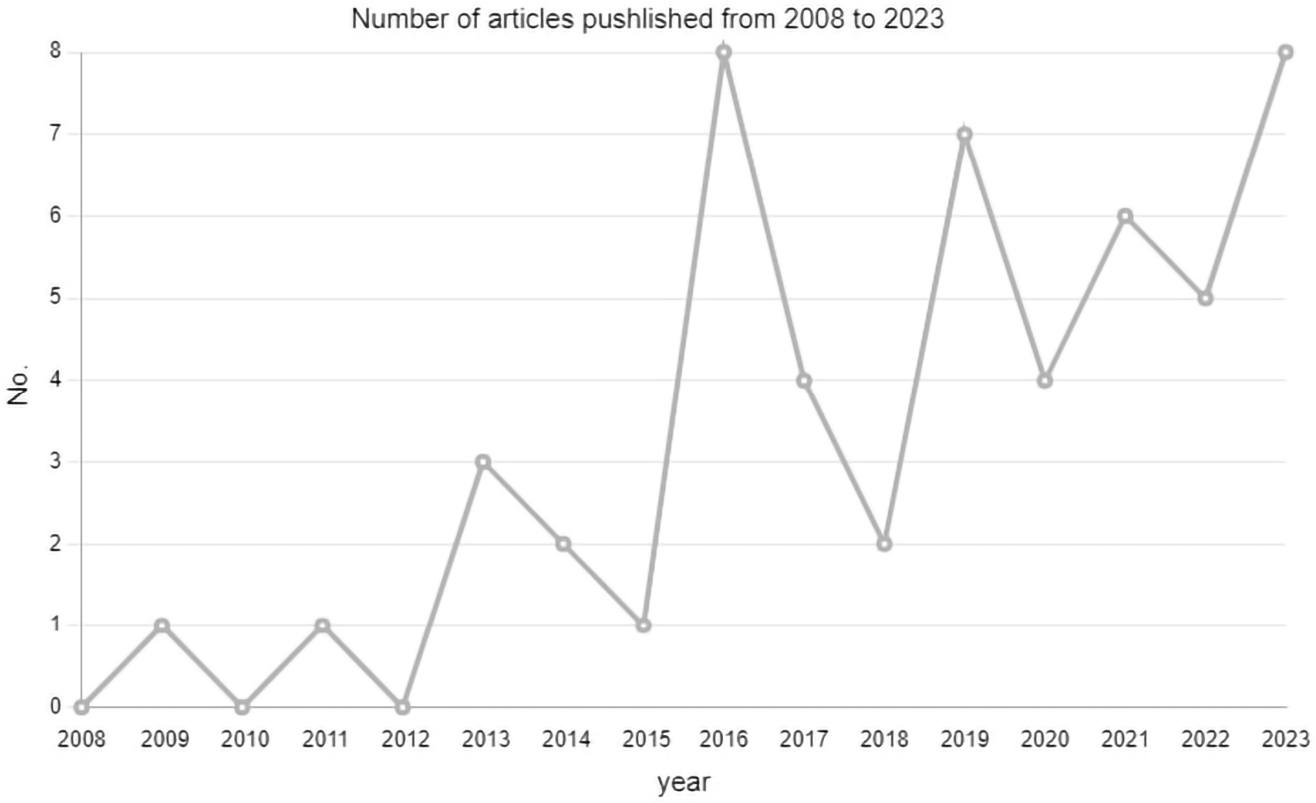

Figure 3. Number of publications from 2008 to 2023.

Middle East: Saudi Arabia (4 articles), Iraq (4 articles), Yemen, Bahrain, and Amman (1 article each).

- South Asia: Pakistan (5 articles), India (2 articles), and Bangladesh (2 articles).
- Southeast Asia: Malaysia (3 articles), the Philippines (2 articles), and Indonesia (2 articles).
- Southwest Asia: Iran (4 articles).
- In Europe, the articles cover several countries:
- Poland: 5 articles.
- Lithuania: 3 articles.
- Slovenia: 2 articles.
- Denmark, Turkey, and Romania: 1 article each.

In Africa, the research primarily focuses on Nigeria (2 articles) and Egypt (1 article). In North America, Colombia is represented by one article. Additionally, several articles do not

focus on a specific region. In general, the geographical distribution of the selected articles indicates that visual pollution is still predominantly observed in developing countries and underdeveloped regions. While developed countries are also affected by visual pollution, the number of articles on this topic is relatively low. This trend suggests that visual pollution may be a more pressing or visible issue in regions undergoing rapid urbanization and industrialization.

3.1. Types and Characteristics of Visual Pollutants

Undoubtedly, numerous studies [9,14–19,22–26,28,29,37–43] have identified OAs, including both printed and electronic billboards, as primary contributors to visual pollution in many countries across Asia, Europe, Africa, and North America mentioned in the previous Section 3.1. This pollutant detrimentally impacts ecological environments, human visual spaces, and human emotion and well-being. Key factors often attributed to this impact include billboards' size, material, appearance, and placement [17,19,28,29,44], with billboards' problematic content exacerbating this issue further [24]. Moreover, billboards' color content and cumulative area are also recognized factors that cause visual pollution [22]. Excessive proliferation of poorly designed or maintained billboards also intensifies visual pollution, detracting from the aesthetic quality of urban environments [23,45].

With the continuous expansion of the built environment, human activities introducing other forms of visual pollutants have become increasingly prevalent. The focus of attention on visual pollutants has also shifted from OA to other forms of pollutants. Such visual pollutants include other utility infrastructures and facilities almost exclusively in Asian countries—such as hanging wires, poles, broken roads, and mobile towers—adding to the landscape's visual degradation [10,12,13,16,31,32,35,44,46–52]. In particular, a study in Iraq [39] has noted that the militarization of society and the military machine has become a distinctive form of visual pollutants due to the conditions of war. Incineration facilities in Iran also disrupt urban landscapes by blocking views and degrading the aesthetic quality [48]. In addition, installing wind turbines near residential areas in Denmark has been shown to significantly detract from the visual appeal of the area and enjoyment for the residents [11]. The visual quality of roadways in Saudi Arabia is further diminished by excavation barriers, potholes, and deteriorated sidewalks [30,34]. Similarly, the accumulation of litter on the streets and the location of litter piles hurt the overall visual environment in India [50]. Interestingly, the characteristics of unmanned aerial vehicles, including dimensions, lights, color, quantity, and icons, can be perceived as visual influences and may be regarded as a form of visual pollution [53].

