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Review

Impacts of Air Pollution on Community Well-Being in the Tourism Sector: A Comprehensive Literature Review

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Abstract: This critical review examines the interplay between air pollution and community well-being within the tourism industry. Utilizing a systematic literature review methodology, the study focuses on three domains: air quality, tourism, and sustainability. Employing VOSviewer for bibliometric analysis, the research identifies key themes and trends. The findings reveal that air pollution, particularly in urban tourist destinations, negatively impacts tourist behavior, reduces visitor numbers, and threatens the economic sustainability of tourism. Additionally, it highlights health risks to both tourists and local communities, underscoring the need for adaptive strategies and sustainable practices. The study prioritizes articles employing statistical methods and incorporates geographic visualizations using GeoPandas and Matplotlib to illustrate research distribution. By synthesizing the existing literature, this review emphasizes the importance of effective policies that balance tourism growth with environmental protection amidst escalating ecological challenges.

Keywords: tourism; well-being; air quality and health; sustainable tourism; environmental impact

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1. Introduction

Air pollution is a major concern for contemporary society due to its significant impact on industries [1,2]. Tourism, one of the sectors most reliant on environmental quality, is particularly vulnerable to this issue [3]. Studies show that continuous environmental degradation, including air quality decline, significantly affects the quality of the tourism experience and reduces consumer satisfaction [4]. Tourism is an important industry that supports the financial, social, and cultural fabric of rural areas, contributing to the revitalization and growth of provincial economies [5,6]. Addressing air pollution is therefore necessary, not only to sustain tourism but also to preserve its positive effects on local communities.

The significant growth in tourist numbers and the rapid development of tourism as a standalone industry highlight its dual impact, positive and negative, on the resources underpinning tourism activities. This phenomenon is both strongly visible and widely studied. Although there is a substantial body of literature addressing natural resources and their importance for the tourism industry, relatively few scientific analyses investigate the correlations between air quality and tourism [7]. The purpose of this section is to review prior work, existing studies, and different methodological approaches to this issue, focusing on sustainable tourism development and the well-being of its key stakeholders, the tourists. The research also aims to explore concepts of air quality, related indices, and air quality measurement methods.

In various areas, tourism has been actively promoted, contributing positively to the locality by attracting guests, tourists, and private companies, thereby fostering both financial and human development [7–10]. The correlation between tourism, particularly ecotourism, and outdoor recreation is increasingly prominent, creating tangible pressures on the material foundation of tourism in both developed and developing countries [11]. A major motivation for modern travelers is to escape ordinary, crowded environments in search of peaceful and comfortable places, with psychological relaxation as a primary goal [12].

While the concept of environmental pollution has been widely recognized since the Industrial Revolution, some authors [13–16] incorporate environmental quality into the quality of natural attractions, resulting in destinations that are considered environmentally premium. The emergence of the air quality concept has been accompanied by technological advances in medicine and a heightened awareness of severe pollution-related health issues [17].

Although air quality is frequently analyzed by public health professionals and environmental analysts, limited research focuses on how these quality indicators impact the tourism industry [18]. Among studies on tourism competitiveness, only a small fraction investigates the interdependent relationship between air quality and the strategic or competitive positioning of destinations [19–24].

Authors have explored various approaches to understanding the relationship between air quality and its influence on the tourism industry, focusing on themes such as air quality terms within the tourism industry, the implications for public health, and the effects of pollution on the well-being and satisfaction of tourists [25]. According to the Global Sustainable Tourism Council's 2019 Sustainable Travel Report, 70% of travelers worldwide stated they would be more likely to book accommodation if it were eco-friendly and situated in a sustainable environment, even if it involved higher costs [26].

Considering the complexity of tourism research and the multiple dimensions it encompasses, alongside the heightened interest in air quality standardization, this study will adopt a dual approach, both qualitative and quantitative, to interpret and analyze the data. The quantitative approach focuses on bibliometric analysis using VOSviewer 1.6.20 and inferential statistical techniques to explore patterns and relationships between air quality and tourism. This method allows for the identification of key thematic clusters and the measurement of keyword co-occurrence, helping to highlight research trends and regional focuses. The purpose of this quantitative analysis is to provide a structured understanding of the thematic landscape and its evolution over time, enabling a systematic identification of research gaps and priorities.

The qualitative approach complements this by critically analyzing the content of selected studies. This involves exploring the methods, contexts, and implications highlighted in the literature to provide deeper insights into the multidisciplinary aspects of the relationship between air quality and tourism, particularly regarding health, community well-being, and sustainability. Qualitative analysis adds depth to the understanding of the identified clusters and ensures a more nuanced interpretation of the data that cannot be captured through bibliometric techniques alone [27].

To guide this research, the following questions were formulated:

How do thematic clusters identified in the literature (e.g., pollution metrics, tourist satisfaction, health impacts, and sustainability) demonstrate interconnected relationships?

How has the focus of air quality and tourism research evolved over time, and what are the emerging areas of interest?

Why do certain regions, particularly Asia, dominate the research landscape, and how does this influence the global understanding of the field?

Numerous studies have explored the negative impact of air pollution on tourism [2,5,18–20,24]. Since 2000, studies have estimated the effect of atmospheric pollution, particularly smog, on the tourism industry, such as in Brunei Darussalam, where atmospheric haze has reportedly reduced monthly tourist arrivals by around 28.7%, with

projected direct losses of approximately BND 8 million [28]. The need for sustainable environmental management to protect mountain resorts is also essential, as global warming affects winter tourism by increasing temperatures and decreasing tourist numbers [29].

Additional studies have focused on traveler perceptions of air quality before choosing a destination. For instance, Cheung and Law (2001) observed that Asian tourists expressed greater concern for air quality when selecting destinations compared to European tourists, as seen in Hong Kong [30]. Similarly, low air quality indices may visibly impact tourism in Vancouver and the Lower Fraser Valley [31]. Climate change is another factor predicted to cause a long-term decline in international tourism [32,33].

2. Materials and Methods

This literature review adopts a systematic approach to examine the intersection of air quality, tourism, and sustainability. The research methodology is structured around three primary domains essential to understanding this field, as follows:

- Air Quality/Air Pollution;
- Tourism Industry;
- Well-being/Sustainability.

These domains serve as the foundation for selecting and analyzing relevant studies, focusing on their statistical rigor and methodological contributions.

The process began with an initial search using VOSviewer to explore and categorize articles indexed in the Web of Science (WoS) database. VOSviewer enabled the identification of key themes within the literature, initially generating five clusters, which were later refined to four clusters based on thematic alignment. This clustering helped streamline the dataset and provided a preliminary structure for organizing the subsequent analysis.

In the context of a limited number of studies investigating the impact of air quality on tourism, the methodology used in this paper builds on systematic approaches seen in prior research. For instance, a recent study [7] employs a systematic literature review to analyze the impact of air quality on tourism demand and identifies existing research gaps. However, this paper makes a distinct methodological contribution by utilizing bibliometric analysis with VOSviewer to identify and visualize key themes and their interconnections. This approach offers an innovative perspective on the structure and evolution of research in this field, complementing existing methods.

