Towards Sustainable Ecosystems: Engineering Solutions for Monitoring and Reducing Noise and Light Pollution

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Abstract. Light and noise pollution are now recognized as major environmental issues, which put human health, biodiversity, and the sustainability of urban areas at risk. Combined scientometric study that synthesizes the two areas is still rare, despite the increased volume of research. This paper maps trends in noise and light pollution research between 2020-2025 using Scopus database searches. Analysis of bibliometric indicators including publication growth, citations, author productivity, collaboration networks, and keyword co-occurrence was conducted using Biblioshiny, VOSviewer, and CitedSpace. The study analyzed 2,268 documents from 535 sources, with 7,915 authors and 17,843 references, averaging 8.027 citations per article. Results showed interdisciplinary connections across environmental science, acoustics, computing and urban studies, with China, USA, and European countries as leaders, while India and Malaysia showed increased collaboration. Thematic development pointed to a change in exposure and measurement of noise to IoT-based smart city applications and sustainable city planning. These results are of great importance to researchers, policymakers, and planners because they offer recommendations on the future research, evidence-based policies, and sustainable ecosystem management.

Keywords: Noise Pollution, Light Pollution, Scientometric Analysis, Environmental Sustainability, Smart Cities

1 Introduction

Noise and light pollution have became the burning environmental issues with great ramifications on the health of the population, the sustainability of the city, and the stability of the ecosystem (Khan & Burdzik, 2023; Reddy et al., 2024). The transportation, industrial and urban development noise into the environment is also a contributor to hearing loss, cardiovascular stress and poor quality of life, artificial light at night is also a disruption to the circadian rhythm, biodiversity is affected and the use of energy is increased (Pascale et al., 2023; Botero-Valencia et al., 2023). These types of pollution are coupled with each other as silent but extensive problems that overlap with the efforts of urbanization, climate change, and sustainable development goals (SDGs) (Mander

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et al., 2023; Bhavani et al., 2021). The recent scholarly literature indicates that there is a pressing necessity to reduce the impact of the noise and light pollution by means of scientific surveillance, inventive technologies, and evidence-based policies (Casado et al., 2023). To policymakers, urban planners and environmental engineers, a synthesized knowledge on the research landscape is essential to make decisions (Hao et al., 2024).

Scientometric and bibliometric techniques are useful to trace the trends in the world knowledge, locate the research hotspots, reveal the collaboration networks which may be used to contribute to the development of cross-disciplinary and cross-national strategies (Ghaffarpasand et al., 2023; Gao et al., 2024; Ramu et al., 2024). The synthesis of this knowledge would allow the transfer of scholarly research to the city planning systems, smart city models, and environmental laws that prioritize sustainable lifestyles (Tilly et al., 2024). Regardless of the increased number of publications during the past five years (2020-2025), there is no significant trend, pattern of collaboration, or shift of the theme present in this research field. In the absence of the analysis, policymakers and researchers do not have a clear roadmap on which to prioritize the interventions and future research (Song et al., 2024; Škultéty et al., 2023). The proposed study will seek to address this gap by conducting a scientometric review of noise and light pollution studies published between 2020 and 2025 (Rossi et al., 2024; Chen & Niu, 2023). The paper was analyzed with the help of bibliometric indicators and visualization tools, namely, publication growth, citation impact, development of key words, author and institutional contribution as well as patterns of international collaboration. The results are important in understanding the dynamics of this area, further research, interdisciplinary cooperation, and policy intervention.

The analysis also demonstrates that noise and light pollution has a wide interdisciplinary basis of research. The environmental science, acoustics and urban works contribute the core, and the computing, materials science and remote sensing are those with strong intersections (Tiwari et al., 2024; Yunus et al., 2023). The keywords or terms like traffic noise, acoustic measurement, Internet of Things, forecasting, and smart cities demonstrate how the research has grown past the traditional environmental monitoring and includes data-driven and technology-based solutions. China, the USA, and European countries (United Kingdom, Germany, France, Netherlands) are the most influential hubs that the country collaboration network identifies (Bakker et al., 2023; Rapino et al., 2023). Their bigger nodes and thick interconnectivity attest their high capacity of research and great international cooperation. Also visible is India which is now taking a leading position in environmental sustainability research (Liu et al., 2023; Abbasi et al., 2024). Countries like Italy, Sweden and Belgium located in Europe are mediators and they bridge continental collaborations. It has become a member of emerging economies such as India, Malaysia, and Saudi Arabia.