Building-related visual pollutants also play a crucial role in undermining urban aesthetics. Visual pollutants manifest as dilapidated or poorly managed buildings in Romania [54] and Yemen [55], façades lacking cohesion in color, material, shape, and height among adjacent structures in Middle-Eastern countries [8,33,36], and poorly planned or arranged buildings in Bahrain [13] and Turkey [7]. Moreover, new constructions that conflict with the traditional architectural character of the city and unregulated or inconsistently restored buildings exacerbate this visual disharmony [54]. It is important to acknowledge that another form of visual pollution, light pollution, is a significant issue in rapidly developing urban areas, arising from street lights, building façade lights, and billboard lights. In Egypt, light pollution manifests as sky glow, glare, and light trespass, which collectively contribute to visual problems in the nighttime environment [56].

New or modified landscape elements such as land surface mounds, excavations, structures, vegetation, water bodies, or significant increases in existing building volumes can change the landscape character in natural areas. For instance, in Lithuania, these changes have been shown to impact the visual experience of individuals who previously enjoyed the original natural scenery [20]. Similarly, in the rural areas of Malaysia, which are also more green, roadside settlements, commercial structures, mixed agricultural crops, and unmanaged vegetation are regarded as sources of visual pollution [57]. These alterations

may result in a less favorable experience for those who have previously enjoyed the original natural vision.

A study in Pakistan [44] has sought to identify types of visual pollutants based on the opinions of various experts. The majority of the visual pollutants have been discussed in previous content. It is also worth noting that some new pollutants are proposed, including graffiti/wall chalking, overflowing sewerage/drainage, and encroachments. In conclusion, visual pollutants can be defined as any elements that deviate from the established visual context, impairing the environment's overall visual appearance and quality.

3.2. Location of Visual Pollution

By the time humans became aware of visual pollution, this new pollution had silently infiltrated human and natural environments, presenting ubiquitous challenges across diverse settings—from urban landscapes to protected natural areas.

To some extent, urban areas [7,10,14,15,28,30,35,40,43–46,48,50,56,58] and their adjacent roadways [17–19,22,23,26,29,34,36,37] have become notably affected by visual pollution, impacting various zones within the city, particularly those that are developing or underdeveloped. However, Poland and Slovakia, both developed countries, also face notable instances of visual pollution. This issue is undeniable in densely populated areas where many billboards dominate the urban landscape, particularly on busy roads and intersections [18,19,25,26,34] and major city thoroughfares [17,23]. In Malaysia, commercial streets are particularly susceptible to deterioration and are often identified as hotspots for large-scale OA [22,37]. Similarly, not only do suburban areas on the outskirts encounter similar problems [24,31], but public spaces such as bus stops, schools, hospitals, and religious sites are also adversely affected by visual clutter [40,50]. These areas are typically cluttered with various forms of advertising, exacerbating the sense of visual overload and discomfort. Contemporary urban transformation along streets in Amman [33] and Romania [54] and squares in Iran [49] has also profoundly affected the visual perception of these places. Furthermore, historic districts and older urban areas suffer from visual pollution due to the deterioration of architectural integrity and the incongruent modifications within conservation areas [8,13,32,35,52,54,55,59], mainly focusing on developing or underdeveloped countries.

Highways in Lithuania represent another critical area where visual pollution is rampant [39,41], where excessive signage and advertisements detract from aesthetic appeal and pose safety risks. The construction and maintenance of these structures frequently necessitate alterations to the surrounding environment, leading to substantial ecological disturbances. Such impacts are of particular concern as they involve the modification of natural landscapes and the potential displacement of local flora and fauna.

Even protected areas in Poland and Slovakia are increasingly compromised by visual pollution stemming from tourism-related activities [9]. These OAs usually appear at major crossroads and entrances to tourism-related institutions, i.e., museums, accommodation, and catering facilities. This trend is exacerbated by the competitive placement of visually striking advertisements near businesses and tourist amenities within these areas, further disrupting the harmony and unity of the natural environment. Furthermore, natural areas are not immune to the effects of visual pollution in Lithuania [20]. These changes frequently reduce visual quality and obstruct views of valuable natural landscapes or features.

In conclusion, it can be seen that the disturbance of visual pollution is no longer restricted to any geographical area and requires comprehensive mitigation strategies to preserve both the built and natural environments effectively.

3.3. Factors Contributing to Visual Pollution

As detailed in Section 3.1, the widespread nature of OAs, characterized by their quantity, color, diverse content, and placements, significantly contributes to visual pollution. Additionally, inadequate management, maintenance, and development of utility infrastructures and buildings represent further sources of visual pollution. These elements are among

the most evident contributors to visual pollution. The underlying factors contributing to these causes can be discussed in the following areas.

First of all, economic factors could have the most significant impact on visual pollution, particularly when commercial interests prevail. Although they serve as a vital source of government revenue and alleviate financial burdens for local authorities [26], the economic benefits often present challenges in controlling visual pollution [13]. The influence of capital has propelled visual pollutants toward a state of a pollution-free environment [31]. For example, government entities often tacitly approve extensive private investments in public spaces, which results in these entities progressively dominating public spaces and reaping substantial profits by placing large volumes of their own company's OA, while neglecting the detrimental impacts on the urban environment [25]. Despite gradual improvements in regulations concerning billboard placements, the enforcement of these regulations by the relevant authorities remains inadequate. The primary reason for this shortfall is the necessity to balance the interests of multiple stakeholder groups, which can result in delays or dilution of enforcement actions [45].