In addition to bibliometric analysis, qualitative analysis was conducted to gain deeper insights into the context and implications of the identified clusters. This analysis involved a critical examination of selected studies, focusing on the methods, geographic contexts, and conclusions they presented. By exploring these studies qualitatively, this research was able to interpret the significance of the thematic clusters, uncover underlying patterns, and provide a more nuanced understanding of the relationship between air quality and tourism. The qualitative component was essential in addressing aspects such as health impacts, community well-being, and sustainability dimensions, which are not fully captured through bibliometric techniques alone.

Following this, a systematic selection of relevant articles was conducted. Priority was given to studies that employed statistical analysis of air quality data, alongside tourism and sustainability metrics, ensuring relevance and analytical depth. The following inclusion criteria were designed to maintain a high standard of rigor:

- Air quality/air pollution with data about PM2.5, PM10, and CO_2 levels, providing a basis for assessing pollution levels and their potential impact on tourism.
- Sustainable tourism indicators include carbon footprint assessments, ecological footprint evaluations, and life cycle analyses, which capture the broader environmental impacts of tourism activities on destinations.
- Tourism-specific indicators, such as visitor arrivals, destination image, and tourist satisfaction. Offering insight into how air quality affects tourism demand and perceptions.

In addition to these content criteria, only studies employing robust statistical methods—such as regression analysis, structural equation modeling, and descriptive statistics—were considered. This ensured a high level of analytical sophistication, allowing for in-depth exploration of the connections between air quality, tourism, and sustainability.

Once the relevant articles were identified, a geographic visualization was created to illustrate the global distribution of research on this topic. The map specifically includes studies that explicitly reference the location of the study in their titles, thereby ensuring that each country highlighted represents targeted research in that region.

Article counts per country were derived from the literature review and visualized using GeoPandas 1.0.1 and Matplotlib in Python 3.13.1. This color-coded map uses darker shades to indicate countries with a higher concentration of studies, with China and other Asian countries emerging as focal points. The prominence of these regions aligns with high pollution levels and significant tourism activity, underscoring the urgent need for research in these areas.

To complement the map, a table was constructed to provide a quantitative overview of the distribution of articles by country. The table was systematically organized based on each study's geographic focus, grouping countries with a high frequency of relevant publications. This dual approach—visual and tabular—offers a comprehensive, data-driven view of where research efforts are concentrated globally, helping to highlight regions where air quality and tourism intersect as research priorities.

This structured methodology, combining a systematic review, bibliometric analysis, and geographic visualization, offers a detailed synthesis of the existing literature. By focusing on studies that incorporate statistical rigor and location-specific analysis, this review provides a foundation for understanding research trends and identifying gaps in the global discourse on air quality and tourism.

3. Results

The initial search conducted in the Web of Science Core Collection using the keywords "Air quality" AND "tourism" yielded a dataset of 607 results. This dataset represents a comprehensive overview of the intersection between environmental quality and tourism-related research. After importing the articles into VOSviewer, a network analysis was performed, resulting in five distinct clusters that reflect major thematic areas within the literature.

3.1. Exploratory Network Analysis of Air Quality and Tourism Research

The clustering analysis, visualized through VOSviewer, highlights the distribution and relationships among keywords across five distinct clusters, each representing a specific thematic focus within the research landscape on air quality and tourism. In the network visualizations, node size indicates the frequency of keywords, while link thickness represents the strength of co-occurrence between terms, providing insight into how these themes are interconnected.

3.1.1. Network Visualization

The network visualization is presented through two formats: one in frames and curved lines (Figure 1), and the other in a circles and straight lines format (Figure 2). Each of these visualizations uses color-coded clusters to reveal unique patterns and focal points, enhancing understanding of the research landscape. The frames format emphasizes structural relationships and boundaries between clusters, while the circles format offers a more interconnected view of keyword associations, highlighting the fluid connections across themes in the literature. Together, these visualizations facilitate an understanding of the thematic concentrations within the field.

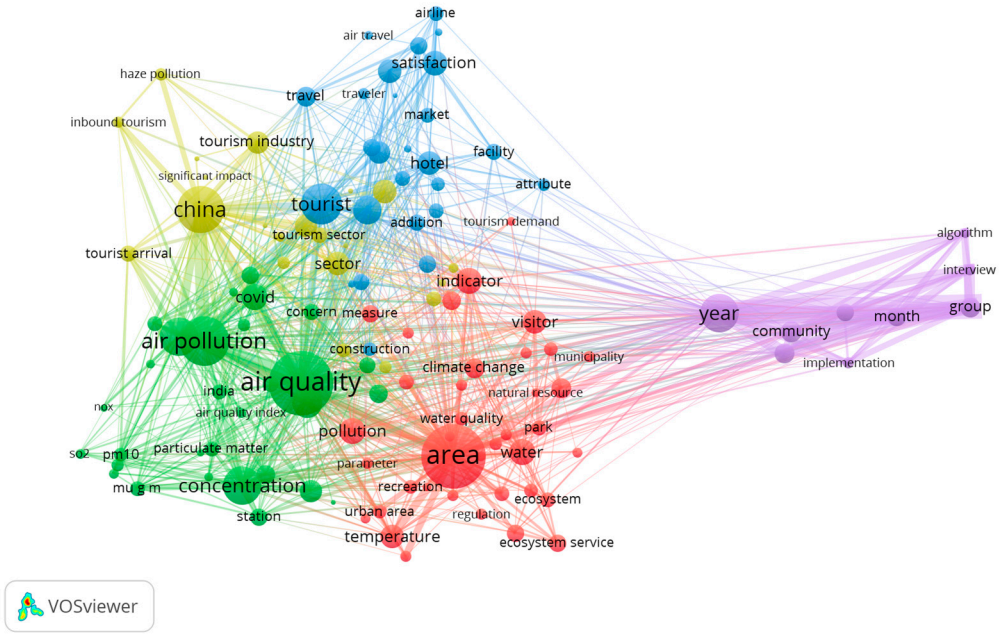


Figure 1. Network visualization (using circles and straight lines format).

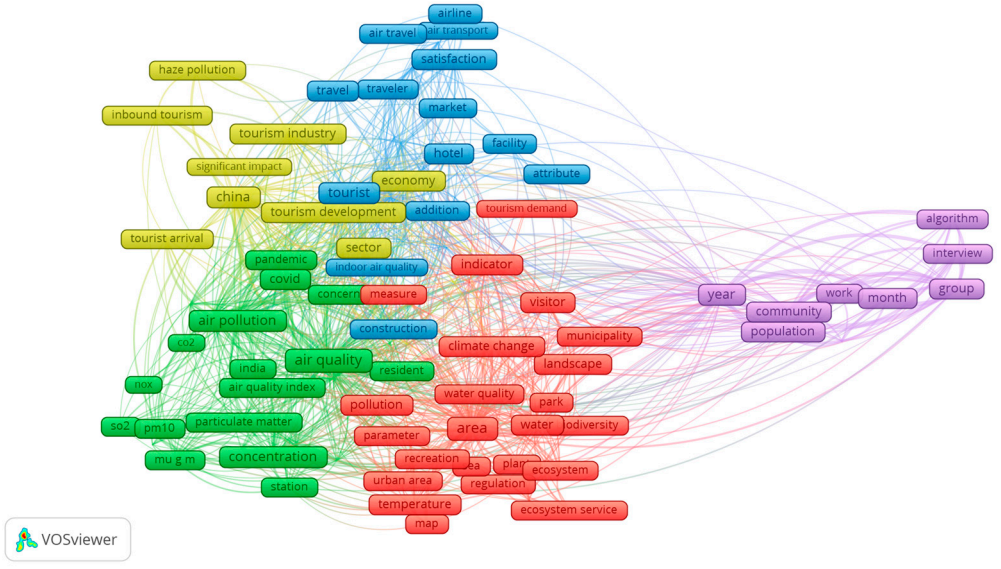


Figure 2. Network visualization (using frames and curved lines format).