Though their research volume is lower than that of the world leaders, the increasing rates of co-authorship indicate growing partnerships and building of capacity (Masri et al., 2024). This is an indicator of a significant trend of developing countries to provide solutions to the world and solve the local problems of urbanization and industrialization (Fang et al., 2023; Pieren et al., 2024). It is evident that there is a developmental trend in the theme of research. The previous focus on exposure to noise, measurement, and barriers has been redirected to the IoT-based smart city applications, real-time

monitoring, and sustainable urban planning. The theme evolution and word cloud accentuate the fact that monitoring the environment has incorporated digital technology and emphasize the fact that acoustics and AI, remote sensing, and smart infrastructure are now combined. The results point to the necessity of evidence-based policy models to incorporate scientific knowledge into urban planning. International standards on urban noise and lighting can be informed by the collaborative networks (del Rosario-Gilabert et al., 2024). There are also new hotspots like the IoT monitoring and the sustainable city design that provide future research directions. Enhancement of interdisciplinary and cross-country collaboration will be crucial to reduce the ecological and social effects of the noise and light pollution.

2 Methodology

The bibliometric data was accessed via the Scopus database which was selected because it is an extensive source of peer-reviewed literature. A systematic search query was created to include the publications on the theme of noise and light pollution and its effects. It took place between 2020 and 2025, meaning that the analysis of the existing research would be conducted considering the modern priorities in sustainability. The first screening was performed by selecting the relevant subject areas, keywords, and language to make sure the scientometric results have been reliable and accurate. The dataset was studied with Biblioshiny (R-bibliometrix), VOSviewer, and CitedSpace that made it possible to perform advanced network visualization and trend mapping. A number of indicators were evaluated such as main dataset data (2,268 documents, 17,843 references, average 8.027 citations per article), year-by-year growth, source information, author productivity and impact, collaboration, keyword co-occurrence as well as citation bursts of institutions. Several visual methods were applied such as Sankey diagrams to visualize the productivity of authors and the impact of their research, word clouds to identify the themes of research, growth curves to represent the publication and citations, and collaboration maps to display scientific networks all around the world. This systematic approach to fig 1 provided a strong and replicable scientometric treatment of the topic of noise and light pollution.

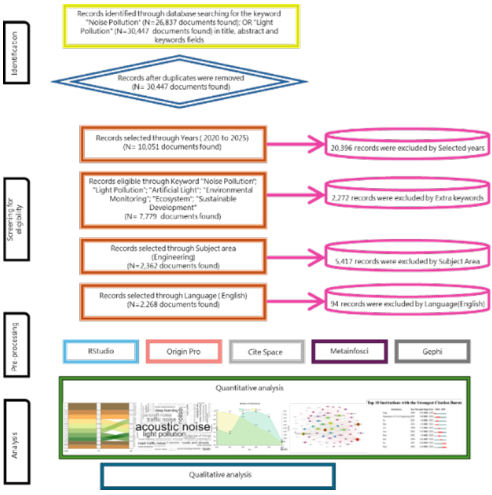

Fig. 1. Methodology

Search Query: (TITLE-ABS-KEY ("Noise Pollution") OR TITLE-ABS-KEY ("Light Pollution")) AND PUBYEAR > 2019 AND PUBYEAR < 2026 AND (LIMIT-TO (EXACTKEYWORD , "Noise Pollution") OR LIMIT-TO (EXACTKEYWORD , "Light Pollution") OR LIMIT-TO (EXACTKEYWORD , "Artificial Light") OR LIMIT-TO (EXACTKEYWORD , "Environmental Monitoring") OR LIMIT-TO (EXACTKEYWORD , "Ecosystem") OR LIMIT-TO (EXACTKEYWORD , "Sustainable Development")) AND (LIMIT-TO (SUBJAREA , "ENGI")) AND (LIMIT-TO (LANGUAGE , "English"))