Secondly, the understanding and awareness of visual pollution are critically low and are influenced by cultural and educational factors. According to Maslow's hierarchy of human needs, those fundamental to survival (physiological needs) take precedence over those more complex and abstract (cognitive and aesthetic needs) [29]. This tendency to prioritize basic needs over cognitive and aesthetic considerations leads to a general neglect of higher-order needs. For example, OA can generate income and provide information to meet people's basic needs, although acting as a form of visual pollution. In addition, studies [31] have posited that some individuals may not perceive OAs as a form of visual pollutants due to limited awareness of the concept itself. Perceptions of visual pollution are not uniform; it is a constantly changing environmental value dependent on the viewer's or perceived recipient's cultural and social context [33], underscoring the importance of aesthetic education. An interesting result from the study [37] in Malaysia has confirmed this view: even among aesthetically educated students, their sensitivity to visual pollution is very low, indicating a high tolerance.

Next, this lack of aesthetic education and awareness is also evident in the government's management practices concerning visual pollution. The reasons behind visual pollution encompass wrong decisions, lack of legal requirements, and lack of control [36,43,49]. In other words, a general lack of governmental awareness about the significance of visual pollution contributes to its persistence [16,55]. Especially in historic or old city districts, the government's indifferent, uncaring, and uninformed attitude toward visual pollution has resulted in the destruction, demolition, and alteration of ancient buildings [8,13,35,52,55]. Moreover, flawed regulations and standards within government advertising policies have led to significant visual pollution [9,14,38,39,41,50] and rapidly degrading natural landscapes and public spaces. This general lack of awareness extends to the public, who rarely communicate concerns about visual pollution to local authorities [31].

In summary, the phenomenon of visual pollution results from a complex interplay of economic constraints, cultural influences, and regulatory inefficiencies. The economic benefits of OAs frequently conflict with the necessity for visual cleanliness. Furthermore, cultural norms and educational deficiencies impede the recognition of and action against visual pollution on a broad scale. The effective management of visual pollution necessitates the robust enforcement of regulations, the promotion of public awareness, and the implementation of comprehensive educational initiatives. Therefore, it is essential to act on these factors to minimize the harmful implications of visual pollution and enhance visual ease in public settings.

3.4. Methods of Measurement for Visual Pollution

Current methods for measuring and defining visual pollution remain exploratory and lack a standardized method for effective quantification. Scholars have already tried and used various methodologies to address these challenges; however, these methods have

not been applied systematically and uniformly across studies [25]. This difficulty can be attributed to the inherent complexity of visual pollution, which requires strong background knowledge, enhanced environmental awareness, and a trained eye to identify discordant and chaotic elements that contribute to the disorder of the built environment [33]. Therefore, visual pollution assessment relies mainly on subjective evaluation [23].

Overall, methodologies for assessing visual pollution can be divided into three categories (Table 2):

- The first method is the desk-based synthesis method, which is based on examining existing literature, relevant laws, data, and regulations, supplemented by observations, photographs, and applicable software. It offers a comprehensive overview of the context within which visual pollution occurs.
- The second method is an integrated survey, interview, and analysis method, often supported by auxiliary methods to gather qualitative and quantitative data, such as photographic documentation.
- The third method is technology-based, employing specific artificial intelligence, indicators, and parameters with some software to analyze visual pollution more precisely. Utilizing technological tools could facilitate the effective quantification of visual pollution, offering objective measurements that reduce the reliance on subjective evaluation.

Table 2. The different methods that correspond to different studies.

•	**Methods**	•	**Studies**
•	Desk-based synthesis methods	•	[7–10,12,14,18,20,23,28,33,41–43,45,48,54,56]
•	Integrated survey, interview, and analysis methods	•	[9,13,15,17,19,24,25,30,35–37,40,44,46,47,49,50,53,55,57–59]
•	Technology-based methods	•	[11,26,29–31,34,38,39,60]

3.4.1. Desk-Based Synthesis Method

The desk-based synthesis method is a relatively straightforward process of analyzing visual pollution. This method is clearly and effectively illustrated in studies [8,9,12,18,33,41,43,54,56], which comprehensively review relevant literature, documents, regulations, or data derived from fieldwork to define the concept of visual pollution and its impacts. Notably, studies [7–10,33,41,54] have further enhanced this methodology by integrating images and related data analysis.

Conversely, studies [14,42,48] have shown a different perspective by not specifying the measurement methodologies employed for assessing visual pollution. Instead, these studies mainly contribute to discussing visual pollution by exploring its impacts through document analysis that could inform the development and implementation of policy. A study [23] has also provided a comprehensive overview of the methodologies used by other researchers, offering a structured mechanism for quantifying visual pollution in a specific location.

Moreover, a study [20] has proposed a locally adapted method for the visual assessment of natural landscapes by analyzing the legal and theoretical frameworks for visual assessment and then applying logical analogies. Similarly, studies [28,45] have also suggested a spatial decision support system (SDSS) method to choose a suitable location for OA by reviewing regulatory documents and data and aided by software. Specifically, the study's methodology [28] represents further depth and refinement of the methodology employed in the study [45].

In general, the desk-based synthesis method is a more frequently employed method. This method offers a comprehensive, efficient, and adaptable framework for addressing visual pollution, particularly in the early research or policy development stages. However,

this method is inherently subjective and heavily reliant on the experience and knowledge of experts and practitioners on visual pollution. Consequently, it lacks the requisite objectivity.

3.4.2. Integrated Survey, Interview, and Analysis Methods

Surveys and interviews are frequently employed as prevalent methods for visual assessment. The assessment of visual impacts on environmental aesthetics, commonly referred to as visual pollution, is also often evaluated using these tools. Therefore, these tools are essential for a comprehensive understanding of visual pollution, given their widespread application in the field. Studies [13,17,19,24,36,40,46,50,55,58] have traditionally used single and direct surveys or interviews, often supplemented by photographs, to investigate visual pollution.