3.1.2. Density Visualization

The density visualization, shown in Figure 3, represents the five identified clusters with a black background to enhance the visibility of thematic concentrations. Each color-coded cluster in this view demonstrates the core areas of research within the dataset:

The first cluster, represented in green, primarily focuses on environmental pollutants and air quality metrics, including terms such as "PM10", "PM2.5", "CO_2", "concentration", and "pollution". This cluster emphasizes the measurement and impact of specific pollutants on air quality, which is particularly relevant to studies examining the environmental costs associated with tourism.

The second cluster, in yellow, is associated with tourism-related terms like "tourism industry", "China", "inbound tourism", and "tourist arrival". This cluster points to a focus on tourism growth and environmental concerns, with a notable concentration of studies conducted in Asia, especially regarding the impact of air quality on tourism demand.

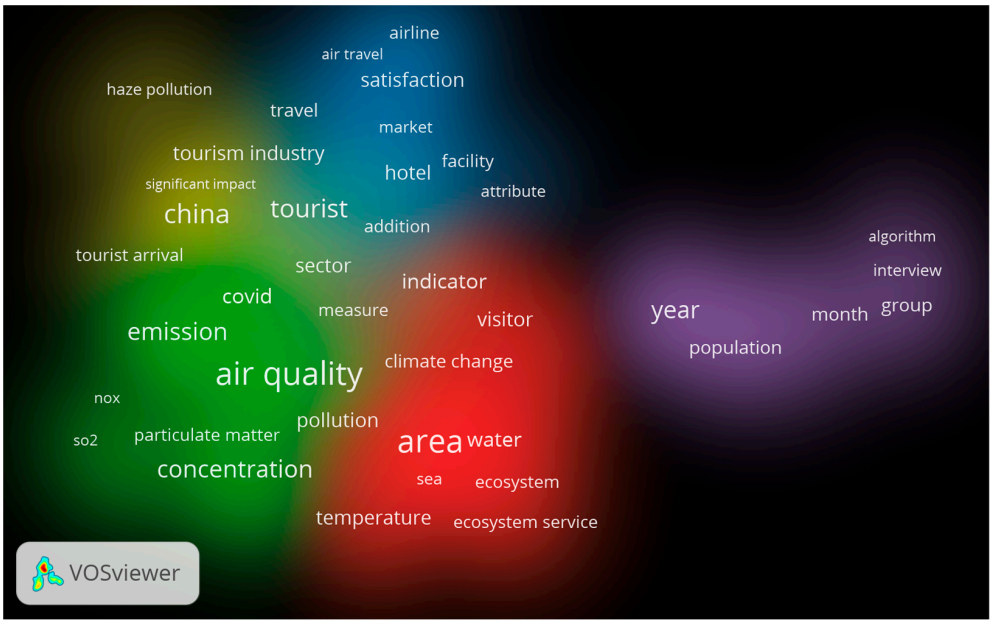


Figure 3. Density visualization (5 clusters).

The third cluster, visualized in blue, includes keywords such as "satisfaction", "hotel", "market", and "traveler". This cluster shows an emphasis on tourist satisfaction, market dynamics, and accommodation, all of which influence tourists' perceptions of environmental quality and affect destination choice.

The fourth cluster, shown in red, connects tourism with broader environmental and ecological themes through keywords like "area", "climate change", "ecosystem", and "recreation". This cluster highlights research focused on natural and social resources impacted by tourism activities, including the preservation of ecosystems and the sustainable use of recreational areas.

Finally, the fifth cluster, represented in purple, includes terms such as "year", "community", "population", and "group". This cluster addresses research related to community well-being, social demographics, and the social impacts of tourism, particularly regarding the effects of environmental quality on local populations and community resilience.

Collectively, these five clusters provide an organized view of the research landscape, illustrating the diverse and interconnected themes related to air quality and tourism. Density visualization enhances the understanding of these thematic concentrations and highlights the relationships between different research areas, emphasizing the multi-dimensional approach that studies in this field often take.

3.1.3. Overlay Visualization

Keywords associated with earlier years, such as "air quality", "air pollution", "PM10", and "concentration", are represented in shades of blue. This suggests that foundational research focused primarily on quantifying pollutants and assessing their environmental and public health impacts. As research in this field advanced, additional emphasis on the tourism industry began to surface, with keywords like "tourism industry", "tourist", and "tourist satisfaction" appearing in green and yellow shades. This shift indicates a growing interest in understanding the influence of air quality on tourism dynamics, visitor satisfaction, and destination attractiveness, especially in regions affected by significant air pollution, such as China.

Figure 4 illustrates a temporal visualization of the keyword network in research related to air quality and tourism, using a color gradient to represent the publication years of the articles. The gradient, which ranges from dark blue (2017) to bright yellow (2021), reveals

the progression of topics over time, showcasing recent trends and the emergence of new research areas within the field.

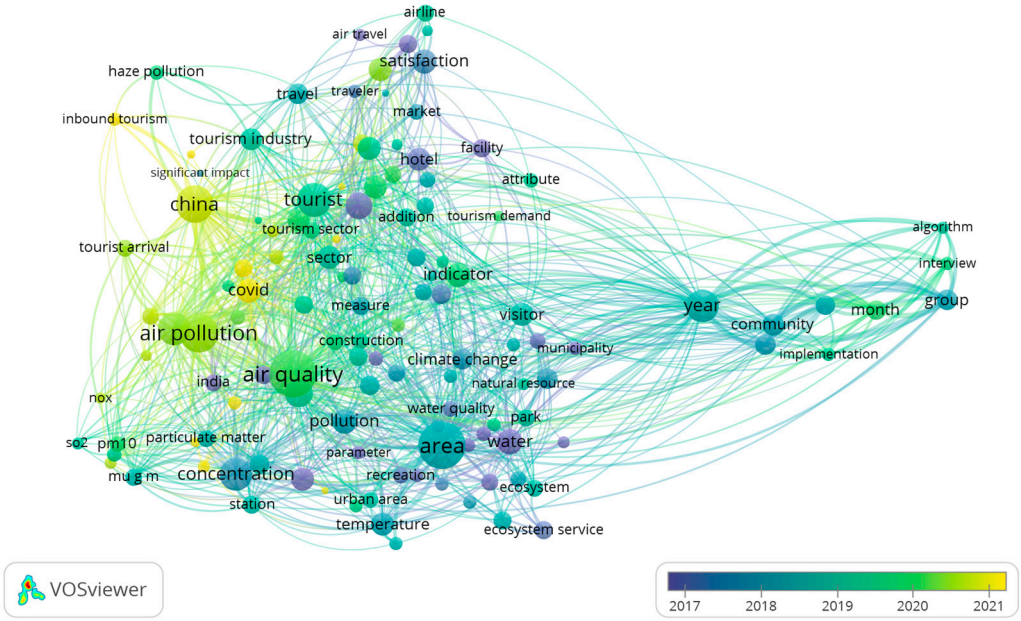


Figure 4. Overlay visualization (2017–2021).