The search query provided in Scopus is developed to retrieve the articles concerning the noise pollution and the light pollution. It scans documents containing either Noise Pollution or Light Pollution in their title, abstract or keywords. The limitations are restricted to the number of publication years 20202025 (PUBYEAR > 2019 AND PUBYEAR < 2026) and articles in English. To narrow down on relevance, it limits search results to documents that are specifically tagged with keywords like Noise Pollution, Light Pollution, Artificial Light, Environmental Monitoring, Ecosystem or Sustainable Development. Besides, subject area filter (SUBJAREA, "ENGI") is used to further guarantee that the documents retrieved fall under the field of Engineering. This renders the query specific, narrow and relevant to the context of the research of environmental engineering and sustainability.

3 Result and discussion

Table 1. Main Information about the Dataset

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2020:2025

Sources (Journals, Books, etc)	535
Documents	2268
Annual Growth Rate %	-3.64
Document Average Age	2.51
Average citations per doc	8.027
References	17843
DOCUMENT CONTENTS	
Keywords Plus (ID)	15400
Author's Keywords (DE)	18292
AUTHORS	
Authors	7915
Authors of single-authored docs	125
AUTHORS COLLABORATION	
Single-authored docs	132
Co-Authors per Doc	4.13
International co-authorships %	19.14
DOCUMENT TYPES	
article	1238
book	5
book chapter	60
conference paper	891
note	1
retracted	3
review	70

A complete bibliometric overview of the years 2020-2025 is shown in the table 1. The sources used acquired 2,268 documents relevant to 535 journals, books, and other sources, and the annual growth rate was -3.64. The average age of documents is 2.51 years old, and the average number of citations per document is 8.027, which is backed by 17,843 references. Content-wise, 15,400 Keywords Plus and 18,292 author keywords were found. There are 7,915 authors in the dataset, 125 of which are single-authored contributions. The degree of collaboration is also remarkable, with the average number of co-authors per paper constituting 4.13 and the percentage of international co-authorship constituting 19.14. The types of documents used are 1,238 articles, 891 conference papers, 70 reviews, and smaller documents such as books, chapters, notes and retracted papers.

Table 2. Annual Publications in Leading Sources

Year	Transportation Research Part D: Transport and Environment	Proceedings of the International Congress on Acoustics	Proceedings of Spie - The International Society for Optical Engineering	Building And Environment	Sensors
2020	12	0	5	9	16
2021	30	0	8	16	26
2022	45	66	16	24	37
2023	56	66	36	31	47
2024	68	66	52	45	52
2025	72	66	62	61	58

The table 2 provides the summary of the annual outputs (2020–2025) of five venues: Transportation Research Part D, International Congress on Acoustics, Proceedings of SPIE, Building and Environment, and Sensors. All trend upward, peaking in 2025. Transportation Research Part D expands six times (1272). SPIE proceedings increase most of all (562). Building and Environment gains steadily between 9 and 61 and Sensors gains steadily between 16 and 58. International Congress on Acoustics has a zero output up to 2022, and after that a constant 66/year up to 2025. In general, the data signal continued to experience growth and diversification in transport and acoustics, optics, the built environment and sensing fields, due to the increase in interdisciplinary interactions.

Table 3. Top Cited Documents with DOI and Citation Counts

DOI	Total Citations
10.1002/admt.202100698	397
10.1016/j.suscom.2022.100739	163
10.1109/TTE.2020.3006045	161
10.1016/j.scs.2020.102597	148
10.1016/j.isprsjprs.2023.05.028	136
10.1016/j.buildenv.2022.108753	134
10.1002/adma.202104552	134
10.1109/TSP.2020.2994514	129
10.1016/j.buildenv.2021.107928	117
10.1016/j.buildenv.2020.107087	115

The table 3 identifies the most cited publications in terms of DOI and the number of citations. The article with the strongest impact with 397 citations is the most influential

one as it was published in Advanced Materials Technologies (DOI: 10.1002/admt.202100698). This is then succeeded by articles in Sustainable Computing (163 citations) and in IEEE Transactions on Transportation Electrification (161 citations). The other prominent ones are the Journal of Systems and Software (148 citations), ISPRS Journal of Photogrammetry and Remote Sensing (136 citations), and Building and Environment (134, 117, and 115 citations). Such findings show that it is interdisciplinary, covering materials science, computing, transportation, remote sensing, and environmental studies.