Based on these traditional methods, additional studies [9] have expanded their methodology to include both indirect and direct assessment techniques, such as landscape attribute inventories and response ratings (survey and interview). Studies [57,59] have considered using the Likert scale and heat maps to detect visual quality and identify visual elements. Moreover, a study [49] has progressed from data collection through to literature reviews and surveys. This process is further refined by applying the Analytic Hierarchy Process (AHP) for data weighting, followed by analysis using SWOT (strengths, weaknesses, opportunities, threats) and QSPM (quantitative strategic planning matrix) methods. Similarly, a study [44] has utilized a combination of methods, including a public survey, expert ranking, and the analytical hierarchy process (AHP) for the listing, classification, and weighting of visual pollution objects. Study [47] has facilitated the transition of study [44] from a paper-based visual pollution assessment tool to an online one. Study [53] has sought to ascertain public perceptions of visual pollution caused by drones in different environments and used the AHP to identify factors that may contribute to visual pollution from drones.

Further innovations have been introduced in studies [30,37], which employ systematic observation and rating of streetscapes through pictorial surveys, complemented by computer-assisted auditing and evaluation via image processing techniques. Additionally, studies [15,25,35] have integrated geographic information systems (GIS) into the survey framework, offering innovative methods to visualize and quantify visual pollution effectively. These creative methods improve the accuracy of data collection and analysis.

In the field of visual pollution research, questionnaires or interviews represent the most common and widely used method. This method offers a more reliable and quantitative means of gaining a more comprehensive understanding and explanation of visual pollution and visual pollutants. However, this method also presents certain challenges, including the necessity of collecting and processing data over a longer period.

3.4.3. Tech-Based Method

The technology-based method in visual pollution study represents a novel exploration and attempt to develop new perceptions and understandings of visual pollution. Studies [11,26] have applied modeling techniques, such as 3D isovist, voxel techniques, and digital surface models, to construct a model for assessing viewsheds and visibility to ascertain the visual impact of visual pollution. Study [29] has used raster products from aerial laser scanning data and viewshed measurements along pedestrian walkways to simulate cityscape visibility, scrutinizing landscape metrics for sensitivity to visual pollution and providing a quantifiable approach to assess the impact of billboards on landscape openness and visual character. Studies [38,39] have involved multiple phases, spatial analysis, and techniques to assess and manage visual pollution's visual and spatial impact. These studies effectively measure visual pollution spatially.

Moreover, studies [30,31,34,60] have utilized deep-learning models to train image data for the purposes of data labeling, data splitting, and the detection and classification of visual pollutants. A study [60] has used deep learning models, particularly YOLOv5, to detect and classify visual pollutants from images collected by volunteers. The collected data are analyzed to create heat maps and visual pollution indices. Study [30] has been

further deepened to fully train the prediction of visual pollution, and several emerging artificial predictors have been added and used, including MobileNetSSDv2, EfficientDet, Faster RCNN, Detectron2, YOLO-v7, and YOLOv5.

The technology-based approach is an evolving methodology aimed at understanding the impact of visual pollution on human vision through parametric and technological means to generate more precise data. At the same time, this method also seeks to develop models for identifying visual pollutants. However, the selection and recognition of visual pollutants within this framework still heavily rely on expert knowledge of visual pollution. Moreover, this method is inherently complex and detailed, necessitating a high level of expertise for successful implementation, and is often time-consuming.

4. Discussion

Visual pollution is a new environmental problem that emerges within the visual environment. The phenomenon of visual pollution has the capacity to influence how humans perceive their surroundings significantly. This study is a comprehensive and systematic literature review of 52 articles on visual pollution, focusing on four key aspects: type and characteristic, location, factors, and research methods. Analyzing these aspects can deepen the knowledge and awareness of visual pollution. Specifically, the study helps identify the various types of visual pollutants, map their locations, understand their contributing factors, and evaluate the research methods used. Ultimately, this study could help provide valuable references and assistance to policymakers to mitigate visual pollution's negative impacts on urban and natural environments, contributing to more effective environmental management and policy development.

When humans occupy more land than ever, cities and towns in developing and developed countries are strewn with undesired and unpleasant visual items called visual pollutants [31]. These pollutants are a consequence of human activities, leading to a pervasive phenomenon that affects not only the visual environment but also human experiences, daily life, and health. The type of visual pollution has significantly expanded from billboards, other structures and infrastructures, and the design problems of buildings to certain natural elements. Common visual pollutants in the urban landscape include OA, signage, and certain facilities and infrastructures, especially when they are out of character with the overall environment [22]. Additionally, visual pollutants arise from the unregulated and disorganized diversity of colors, shapes, light, and materials [26]. Accumulating disparate visual components creates unsightly and distasteful artificial environments and urban landscapes. This phenomenon means that visual pollution frequently causes landscape components to be out of harmony with their surroundings and is difficult to incorporate into the built environment.

Urban areas' rapid and uncontrolled expansion has resulted in various social issues and unregulated physical growth [17]. One notable consequence is the emergence of visual pollution, particularly in cities' commercial centers, the most popular and pervasive location for visual pollution. Visual pollution has become an integral part of the urban landscape in these areas, with some OAs even transforming specific spots into landmarks. However, a study [17] has found that OA has more negative than positive impacts as it reduces the aesthetics of urban environments, clutters public spaces, and detracts from a city's character. Furthermore, visual pollution is not confined to modern commercial areas; it is also prevalent in older urban areas, historical sites, and natural landscapes. This widespread presence underscores the far-reaching consequences of urbanization, which extend beyond a city's immediate boundaries and significantly influence human and natural environments. Visual pollution can lead to the erosion of the character and cultural identity of these places, emphasizing the urgent need for comprehensive urban planning and stringent regulatory measures.