More recent studies, marked in yellow (closer to 2021), increasingly examine community and public health impacts, as reflected by keywords like "COVID", "pandemic", "community", and "well-being". This trend signals a shift toward addressing the broader social implications of air quality, especially in the context of public health crises and environmental sustainability. The evolution of these themes highlights a transition from basic environmental assessments to a more holistic exploration that considers tourism's social, economic, and health dimensions, underscoring the field's adaptation to contemporary global challenges.

In summary, Figure 4 demonstrates how research on air quality and tourism has evolved over recent years. The visual progression from blue to yellow illustrates an expanding scope of inquiry, moving from pollutant measurement and environmental impacts to an integrated analysis that includes the effects of air quality on public health, community well-being, and sustainable tourism development. This temporal pattern underscores the interdisciplinary growth within the field, reflecting its response to current global issues in environmental health and sustainable tourism.

3.2. Refined Analysis of Key Terms and Thematic Clusters

To enhance the focus and relevance of the network analysis, the dataset was refined using VOSviewer's threshold settings. Out of a total of 17,484 terms identified in the corpus, a minimum occurrence threshold of 25 was applied, narrowing the selection down to 199 terms. This filtering step ensured that only frequently recurring terms, which are more likely to represent significant themes in the literature, were retained for further analysis.

From these 199 terms, a relevance score was calculated, allowing for the selection of the top 60% most relevant terms. This approach yielded a subset of 120 terms, which formed the basis for a more targeted and meaningful clustering analysis. By focusing on these highly relevant terms, the refined analysis offers a clearer insight into the primary themes and interrelationships within the literature on air quality and tourism. This method enhances the interpretability of the clusters, allowing for a more precise exploration of the conceptual connections that shape the current research in this field.

3.2.1. Detailed Cluster Composition and Thematic Density Analysis

The density visualization in Figure 5 offers an in-depth representation of the refined thematic clusters, showcasing the most prominent research areas at the intersection of air quality and tourism. Each color represents a distinct cluster, with higher density areas highlighting terms that are not only frequent but also closely interconnected, providing insight into the main focal points of the literature.

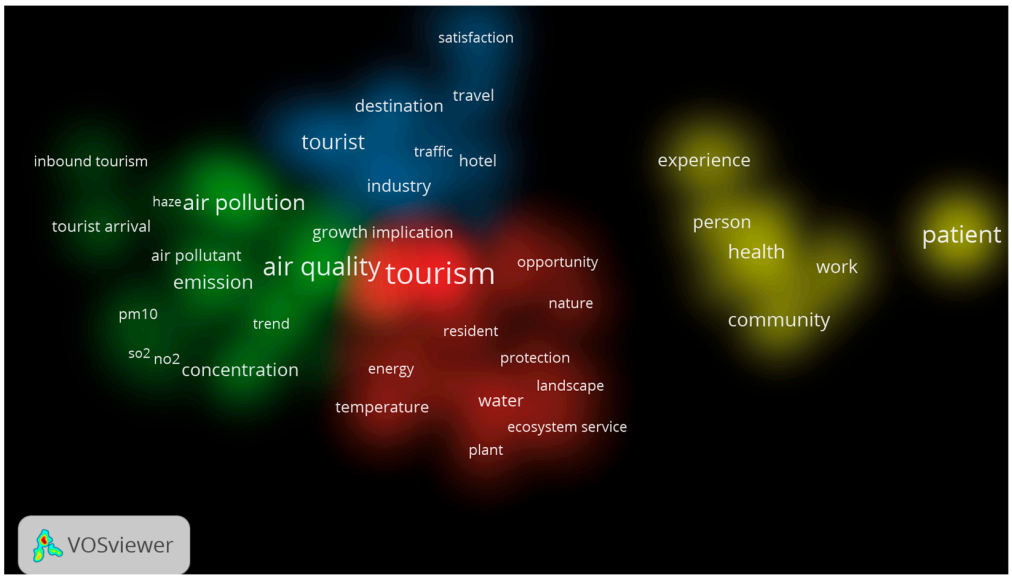


Figure 5. Density visualization (4 clusters).

The green cluster comprises 26 terms primarily related to air quality and pollutants, including "air pollution", "air pollutant", "emission", "PM10", "concentration", and "tourist arrival". This cluster emphasizes the environmental impact of air pollutants and their significance within tourism research, especially regarding visitor perceptions and potential health effects.

In the blue cluster, containing 20 terms, the focus shifts to the tourism industry itself, with keywords such as "tourist", "destination", "hotel", "industry", and "satisfaction". This cluster highlights the core components of the tourism experience and the supporting infrastructure, underscoring the relationship between environmental conditions and tourist satisfaction, an important factor in destination attractiveness.

The red cluster encompasses 30 terms related to natural resources and sustainability, including "ecosystem service", "energy", "water", "temperature", "landscape", and "conservation". This grouping suggests a strong research interest in sustainable tourism practices and the preservation of ecosystems affected by tourism, pointing to the environmental stewardship needed for long-term destination viability.

Finally, the yellow cluster contains 11 terms addressing community and health dimensions, with terms such as "community", "health", "patient", "experience", and "population". This cluster reflects research focused on the social impact of tourism, particularly the influence of environmental quality on community well-being and individual health, integrating a public health perspective into the field of tourism studies.

Through this density visualization, Figure 5 encapsulates the thematic concentrations within the literature, illustrating the interconnected and interdisciplinary nature of research topics that bridge environmental science, tourism, sustainability, and community health. This analysis provides a structured view of the research landscape, highlighting both the depth and breadth of scholarship in this field.

3.2.2. Structural and Interconnected Network Visualization of Thematic Clusters

The network visualizations in Figures 6 and 7 provide distinct perspectives on the structure and thematic relationships within the research on air quality and tourism, each using a different visual approach.

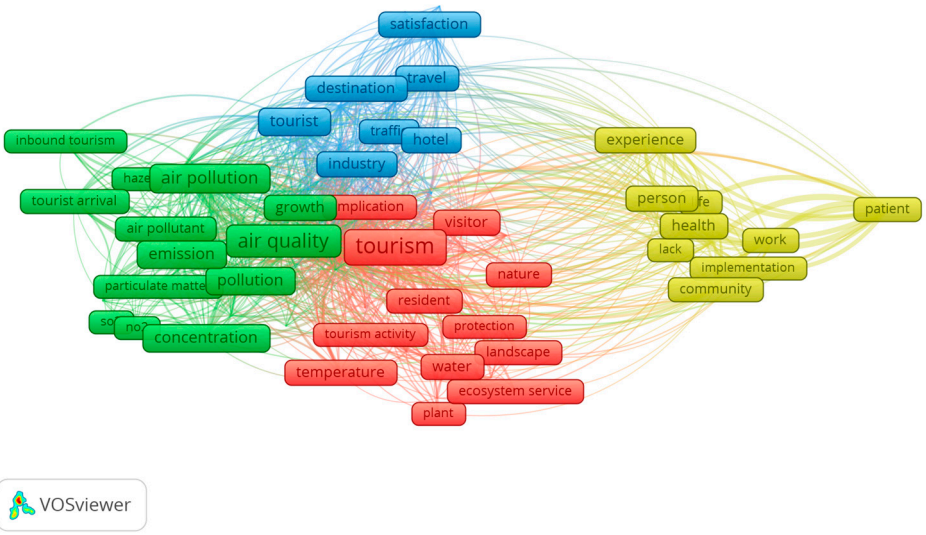


Figure 6. Network visualization (using frames and curved lines format).