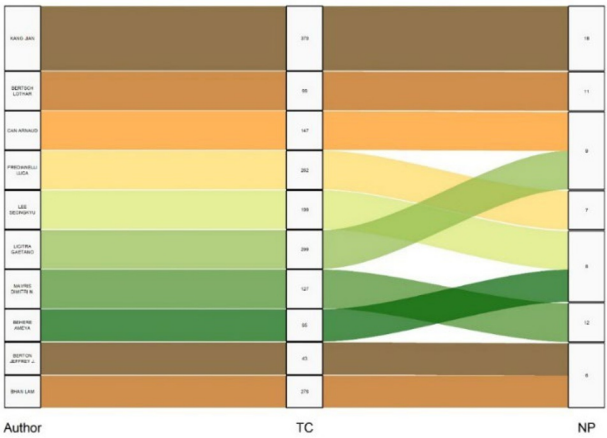

Fig. 2. Mapping authors' research output and citation impact across publications

The Sankey diagram shown in fig 2 displays authors, their number of publications (NP), and total citations (TC). Kang Jian has the highest number of citations of 370 in 18 articles, and then we have Bhan Lam of 270 citations in 6 articles. Lucitra Gaetano and Friedanelli Luca are also of great impact with 209 and 262 citations, respectively. The 12 publications have been consistent as Behere Ameaya boasts 95 citations. Bertsch Lothar and Mavris Dimitri N. also play a great role in the same with equal input of citation and publication. In summary, it is evident in both productivity and citation impact visualization that there are diverse impacts of research among the top authors.

Fig. 3. Word cloud depicting major research themes

Fig 3 is a word cloud visualization which shows the most recurrent keywords used in the research field of noise and pollution. The key words are light pollution, traffic noise, aircraft noise, acoustic noise measurement, and background noise, which implies that they are the central ones in the literature. Noise exposure, noise levels, acoustics, forecasting, internet of things, and roads and streets are some of the concepts that show the interdisciplinary nature, making environmental monitoring, urban planning, and smart city applications interconnected. Smaller but significant words such as railroad, aerodynamics, noise barriers, and sound absorbing further enlarge the network of themes, underlining the extent of the cross-disciplinary influence of the study of noise.

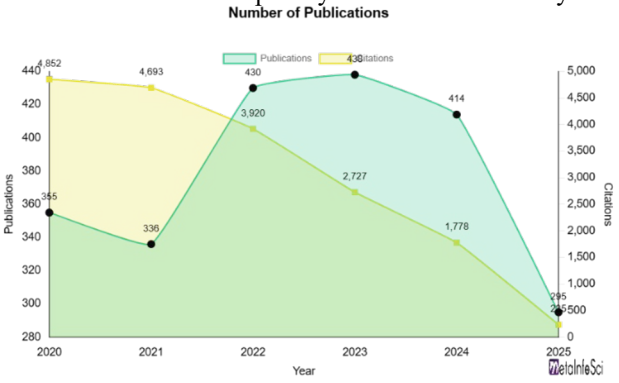

Fig. 4. Comparative Growth of Publications and Citations

The fig 4 below shows a comparative trend of publications and citations in a specified period. The publication (green) has shown a similar upward trend but at a very slow rate as it reached the highest peak of 3,920, and then slowly started to decrease to 2 in the current year. Citations (yellow) prevail initially with 4,655 but once this dropped drastically to 336, it goes on to reduce parallel to publications and this can be noted as 2. The intersection of citations and publications is an indication of a change in the visibility and influence of research. In general, the graph shows a high research output

period that includes a decrease and the citation trends mostly reflect the trends in publication, which reflects the variation in the academic influence across the time period.