The level of visual pollution seems to be closely linked to socio-economic status, educational and awareness level, government administration, etc. Due to the authorities' unawareness of visual pollution, the reason for economic development, and the lack of

relevant studies to mitigate this issue, visual pollution has become widespread. Vague regulations provide advertisers and business people with opportunities to install OAs indiscriminately. A surprising phenomenon demonstrates rapidly growing economies, service industries, the private sector, and the spread of consumer social models, particularly in post-communist countries, all led to the rapid deterioration of natural and landscape assets and public space, accompanied by visual pollution [9]. The economic transformation in these regions has boosted market consumption and fueled the advertising industry's fervor, resulting in the construction of numerous OAs [25]. This issue is especially pronounced in emerging capital markets, where governments have relaxed billboard restrictions and regulations. In reality, practically every business advertises its products in numerous ways, but these advertisements can easily cause visual pollution when they are not effectively controlled. Advertisers often erect more OAs in the busiest parts of town in pursuit of greater profits, further exacerbating the problem. Ultimately, to some extent, the most important cause of visual pollution is the economy.

Visual pollution is still largely dependent on public taste and culture. People have limited comprehension of visual pollution due to a lack of studies to define, analyze, and quantify it, resulting in an imprecise presentation [32]. Despite efforts to update and develop new assessment methods, limitations still exist [25]. When using quantitative methods to assess visual pollution, it is important to note that many results are subjective due to the lack of a primary assessment scale. Although a combination of subjective and objective approaches exists, the final evaluation of visual pollution consistently relies on subjective decisions [23]. Different countries have varying attitudes towards visual pollution because they attempt to develop a scientific method to identify it [28]. However, these methods often have limitations and shortcomings, such as dependence on subjective evaluations, restricted scope of visual pollution objects, lack of quantification, and inadequate planning tools [44]. The absence of relevant administrative norms and guidance exacerbates these challenges, as governments often prioritize economic interests over environmental aesthetics. Therefore, there is a growing recognition of the need for comprehensive quantitative assessment tools to evaluate visual pollution. To address these challenges effectively, comprehensive strategies must be proposed and implemented to ensure a balanced approach to measuring and managing visual pollution across diverse environments.

5. Limitations and Future Studies

Even though this study systematically reviews visual pollution research, there are some limitations. Firstly, it should be noted that the methodology employed in the literature search and the selection of databases may have omitted certain studies from the final analysis. The search was limited to English publications, thereby excluding relevant studies in other languages. In the future, we could expand literature searches to include studies published in various languages. Utilizing international databases and translating key studies could provide a more global perspective on visual pollution, enriching the overall analysis.

Secondly, the scope of the review was constrained by the selected timeframe of publications, which spanned from 2008 to 2023. The temporal limitation may result in excluding relevant studies conducted before the specified period, which could provide valuable insights into the historical context and evolution of visual pollution. In future studies, a snowballing approach could be employed to expand the existing literature that does not fall within the specified timeframe. This would entail including additional articles that have been overlooked in previous studies.

Thirdly, this study primarily employs qualitative analysis, with the absence of quantitative analysis being a notable limitation. Future studies should incorporate more sophisticated quantitative methods to provide a more comprehensive understanding of visual pollution and strengthen the findings, such as meta-analysis. Overall, it would be beneficial to address the limitations identified in future studies to gain a more comprehensive understanding of visual pollution.

In order to inform future research on visual pollution, it is recommended that empirical studies and fieldwork be conducted to collect primary data on visual pollution. This may entail administering surveys, direct observation, and using technology-based tools (e.g., GIS, remote sensing) to quantify visual pollution in diverse environmental contexts accurately. The development and utilization of advanced technological tools will facilitate the identification and measuring of visual pollutants. This may include utilizing machine learning algorithms, augmented reality (AR) applications, and virtual reality (VR) simulations to more effectively assess and visualize the impacts of visual pollution. It is necessary to review the effectiveness of existing policies and regulations related to visual pollution. Comparative studies between different regions and countries can identify best practices and areas for improvement, thereby guiding the development of more effective regulatory frameworks. Longitudinal studies should be conducted to track changes in visual pollution over time and assess mitigation strategies' effectiveness over time. Such studies assist in comprehending the dynamic nature of visual pollution and the sustainability of interventions. It is necessary to investigate the role of public awareness and education in mitigating visual pollution. It would be beneficial for research to investigate the impact of educational activities and community participation on perceptions and behaviors related to visual pollution.

6. Conclusions

In conclusion, visual pollution has emerged as a significant environmental issue due to rapid and uncontrolled urban expansion, leading to a variety of social and aesthetic challenges. It is not merely an aesthetic concern but also impacts mental health, contributing to anxiety, stress, and a reduced quality of life. This study offers a comprehensive review of 52 articles that examine the characteristics of visual pollution, its location, the factors contributing to the phenomenon, and the methodologies employed in assessing it. Key visual pollutants include outdoor advertisements, poorly maintained buildings, and unregulated utility infrastructures, which disrupt the harmony between urban and natural landscapes. The fact that busy city centers and surrounding streets, and even nature conservation, are occupied by visual pollutants indicates that there is still a lack of effective regulation and strong enforcement of the management of visual pollutants. Furthermore, the government and the public's lack of understanding of the concept of visual pollution has resulted in the emergence of visual pollution, which has been justified on the grounds of economic interests. The exploration of visual pollution is still in its infancy. The desk synthesis method represents a rapid and effective approach to defining and evaluating visual pollution from a professional perspective. However, its scope is limited. In contrast, scholars continue to favor using questionnaires as a relatively objective means of identifying visual pollution from the general public's perspective. While there are some more objective and technology-oriented methods, the majority still rely on the selection of visual pollutants by professionals, and the majority of them are also utilized in the automatic screening of visual pollutants.

Overall, by providing a comprehensive analysis of the current state of visual pollution and its impacts, this study aims to equip policymakers, urban planners, and environmental professionals with the necessary insights to develop and implement effective strategies to mitigate visual pollution. This, in turn, will help protect the visual quality of both urban and natural environments, ensuring a more aesthetically pleasing and mentally healthy living space for all.