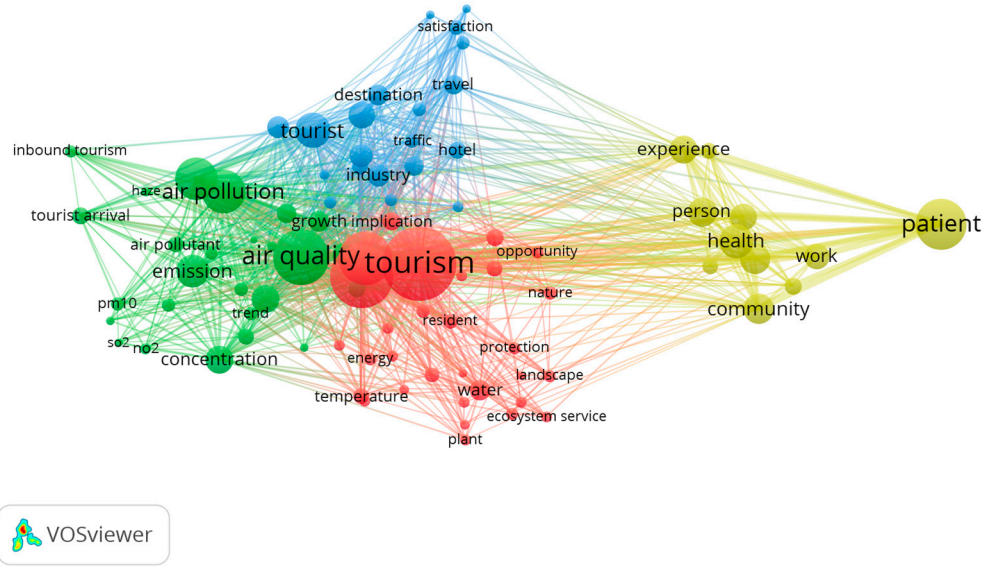


Figure 7. Network visualization (using circles and straight lines format).

In Figure 6, the network is displayed using the frames format, where each keyword is enclosed in a rectangular frame. This format highlights the boundaries and delineations of each thematic cluster, facilitating the identification of distinct areas within the research landscape. The clusters are color-coded, as follows: The green cluster includes terms such as "air pollution", "emission", and "PM10", focusing on environmental pollutants and their implications. The blue cluster contains terms like "tourist", "destination", and "satisfaction", capturing essential elements related to the tourism industry and visitor experience. The red cluster, with keywords such as "ecosystem service", "water", and "landscape", emphasizes environmental sustainability and resource conservation. Finally, the yellow cluster features terms such as "health", "community", and "experience", which reflect the social and health-related dimensions of the literature. The frames format in

Figure 6 effectively demarcates these clusters, providing a structured view of the core themes and their boundaries within the field.

In Figure 7, the network is visualized using the circles format, which emphasizes the interconnectedness of terms by arranging related keywords within overlapping circular clusters. This format allows for a fluid representation of relationships, highlighting keywords that serve as bridges between thematic areas. For example, terms like "tourism" and "air quality" appear as central nodes, underscoring their role in linking environmental, social, and economic dimensions within the research. The circles format in Figure 7 offers an integrated view of thematic connections, revealing how core topics like tourism and air quality intersect with sustainability, public health, and community well-being across the literature.

Each visualization thus offers a unique lens on the research landscape, with Figure 6 presenting a more structured, delineated perspective and Figure 7 illustrating the nuanced interplay and overlap between central themes in air quality and tourism studies.

3.3. Analysis of Key Studies on Air Quality and Tourism

3.3.1. Methodologies and Statistical Approaches in Studies on the Impact of Air Quality on Tourism

This section presents a curated selection of key studies examining the intersection of air quality and tourism, emphasizing the methodologies and statistical approaches employed to analyze the effects of air quality on tourist behavior, satisfaction, and destination attractiveness. The studies included in Table 1 are chosen based on their use of relevant air quality data (e.g., PM2.5, PM10, CO_2 concentrations), sustainable indicators (such as carbon footprint, ecological impact, or other environmental performance metrics), and tourism indicators (like visitor numbers, destination image, or tourist satisfaction). Only studies that applied statistical analyses to assess these factors were considered, ensuring a robust and quantifiable insight into the impact of poor air quality on tourism.

Table 1. Overview of key studies investigating the relationship between air quality and tourism: methods and citation impact.

Authors	Year	Title of Research	Statistical Methods Used	Google Scholar Citations
Anaman and Looi [28]	2000	Economic Impact of Haze-Related Air Pollution on the Tourism Industry in Brunei Darussalam	Descriptive Statistics	101
Godde et al. [29]	2000	Tourism and Development in Mountain Regions	Regression Analysis	276
Mcneill and Roberge [31]	2000	The Impact of Visual Air Quality on Tourism Revenues in Greater Vancouver and the Lower Fraser	Descriptive Statistics	19
Cheung and Law [30]	2001	The impact of air quality on tourism: The case of Hong Kong	Regression Analysis, Descriptive Statistics	44
Hamilton et al. [26]	2005	Effects of climate change on international tourism	Linear Correlations, Regression Analysis	370
Gössling et al. [34]	2006	Tourist Perceptions of Climate Change: A Study of International Tourists in	Descriptive Statistics	337
Law and Cheung [35]	2007	Air Quality in Hong Kong: A Study of the Perception of International Visitors	Simple Linear Correlations, Descriptive Statistics	75
Buckley [36]	2012	Sustainable tourism: Research and reality	Descriptive Variable Analysis	1716

Table 1. *Cont.*

Authors	Year	Title of Research	Statistical Methods Used	Google Scholar Citations
Becken and Wilson [37]	2013	The Impacts of Weather on Tourist Travel	Qualitative Analysis	252
Pang et al. [38]	2013	Climate Change and Tourism: An Overview	Descriptive Statistics	171
Taylor [39]	2014	Visual Air Quality Management	Descriptive Variable Analysis	32
Sajjad et al. [24]	2014	Climate change and air pollution jointly creating nightmare for tourism industry	Descriptive Statistics	161
Zhang et al.[40]	2015	Tourists' Perception of Haze Pollution and the Potential Impacts on Travel: Reshaping the Features of Tourism Seasonality in Beijing, China	Simple Linear Correlations	170
Li et al. [41]	2015	Up in Smoke? The Impact of Smog on Risk Perception and Satisfaction of International Tourists in Beijing	Simple Linear Correlations, Descriptive Statistics	64
Becken et al. [42]	2016	Urban air pollution in China: Destination image and risk perceptions	Structural Equation Modeling (SEM)	271
Sato et al. [43]	2017	Effect of Short-Term Exposure to High Particulate Levels on Cough Reflex Sensitivity in Healthy Tourists: A Pilot Study	Structural Equation Modeling (SEM), ANOVA	20
Cvijanovic et al. [5]	2017	The impact of air quality conditioned by emission of pollutants to the development of rural tourism and potential of rural areas	Tukey's Multiple Comparison, ANOVA	19
Peng and Xiao [44]	2018	How does smog influence domestic tourism in China? A case study of Beijing	Simple Data Analysis	68
Dong et al. [45]	2019	The Impact of Air Pollution on Domestic Tourism in China: A Spatial Econometric Analysis	Structural Equation Modeling (SEM)	42
Qiao et al. [46]	2019	Identifying Causes for the Decline in International Arrivals to China—Perspective of Sustainable Inbound Tourism Development	Linear Regression, Spatial Autocorrelation	12
Robaina et al., [47]	2020	The relationship between tourism and air quality in five European countries	Descriptive Statistics, Linear Regression	47
Gössling and Higham [34]	2020	The Low-Carbon Imperative: Destination Management under Urgent Climate Change	Causality Tests, Vector Autoregressive Model	185
Y. Y. Sun et al. [25]	2020	Managing tourism emissions through optimizing the tourism demand mix: Concept and analysis	Qualitative Data Analysis	96