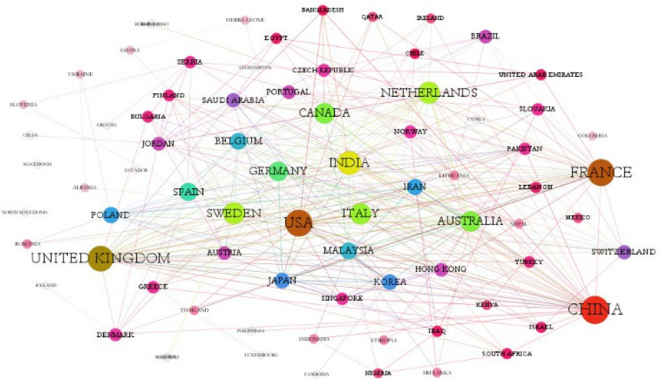

Fig. 5. International Scientific Collaboration Network

The fig 5 represents a country collaboration network map with emphasis on research partnerships worldwide. Several larger nodes like China, USA, United Kingdom, France, India, Germany, and Netherlands are signs of their prevailing contribution to international research. The braid of the interconnecting lines suggests a high level of collaboration, especially between the developed countries, but such emerging actors as India, Malaysia, and Saudi Arabia also show increased involvement. European nations such as Sweden, Italy and Belgium hold central spots and this indicates their capacity to act as mediators in international partnerships. In general, the visualization puts the focus on the unity of research across continents where China, USA, and European countries are the most active in terms of knowledge sharing and collaboration.

Top 10 Institutions with the Strongest Citation Bursts

Institutions	Year	Strength	Begin	End	2020 - 2025
Tang	2020	4.43	**2020**	2020	
Department of Civil Engineering	2021	7.89	**2021**	2022	
Yu	2021	4.8	**2021**	2021	
Zhu	2021	4.2	**2021**	2021	
Lee	2020	7.71	**2022**	2022	
Guo	2022	7.67	**2022**	2023	
Kim	2022	4.8	**2022**	2022	
Sun	2020	2.61	**2023**	2023	
Xu	2021	6.39	**2024**	2025	
Zhao	2022	6.14	**2024**	2025	

Fig. 6. Citation Burst Analysis of Leading Institutions

The fig 6 illustrates the top 10 institutions that have the most citation bursts between the years 2020 and 2025, which are indicative of the developing research impact. Burst strength is the highest in the Department of Civil Engineering (7.89) in the period of 20212022, then Lee (7.71) and Guo (7.67) in 2022. Xu (6.39) and Zhao (6.14) show that there are powerful bursts extending to 20242025, which signifies new momentum. Previous bursts are the ones by Tang (2020), Yu (2021), Zhu (2021), Kim (2022), and Sun (2023). The illustration of the timeline highlights how various institutions received attention very quickly in particular years as a result of change in the impact of research and the dynamicity of scientific visibility.

4 Conclusion

This scientometric research paper offers a global literature review on noise and light pollution during the period 2020-25. It was found that the number of research works steadily increases, and 2268 articles were included in the analysis representing 535 sources with more than 7900 authors. Significant leadership was seen in the case of highly productive authors like Kang Jian and Bhan Lam, and significant institutions reflected significant citation bursts highlighting their contribution in the field influence. Mapping on a country level identified China, the USA and various countries of Europe as the leading contributors and India and other emerging economies have been able to gain strength in terms of international collaborations. These trends can be illustrated by the fact that the participation of the world is becoming diverse as well as the consolidation of the established research hubs. According to thematic analysis, the development of smart monitoring systems, the introduction of IoT, and sustainable urban planning were identified as the key areas of research interest. The old-fashioned stresses on noise exposure and measurements have progressively extended to technological-based solutions that assist in smart cities and environmental sustainability. These changes demonstrate the way the discipline has become an extremely interdisciplinary field that is interconnected with acoustics, environmental science, computing, and urban studies. The study takes into account some limitations, even though it has strengths. The focus on one database (Scopus) can limit the coverage of any other work included in other databases, and the analysis time frame (2020 to 2025) limits the evaluation of long-term trends. Also, as much as the visualizations are insightful, they can simplify intricate collaboration processes. The goal of future research is to implement longitudinal studies over a long period to ensure that the changing trends are accurately represented. Increased cross-domain integration, including the connection between noise and light pollution and climate change, the health of people, and urban resiliency, will improve the research environment. By aligning future studies with Sustainable Development Goals (SDGs), the societal and policy pertinence of this area can be further reinforced and, accordingly, this evidence-based area can be used to guide scholarly research and interventions to achieve healthier and more sustainable ecosystems.

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