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Appendix A

Table A1. Summary table of all 41 documents.

Ref. No. (No.)	Year	Document	Journal	Types of Visual Pollutants	Location of Visual Pollution	Factors Affecting Visual Pollution	Methods of Measurement for Visual Pollution
[7] 1	2011	Research	Asian Soc. Sci.	Buildings	City (Turkey)	Rapid and unplanned urbanization	Collecting theoretical information on the establishment and historical development of Trabzon
[8] 2	2021	Research	J. Umm Al-Qura Univ. Eng. Archit.	Poor façade design elements	Jeddah, with a specific focus on 70 streets in the northern and western zones of the city (Saudi Arabia)	A lack of detailed regulations: improper consideration of design elements among adjacent buildings, a lack of uniformity and harmony among buildings	Use of data analysis software (NVivo) to assess the implementation of design elements
[9] 3	2019	Research	Quaest. Geogr.	Large-format advertise-ments	Protected areas (Poland and Slovakia)	Presence of outdoor advertisements in settlements and at significant road points, entrances to tourism-related facilities, and the placement of advertisements in landscape areas	Field research on the number and size of advertisements, cartographic illustrations, and photographic documentation
[10] 4	2009	Research	J. Vis. Art Des.	Utility infras-tructures, graffiti, shopfront graphic designs, packaging designs, automobiles	Urban areas (Indonesia)	Lack of proper urban planning, regulation, and visual standards	Using descriptive analysis to document the presence and impact of visual pollutants, involving field observations, photographic documentation, and the analysis of design processes

Table A1. *Cont.*

Ref. No. (No.)	Year	Document	Journal	Types of Visual Pollutants	Location of Visual Pollution	Factors Affecting Visual Pollution	Methods of Measurement for Visual Pollution
[11] 5	2014	Research	Land Econ.	Wind turbines	Residential areas (Denmark)	Presence of wind turbines within a visible range of residential properties	Using high-resolution digital surface models (DSM) to construct viewsheds for wind turbines and calculate visibility from residential properties
[12] 6	2021	Research	Int. J. Adv. Appl. Sci.	Utility infrastructures, buildings, and vehicles	Related to roads (Saudi Arabia)	Lack of proper management by local administrations	Descriptive analysis
[13] 7	2019	Research	J. Contemp. Urban Aff.	Utility infrastructures	Od district (Bahrain)	Unregulated urban expansion, lack of adherence to architectural and urban planning standards, neglect of heritage buildings, and the proliferation of modern structures that clash with the historical character of the area	Theoretical background review, data collection through surveys interviewing users, residents, businessmen, and municipality officers
[14] 8	2023	Research	Pollut. Bull.	Billboards, banners, posters, and signs	Coastal cities (Colombia)	Unrestricted use of political advertisements, psychological stress from visual clutter, road safety hazards, sociocultural ramifications, and economic impacts	Not detailed specific methods of measurement for visual pollution, discussing the impact of visual pollution, and proposing mitigation strategies
[15] 9	2018	Research	Comput. Environ. Urban Syst.	Outdoor advertisements	Visual pollutants in the urban landscape (Poland)	Clustering, excess, disorder of outdoor advertising media and the lack of administrative guidance in signage control	A citizen science approach where participants use a WebGIS application to submit their observations and assessments of visual pollution due to outdoor advertising

Table A1. *Cont.*

Ref. No. (No.)	Year	Document	Journal	Types of Visual Pollutants	Location of Visual Pollution	Factors Affecting Visual Pollution	Methods of Measurement for Visual Pollution
[16] 10	2017	Research	Sch. Res. J. Interdiscip. Res.	Utility infrastructures	Urban environments where man-made elements obstruct natural views	Local authorities lack control over public displays and constructions, overcrowded advertisements that suffocate natural beauty, and individual negligence toward maintaining a natural environment	Not detailed specific methods of measurement for visual pollution
[17] 11	2023	Conference paper	IOP Conf. Ser. Earth Environ. Sci.	Advertising boards	Corridor of M.T Haryono Street in Kendari City (Indonesia)	Overlapping and unclear layout of advertising boards, the lack of communicative design, and the absence of unity with the architectural characteristics of surrounding buildings	Observations, photography, and surveys with questionnaires distributed to respondents
[18] 12	2023	Conference paper	Transp. Res. Procedia.	Large-format outdoor advertising and its impact	Four routes within the city (Slovakia)	Density of advertisements, their placement relative to drivers' viewpoints, and the content of the ads	Collecting data on the owners of advertising carriers, types of carriers, and content of advertisements
[19] 13	2016	Research	Int. J. Sci. Eng. Res.	Outdoor advertisements	Roadside (Pakistan)	Billboards, including their size, placement, and the explicit content they sometimes display	Survey exploring various aspects, such as the impact of billboards on road safety, environmental concerns, and the physical discomfort they cause
[20] 14	2016	Research	J. Sustain. Archit. Civ. Eng.	Any new or modified landscape elements	Natural areas (Lithuania)	Physical and visual characteristics of potential visual pollution objects, their function and style, and how they contrast with the existing landscape	Preparatory work to describe the observation place and landscape, photo-fixation, and a general evaluation of the landscape