Table 1. *Cont.*

Authors	Year	Title of Research	Statistical Methods Used	Google Scholar Citations
Kitamura et al. [48]	2020	Carbon Footprint Evaluation Based on Tourist Consumption toward Sustainable Tourism in Japan	Qualitative Data Analysis	44
W. Zhang et al. [49]	2021	The Impact of Air Quality on Inbound Tourist Arrivals over China Based on Grey Relational Analysis	LCA Analysis (Life Cycle Assessment), Quantitative Analysis	4
Bhaktikul et al. [50]	2021	Toward a low-carbon tourism for sustainable development: a study based on a royal project for highland community development in Chiang Rai, Thailand	Gray Relational Analysis	36
Ciarlantini et al. [51]	2022	Air pollution and tourism growth relationship: exploring regional dynamics in five European countries through an EKC model	Qualitative Data Analysis	28
Carneiro et al. [18]	2021	Visitors' behavioural intention towards an episode of air pollution: a segmentation analysis	EKC Analysis (Environmental Kuznets Curve)	11
Bacos and Gabor [52]	2021	Air Quality Indices—Case Study: Environmental Sustainability Pillar and Romania's Positioning in the European and Global Context	Qualitative Data Analysis Inferential Statistics	5
Huang and Tang [53]	2021	Estimation of tourism carbon footprint and carbon capacity	Regression Analysis, ANOVA Test	25
Mancini et al. [54]	2022	Ecological Footprint and tourism: Development and sustainability monitoring of ecotourism packages in Mediterranean Protected Areas	Descriptive Statistics, Quantitative Analysis	38
Iftikhar et al.[55]	2022	Impact of tourism on sustainable development in BRI countries: The moderating role of institutional quality	Quantitative Analysis	39
Bacos and Gabor [56]	2022	Comparative Quantitative Analysis of Air Quality Indicators and Macroeconomic Indicators for EU and Non-EU Member Countries	Quantitative Analysis Correlations	4
Bogalecka and Grobelna [32]	2023	Air Pollution and Its Potential Consequences for Tourism and Career Development from Students' Perspective: A Case Study of the Gdańsk Agglomeration in Poland	Descriptive Statistics, Correlation Analysis, Inferential Statistics	10
Chien et al. [27]	2023	Does air pollution affect the tourism industry in the USA? Evidence from the quantile autoregressive distributed lagged approach	Quantile Autoregressive Distributed Lag (QARDL), Granger Causality Test	62

Table 1. *Cont.*

Authors	Year	Title of Research	Statistical Methods Used	Google Scholar Citations
Qiang et al. [33]	2024	How air pollution affects tourism revenue: evidence from China	Descriptive Statistics, Regression Analysis, Instrumental Variable (IV) Regression	4
Xiao et al. [57]	2024	How far can air pollution affect tourism in China? Evidence from panel unconditional quantile regressions	Descriptive statistics, Correlations	0

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The abstracts of each article were examined to extract core information, with selected studies demonstrating a significant impact on the academic community, as reflected in citation counts. These articles provide a comprehensive overview of methodological diversity, and the analytical rigor applied to study the complex relationship between tourism and air quality.

The articles were selected through a systematic approach focusing on studies that integrate statistical analysis of air quality data alongside tourism and sustainability metrics. Emphasis was placed on studies that involved the following:

- Utilized quantitative air quality data such as PM2.5, PM10, and CO_2 levels to objectively measure pollution levels.
- Incorporated sustainable tourism indicators, for instance, carbon footprint evaluations, ecological footprint, and life cycle assessments, to reflect the environmental dimensions of tourism.
- Measured tourism-specific indicators like visitor arrivals, destination image, and tourist satisfaction to capture the tourism industry's response to air quality conditions.
- Applied rigorous statistical methods (e.g., regression analysis, structural equation modeling, descriptive statistics) to ensure analytical depth in exploring how pollution affects tourism dynamics.

Table 1 details each study's authors, publication year, research title, the statistical methodologies used, and Google Scholar citation counts, highlighting the impact and recognition within the research field. This structured summary provides an accessible reference for the methodological contributions and thematic breadth of each study.

This section and table serve to underscore the value of these studies in shaping our understanding of how air pollution and sustainability are pivotal to modern tourism dynamics. Through a synthesis of their findings, this review aims to inform future research directions and policy considerations in tourism and environmental management.

3.3.2. Geographic Distribution of Research on Air Quality and Tourism

Figure 8 was created using GeoPandas and Matplotlib tools in Python. The dataset includes only articles with explicit location references in their titles, ensuring that each data point corresponds directly to a specific country mentioned in the research. The number of articles per country was calculated based on a comprehensive review of the literature on air quality and tourism, focusing on studies that explicitly link environmental conditions to tourist behavior in defined geographic regions. This approach provides a clear and visually accessible summary of the most researched locations in this field, facilitating a better understanding of regional research trends and priorities.

Asia, particularly China, stands out as a focal region in the field of air quality and tourism research due to its dual role as both a major tourist destination and an area experiencing high levels of air pollution. Studies have shown that poor air quality significantly

impacts tourism in various Asian cities, deterring potential visitors and affecting the overall experience of tourists.