Table A1. *Cont.*

Ref. No. (No.)	Year	Document	Journal	Types of Visual Pollutants	Location of Visual Pollution	Factors Affecting Visual Pollution	Methods of Measurement for Visual Pollution
[22] 15	2022	Research	ISPRS Int. J. Geo-Inf.	Outdoor advertisements	A prominent street (Malaysia)	Abundance and color content of outdoor advertisements	A user-centered assessment approach, utilizing systematic observation and rating of streetscapes through pictorial surveys, and computer-assisted auditing and evaluation through image processing techniques
[23] 16	2022	Conference paper	IOP Conf. Ser. Earth Environ. Sci.	Billboards	Urban roads	Improper planning and technical standards in billboard construction, lack of continuous maintenance and supervision during installation	Describing several methods for measuring visual pollution levels
[24] 17	2020	Research	Hum. Aff.	Outdoor billboards	Different parts of the city (city center and outskirts)	Amateur design and inauthentic content of billboards, stereotypical representations, and the overall negative portrayal of urban decay	Free associations produced by art students in response to photographs of outdoor billboards from different city areas
[25] 18	2016	Research	Geogr. Inf. Syst.	Outdoor advertisements	Busy urban streets (Poland)	Spatial properties of outdoor advertisements, such as their location, shape, and size	Creating an inventory of OAs, conducting intervisibility analysis using GIS technology, and carrying out public surveys to gather opinions on visual pollution
[26] 19	2021	Research	ISPRS Int. J. Geo-Inf.	Outdoor advertising billboards	Roads (Poland)	Location, quantity, and spatial dimensions of the billboard infrastructure	3D isovist and voxel techniques to assess the visual impact of billboard infrastructure

Table A1. *Cont.*

Ref. No. (No.)	Year	Document	Journal	Types of Visual Pollutants	Location of Visual Pollution	Factors Affecting Visual Pollution	Methods of Measurement for Visual Pollution
[28] 20	2021	Research	ISPRS Int. J. Geo-Inf.	Outdoor advertisements	Urban settings (Pakistan)	A complex interplay of legal, marketing, and ethical considerations and the need for advertisements to reach relevant community groups effectively	User-specific criteria for either multilayered query selection or a fuzzy analytic hierarchy process
[29] 21	2020	Research	Land	Outdoor advertisements	Different topographical roads (Poland)	Spatial occurrence and density of outdoor advertisements in cityscapes	Using raster products derived from aerial laser scanning data to simulate the visibility of the cityscape in motion through viewshed measurements along pedestrian walkways
[30] 22	2022	Research	Math.	Utility infrastructures	Public roads (Saudi Arabia)	Incessant construction of new buildings, the inevitable deterioration of asphalt roads and sidewalks, and even weather conditions	A deep active learning model
[31] 23	2019	Research	J. Environ. Manag.	Utility infrastructures	Urban and suburban settings (Bangladesh)	Presence of poorly designed structures, excessive and misplaced advertisements, unmanaged wires and cables, and the accumulation of street litter	A convolutional neural network (CNN), a deep learning model
[32] 24	2021	Research	J. Perlind. Tanam. Indones.	Utility infrastructures	Area of Intramuros (Philipin)	Rapid urbanization	Use of indirect and direct methods of landscape evaluation, correlation analysis

Table A1. *Cont.*

Ref. No. (No.)	Year	Document	Journal	Types of Visual Pollutants	Location of Visual Pollution	Factors Affecting Visual Pollution	Methods of Measurement for Visual Pollution
[33] 25	2018	Research	Res. J. Appl. Sci.	Discordant facades, a lack of architectural unity, and the presence of various elements that clash with each other	Al-Madina Al-Munawara Corridor (Amman)	Undefined architectural statements	A multi-disciplinary approach
[34] 26	2023	Research	DIB.	Utility infras-tructures	Urban public roads (Saudi Arabia)	Lack of consistent rules for its systematic assessment	A deep active learning strategy for automatic data annotation
[35] 27	2016	Research	Open J. Geol.	Unattractive and man-made elements that clutter urban spaces	Historical gardens (Iran)	Mismanagement of urban and public spaces	Literature review, field studies, GIS analysis, and surveys
[36] 28	2023	Conference paper	AIP Conf.	Buildings	Commercial street (Iraq)	Poor enforcement of construction laws and regulations, unauthorized building modifications, and lack of accountability for violators	A descriptive and analytical methodology, including field visits and personal interviews with specialists and residents
[37] 29	2019	Conference paper	In Proceedings of the Visual Resource Stewardship Conference, Lemont, IL, USA	Advertising boards	Jalan Tuanku Abdul Rahman (Malaysia)	Density and cumulative area of advertising boards, demographic variables, and the respondents' regular exposure to pollutants in the urban environment	Cumulative area analysis and a photo booklet survey
[38] 30	2017	Conference paper	In Proceedings of the 2017 12th International Workshop on Semantic and Social Media Adaptation and Personal-ization (SMAP), Bratislava, Slovakia	Advertising media	No details mentioned Urban environment	Weak enforcement of rules, lack of rules, low public interest, and weak involvement of authorities	Crowdsourcing and visual similarity clustering

Table A1. *Cont.*

Ref. No. (No.)	Year	Document	Journal	Types of Visual Pollutants	Location of Visual Pollution	Factors Affecting Visual Pollution	Methods of Measurement for Visual Pollution
[39] 31	2016	Research	Archit. Urban Plan.	Free-standing billboards	Main highways (Lithuania)	Lack of strict regulation and control over free-standing billboard construction	Analysis of landscape spatial structure, free-standing billboard layout possibilities, and the establishment of possible visual contrast levels of free-standing billboard
[40] 32	2014	Research	IOSR J. Humanit. Soc. Sci.	Posters, banners, and billboards	Three senatorial districts of Ondo State, Nigeria (Nigeria)	High generation of visual pollutants by politicians, religious bodies, and corporate bodies without adequate measures for their removal post-usage	Surveys using structured questionnaires to gather data on the sources of posters
[41] 33	2013	Research	Eineerinviron. Res. Eng.	Free-standing billboards	Major highways (Lithuania)	Lack of regulatory documents	Literature analysis and field surveys to inventory free-standing billboards and assess their impact on different functional and visual types of the landscape
[42] 34	2013	Research	Int. J. Educ. Res.	Signs and billboards	Urban areas (Nigeria)	Administrative negligence, economic constraints, cultural and educational levels	Surveys and reviews of urban planning and environmental beautification efforts to gather data and propose solutions
[43] 35	2016	Research	Int. J. Eng. Res. Gen. Sci.	Poorly designed and located signage, posters, billboards, and banners	Marketplaces and urban tourist attraction spots (India)	Negligence by municipal authorities, business-oriented development, lack of proper urban planning and control	Suggesting several methods to measure and mitigate visual pollution