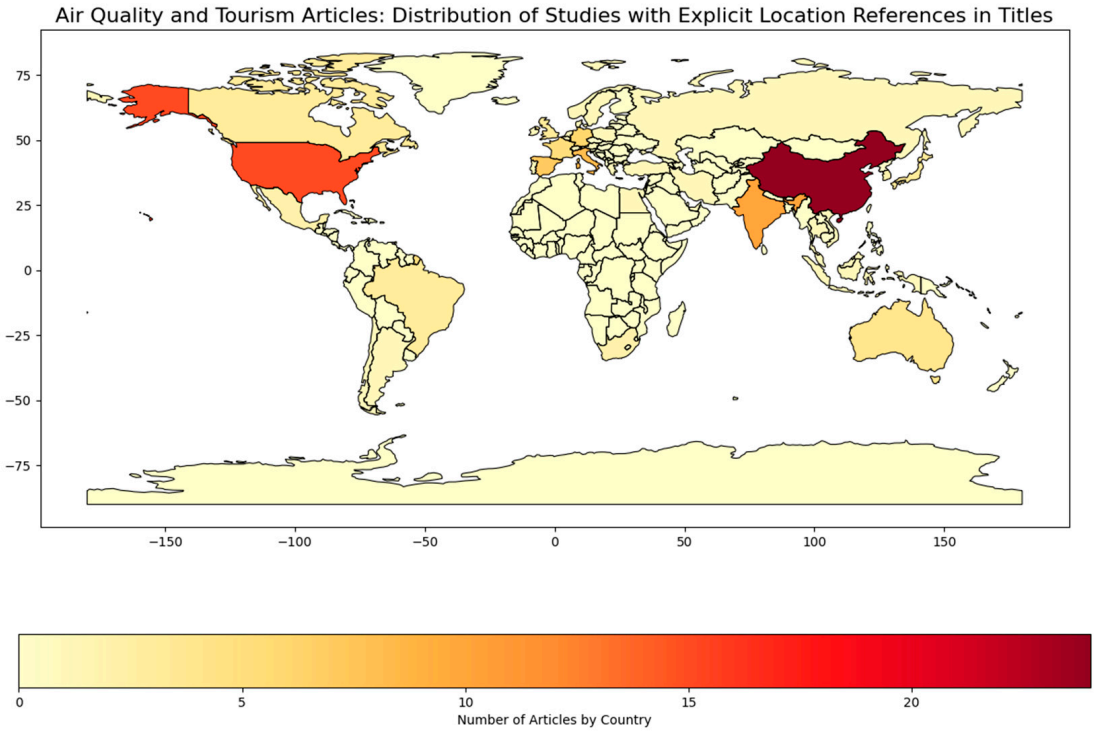


Figure 8. Geographic distribution of research on air quality and tourism: studies with explicit location references in titles. Source: compiled by the author based on a systematic literature review of studies on air quality and tourism from various academic databases.

The prominence of this region in the literature corresponds with the distribution of air quality monitoring stations, underscoring Asia's critical role in the global conversation about the effects of pollution on tourism. Figure 8 visually represents this distribution, with China leading in the number of location-specific studies, highlighting the urgency of addressing pollution issues in tourism-heavy areas within Asia.

Additionally, the map illustrates the spread of research interest across other parts of the world, particularly in the United States and parts of Europe, where air quality is also a concern in popular tourist destinations. This distribution of studies reflects a growing awareness of how environmental conditions influence tourism patterns globally, pointing to a need for broader international efforts to mitigate pollution and enhance visitor experiences across diverse regions.

4. Discussion

The relationship between air quality and tourism has gained significant attention in the literature, with a notable concentration of studies focused on Asia, especially China [58]. This regional focus can be attributed to the high levels of air pollution prevalent in various Asian countries, where rapid industrialization, urbanization, and population growth have exacerbated air quality issues [59].

In examining the relationship between air quality and tourism satisfaction, studies often highlight the psychological and health-related concerns of tourists. For example, tourists exposed to high levels of PM2.5 or PM10 in urban tourist destinations are likely to experience dissatisfaction, reduced travel motivation, and potential health risks. This finding is consistent across studies, with regression analyses and descriptive statistics commonly used to measure tourists' reactions to varying air quality conditions. The

literature indicates that tourists are becoming increasingly aware of environmental quality when selecting destinations, particularly in highly polluted urban areas.

As a result, the tourism sector in these regions faces unique challenges related to air pollution, making Asia a central area of study for examining the impact of environmental quality on tourism dynamics [60]. The figure below (Figure 9) illustrates the distribution of air quality sensors globally, highlighting that Asia, particularly China, has a dense network of sensors due to its severe air quality challenges. This geographic focus is reflected in the literature, where a significant portion of the research addresses air pollution and its effects on tourism in Asian destinations [61].

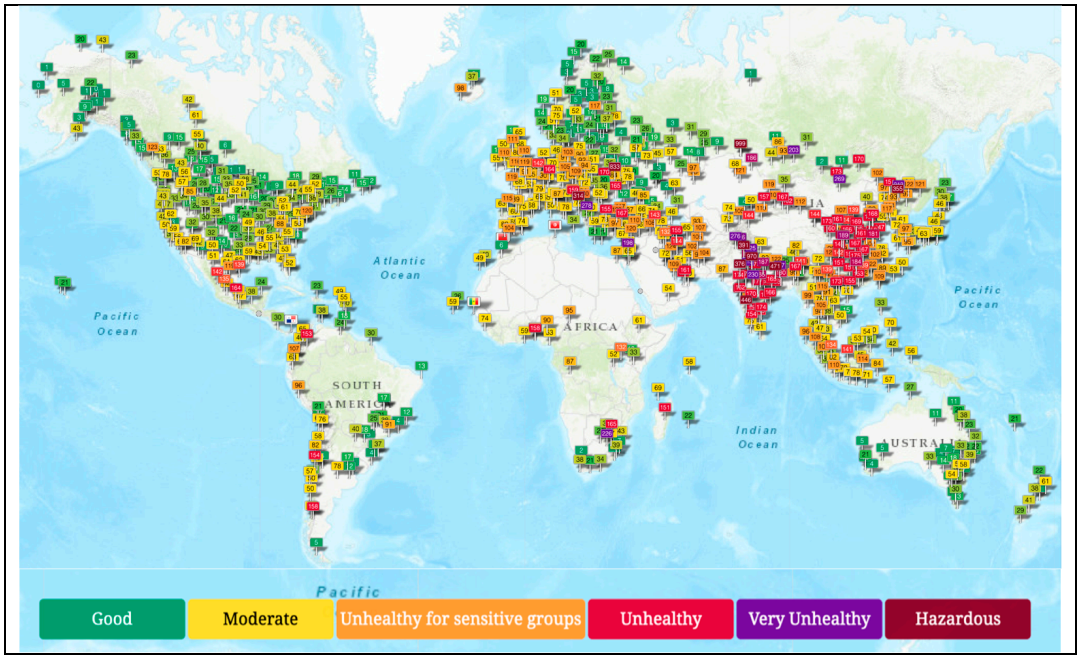


Figure 9. Air pollution in world: real-time air quality index visual map. Source: https://aqicn.org/map/asia/cn/. (Accesed on 5 November 2024).

The first VOSviewer network visualization (Figures 4–7) presents an exploratory network of keywords associated with air quality and tourism, revealing key thematic clusters. The following four primary clusters are evident: The green cluster focuses on specific air pollutants such as PM10, PM2.5, and emissions, reflecting environmental metrics crucial to assessing air quality. The blue cluster emphasizes tourism-related terms such as "tourist", "destination", and "satisfaction", which are vital for understanding how air pollution affects tourist experiences and decision-making. The yellow cluster connects tourism with health-related terms like "patient" and "community", underscoring the importance of well-being in pollution-impacted areas. The red cluster links tourism to broader environmental topics, highlighting the ecological impacts of tourism on resources like water and ecosystem services. This thematic clustering reflects the multidisciplinary approach taken in the literature, where tourism, environmental science, and public health intersect to address the complex issue of air quality.

The second VOSviewer visualization (Figure 2) shows an overlay of keywords, indicating the temporal progression of research topics from 2017 to 2021. The color gradient, from blue (2017) to yellow (2021), reveals that early studies in this area were primarily focused on foundational air quality metrics, such as "PM10" and "concentration". Over time, the focus shifted to include tourism-related terms and broader community impacts, reflecting an evolving interest in understanding how poor air quality influences tourism demand, destination attractiveness, and resident well-being. Notably, recent studies, represented in shades of yellow, increasingly emphasize terms related to health impacts, community

well-being, and responses to environmental challenges, underscoring a growing concern with the social dimensions of air quality in tourism research.