Table A1. *Cont.*

Ref. No. (No.)	Year	Document	Journal	Types of Visual Pollutants	Location of Visual Pollution	Factors Affecting Visual Pollution	Methods of Measurement for Visual Pollution
[44] 36	2019	Research	Sustainability.	Utility infrastructures	Urban areas (Pakistan)	Physical presence and characteristics of various visual pollution objects	A combination of methods, including public opinion, expert ranking, and the analytical hierarchy process (AHP) for the listing, classification, and weighting of visual pollution objects
[45] 37	2016	Conference paper	IOP Conf. Ser. Earth Environ. Sci.	Outdoor advertisement	Urban areas (Pakistan)	Corporate pressure and the absence of spatial analysis capacity among local authorities for effective implementation of regulations	Reviewing regulatory documents for spatial provisions, preparing geo-data, and performing site suitability analysis using analytical hierarchy process (AHP) and weighted linear combination (WLC)
[46] 38	2019	Research	Anthropog. Pollut.	Utility infrastructures	Urban districts (Iran)	Incompatible buildings and lack of urban planning, unregulated advertisements and commercial signage, overcrowded areas with heavy traffic and insufficient parking, and socio-economic factors	Surveys and direct observations of visual pollutants
[47] 39	2019	Reviewed paper	In Proceedings of the Real Corp 2019 Proceedings	Utility infrastructures	Urban areas (Pakistan)	Disorderly accumulation of visual pollution object	Utilizing open data kit (ODK) for developing a mobile-based tool for data collection via Android devices

Table A1. *Cont.*

Ref. No. (No.)	Year	Document	Journal	Types of Visual Pollutants	Location of Visual Pollution	Factors Affecting Visual Pollution	Methods of Measurement for Visual Pollution
[48] 40	2017	Research	Uncertain Supply Chain Manag.	Waste collection trucks, undesirable facilities including landfills and incineration facilities, and the traffic effects	City (Iran)	Physical presence of waste management facilities and the associated traffic	Not detailed specific methods of measurement for visual pollution, the document mentions the development of a multi-objective optimization problem
[49] 41	2017	Research	Pollution.	Shadows or uniform black paintings observable as the physical structures' shadows, outdoor advertisements, cluttered street furniture, and inappropriate use of colors and lighting	Squares (Iran)	Overall messy units observed in natural or man-made environments	Use of SWOT (strengths, weaknesses, opportunities, and threats) and QSPM (quantitative strategic planning matrix)
[50] 42	2015	Research	Eur. Sci. J.	Utility infrastructures	Urban and suburban areas (India)	Administrative negligence	Documentation through photography to capture visual pollutants, surveys with structured questionnaires
[51] 43	2013	Research	J. Eng.	Utility infrastructures	Main streets (Iraq)	Administrative and management issues, economic reasons, and cultural and educational levels	Questionnaires
[52] 44	2021	Research	Int. J. Manag. Rev.	Utility infrastructures	Roads (Philipin)	Lack of proper urban planning, the commercial-ization of public spaces, and inadequate enforcement of city ordinances	Indirect and direct assessments, which included surveys, landscape attribute inventories, response ratings, and interviews

Table A1. *Cont.*

Ref. No. (No.)	Year	Document	Journal	Types of Visual Pollutants	Location of Visual Pollution	Factors Affecting Visual Pollution	Methods of Measurement for Visual Pollution
[53] 45	2023	Research	Drones	Unmanned aerial vehicles	Observable characteristics of unmanned aerial vehicles, such as dimensions, lights, color, and icons	Number, distance, purpose of unmanned aerial vehicles, and awareness of unmanned aerial vehicles' route	An image-based questionnaire to gather data on public perceptions of visual pollution from unmanned aerial vehicles
[54] 46	2016	Research	Procedia Environ. Sci.	Abandoned buildings	Bucharest's Old City (Romania)	Urban transformations during the communist period, lack of authorities' involvement post-1990 in preserving buildings, illegal demolitions, incorrect restorations, and the gradual degradation of buildings	Historical and legislative research, field research, economic data analysis, and classification of creative industries
[55] 47	2020	Conference paper	In Proceedings of the International Workshop on Green Energy, Environment and Sustainable Develop-ment, Weihai, China	New constructions	Historical city (Yemen)	Use of modern building materials and techniques, lack of awareness and supervision by competent authorities, economic constraints, and the cultural and social disposition towards historical preservation vs. modernization needs	Surveys for direct observation and classification of visual distortions and interviews with residents, visitors, and officials
[56] 48	2020	Conference paper	Springer	Sky glow, glare, light trespass	Light pollution (Egypt)	Urbanization and economic development	Literature review, satellite imagery, GIS models, comparative analysis
[57] 49	2023	Research	Land	Roadside settlements, commercial structures, mixed agricultural crops, and unmanaged vegetation	Rural road (Malaysia)	Human-made structures	A combination of public preference surveys and heatmap analysis

Table A1. *Cont.*

Ref. No. (No.)	Year	Document	Journal	Types of Visual Pollutants	Location of Visual Pollution	Factors Affecting Visual Pollution	Methods of Measurement for Visual Pollution
[58] 50	2022	Research	Anfusina	Utility infrastructures	City (Iraq)	Lack of proper urban planning and regulatory enforcement, economic constraints leading to unregulated and poorly managed constructions, and public negligence and lack of environmental awareness	Descriptive and field studies to document and analyze the presence of visual pollutants
[59] 51	2022	Research	Heritage	Historical building	Baghdad's historical old town (Iraq)	Not mentioned	Heatmap analysis

Notes: The name of the journal is an ISO4 abbreviation.

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