A significant trend observed across the studies is the use of quantitative data, particularly air quality indicators like PM2.5, PM10, and CO_2 levels. These pollutants are frequently measured due to their known health impacts, which are especially relevant to tourists who may prioritize destinations based on environmental conditions. The methodological rigor in the field is also evident, with many studies employing advanced statistical techniques such as regression analysis, structural equation modeling (SEM), and spatial econometrics. These methods provide robust insights into the causative relationships between air pollution and tourism, allowing researchers to quantify the impacts of specific pollutants on visitor numbers, destination image, and tourist satisfaction.

The literature also emphasizes the role of sustainable tourism indicators, such as carbon footprint, ecological impact, and water usage, which provide a broader understanding of the environmental sustainability of tourism practices in polluted areas [62,63]. Sustainable tourism practices are essential in regions with high levels of air pollution, as they can help mitigate negative environmental impacts and improve destination attractiveness. Life cycle assessments and qualitative data analyses are frequently employed to evaluate the environmental footprint of tourism activities, particularly in high-risk areas like China, where urban pollution and tourism growth are closely linked.

The integration of quantitative bibliometric analysis and qualitative content analysis allows for a holistic understanding of the relationship between air quality and tourism. While bibliometric analysis identifies key themes and temporal trends, qualitative insights add depth by exploring the implications of these themes, such as the socio-economic and health impacts on communities and tourists.

Several studies also discuss the effects of air pollution on local communities, particularly in terms of public health and well-being [64,65]. Communities living in heavily polluted areas are often more vulnerable to respiratory illnesses and other health issues exacerbated by poor air quality. This impact extends to tourists who visit these areas, as prolonged exposure to pollutants like SO_2, NO_2, and ozone can lead to adverse health effects. The literature underscores the need for effective policies that balance tourism growth with environmental protection to safeguard the well-being of both residents and tourists [66].

The temporal progression of research topics also reflects a shift in the literature towards a more holistic approach that considers not only environmental indicators but also socio-economic factors, such as community health and economic sustainability. For instance, recent studies have incorporated the impacts of the COVID-19 pandemic, examining how air quality improved during lockdowns and how these changes affected both residents and the tourism industry [67].

This integrated approach allows researchers to explore the broader implications of air quality management for sustainable tourism, particularly in densely populated areas where pollution levels can fluctuate dramatically.

5. Conclusions

The analysis of literature and network visualizations presented in the study emphasizes the link between air quality and tourism, shedding light on how environmental deterioration can shape tourist behavior and influence the sustainability of destinations. As research shows, degraded air quality tends to discourage tourists, lower satisfaction rates, and, ultimately, compromise the economic stability of areas reliant on tourism. The concentration of studies from Asia, especially China, highlights the urgency of tackling air quality issues in regions where high population density and rapid tourism development intersect [63]. The use of rigorous statistical methods in these studies underscores an increasing commitment to understanding and quantifying these impacts, offering deeper insights into the nuanced dynamics that connect tourism and environmental quality.

The past few years have witnessed a marked surge in interest surrounding the intersection of air quality, tourism, and sustainability, reflecting the escalating global concerns about environmental health. There is a growing recognition among researchers and policymakers that economic growth must be harmonized with ecological protection, especially in tourism hubs, where pollution directly affects both visitor numbers and local quality of life. This awareness has led to the development of concepts like circular tourism, which promotes minimal environmental impact, waste reduction, and sustainable practices at every stage of the tourism process. Applying circular tourism principles could represent a substantial shift, bolstering tourism's resilience against environmental threats, including those posed by air pollution.

Adopting a global viewpoint in studying air quality's role in tourism is critical. While much of the current research is Asia-centric, air pollution is a universal issue that impacts destinations across all continents. From metropolitan centers in North America to historical landmarks in Europe and pristine reserves in South America, each region confronts its own pollution-related challenges. Adopting a worldwide approach in research would not only foster the exchange of effective practices, but also equip policymakers and industry leaders to implement adaptable strategies across diverse geographical and socio-economic settings. This is particularly relevant as climate change amplifies environmental issues, necessitating concerted global efforts to address them.

An important insight emerging from this review is the growing role of sustainable tourism indicators in assessing the ecological footprint of tourism activities [68]. Metrics such as carbon footprint, water consumption, and ecosystem health provide valuable insights into the broader environmental impacts of tourism, especially in heavily polluted regions. Integrating these sustainability indicators into tourism planning allows destinations to adopt practices that prioritize environmental integrity alongside economic benefits. This shift supports the tourism sector's transition from an extractive approach to one that actively contributes to ecological preservation and the well-being of local communities [69].

With air quality remaining a pressing concern in urban and industrialized areas, the tourism sector must evolve to meet the expectations of increasingly eco-conscious travelers. Today's tourists are more informed about the health risks of polluted environments and tend to favor destinations that demonstrate a commitment to sustainable practices. This shift is evidenced by a growing body of research that explores how environmental quality influences tourists' decision-making. Transparent communication about air quality and sustainable initiatives can enhance a destination's appeal to travelers who prioritize health and environmental factors in their travel plans.

The literature reviewed also underscores the importance of cross-sector collaboration to address the challenges posed by air pollution in tourism. To develop effective responses, governments, local communities, and tourism operators must collaborate on sustainable policies and practices that reduce emissions, conserve resources, and enhance air quality. This cooperation is especially crucial in densely populated areas where tourism contributes significantly to the local economy [70]. Such partnerships can foster the development of cleaner transportation options, green infrastructure, and comprehensive air quality monitoring systems, creating healthier and more attractive environments for residents and visitors alike.

The COVID-19 pandemic has further accentuated the link between air quality and tourism. Global lockdowns temporarily improved air quality in many regions, offering a glimpse of the potential benefits of reduced pollution. This experience has reignited discussions around sustainable tourism and raised awareness of the possibility of minimizing tourism's ecological footprint. Moving forward, it will be vital for researchers to investigate how insights gained during the pandemic might inform long-term strategies for enhancing air quality in tourism destinations, thereby fostering a more sustainable and resilient tourism industry.

One limitation of this review lies in the range of databases and sources employed. The study mainly depended on specific academic platforms, such as Web of Science, which may

have led to the omission of relevant works from alternative sources, including regional journals, industry publications, and research not published in English. This reliance on a select set of databases could, therefore, affect the overall scope of the review, especially with respect to research conducted in areas that may not be well-represented in global databases. The geographic visualization of study distribution, which uses article counts per country, may not fully reflect the research depth or impact within each region. Some countries with a lower number of studies may host influential, high-quality research, while regions with more studies may lack depth in certain areas. Although this approach provides useful insights, it may not fully capture the complexity of the research landscape.

While our study brings an important perspective to the relationship between air pollution and tourism, delving deeper into the selected articles would add greater depth and clarity to our findings. Moving forward, we aim to expand this analysis to provide a more thorough exploration of the key themes and their significance for the tourism sector.

In conclusion, the interdependence of air quality, tourism, and sustainability demands ongoing research and a collaborative global approach. The rise of ideas like circular tourism indicates a positive shift towards a more environmentally responsible tourism industry, yet considerable efforts are still required. Future studies should aim to broaden the geographic scope of this research, delving into the effects of air pollution in lesser-studied areas and innovating new strategies for sustainable tourism. By fostering a comprehensive understanding of how air quality impacts tourism and adopting proactive measures, stakeholders can help ensure that tourism continues to make positive contributions to both the economy and the environment on an international scale.

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