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# Research on the Factors Influencing the Development of Green Building based on CiteSpace

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## Abstract

**Taking green building as the research subject, this study utilizes CiteSpace software to construct a knowledge map of related literature, using data from the Web of Science database for publications between 2013 and 2023. The analysis is conducted from three aspects: publication volume, research directions, and research hotspots. The study shows that: (1) Green building, as the main approach for energy conservation and emission reduction in the construction industry, has consistently attracted academic attention, with publication volume showing a stable upward trend; (2) Despite rapid developments in both the depth and breadth of research in the green building field over the past decade, research directions are still primarily focused on Environment Sciences Ecology, Engineering, Science Technology Other Topics, and Construction Building Technology; (3) Based on the keywords extracted using the LLR algorithm, 25 influencing factors are identified and categorized into four dimensions: government functions, market environment, construction implementation phase, and building operation phase, in combination with relevant literature. The above research findings provide the foundation for further analysis in the following sections.**

## Keywords

**Green Building; CiteSpace; Visualization Analysis; Influencing Factors.**

## 1. Introduction

With the continuous advancement of society and the acceleration of urbanization, China has become the world's largest carbon emitter [1]. Therefore, reducing carbon emissions and energy consumption in the construction industry has become an urgent task. As a building model that promotes sustainable development, green buildings can maximize the harmony between humans and nature, making it a key pathway to achieving China's "dual carbon" goals [2]. To understand the current research status of green buildings in China, this paper conducts a quantitative analysis of green building research progress using the CiteSpace visualization software, focusing on publication volume and keyword co-occurrence clustering. It systematically reviews the factors influencing the development of green buildings, providing references for subsequent related research.

## 2. Data Sources and Research Methods

### 2.1 Data Sources.

This study uses CiteSpace to analyze literature from the Web of Science (WOS) Core Collection, specifically the Science Citation Index Expanded (SCI), covering the past five years. The search keywords include Green Building, Green Architecture, and Green Construction, with the language set to English and the time span from 2013 to 2023.

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### 2.2 Research Methods.

By using Cite Space to process the imported data, a detailed visual analysis of research hotspots in the field of green buildings was conducted. To ensure the accuracy of the mapping, the time span was set from 2013 to 2023. In the g-index algorithm, the k value was set to 15, and each year was used as a time slice to capture research trends and development trajectories in the green building field across different years.

## 3. Basic Data Statistics and Analysis

### 3.1 Analysis of Publication Volume and Research Directions.

A total of 1,421 articles were retrieved, primarily distributed across the fields of Environmental Sciences Ecology, Engineering, Science & Technology Other Topics, Construction & Building Technology, Energy & Fuels, and Materials Science. The following Table 1 summarizes the leading research directions based on the WOS literature statistics.

**Table 1.** Research directions and quantities with high publication volume in WOS

| Research focus | Volume of literature | Proportion |
|---|---|---|
| Environment Sciences Ecology | 607 | 42.7% |
| Engineering | 569 | 40.0% |
| Science Technology Other Topics | 449 | 31.6% |
| Construction Building Technology | 376 | 26.5% |
| Energy Fuels | 233 | 16.4% |
| Materials Science | 96 | 6.8% |

Note: Some literature in the table involves interdisciplinary research and belongs to multiple research fields, resulting in overlapping proportions and records.

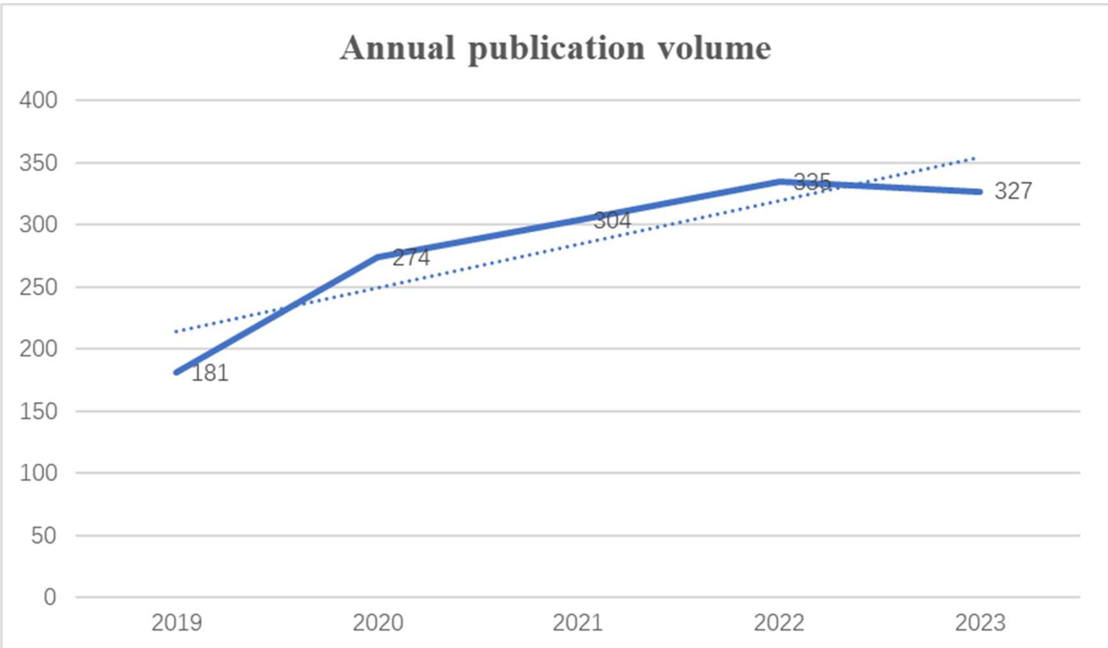


**Figure 1.** Annual publication volume of WOS

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Based on the literature statistics in Table 1, it can be concluded that a considerable number of papers have been published in the fields of Environmental Sciences & Ecology, Engineering, Construction & Building Technology, Materials Science, Energy & Fuels, and Physical Chemistry. Annual publication volume is an important indicator of the research field's popularity and development trends. Over the past five years, the publication volume has shown a steady increase, with a peak in 2022, as shown in Figure 1. This demonstrates that research on green building development has consistently attracted attention from the academic community.

### 3.2 Keyword Co-occurrence Analysis

The analysis of the visualization map includes 280 nodes and 1,554 edges, collectively illustrating the co-occurrence relationships among various keywords in the field of green buildings. Each node represents a research keyword, while the edges indicate the co-occurrence of these keywords in the literature, reflecting their relevance and interconnections in academic research. In the map, colors and node sizes represent the co-occurrence time and frequency of keywords, respectively. The color of a node indicates the temporal distribution of keyword co-occurrence, with color variations reflecting the evolution of research hotspots over time. The size of a node is proportional to the frequency of the keyword's appearance in the literature—the higher the frequency, the larger the node,see Figure 2.


**Figure 2.** WOS keyword co-occurrence table

During the construction of the keyword co-occurrence map, we filtered out keywords with low relevance to the research content to enhance the scientific rigor and accuracy of the analysis. This ensured that the remaining keywords better reflected the core issues and key research directions in the field. After filtering, we further analyzed and organized the remaining keywords, ultimately identifying those with high frequency and centrality greater than 0. These keywords exhibit strong connectivity and influence within the co-occurrence network, highlighting their significance in the research field. The filtering results and statistical information are presented in Table 2.

**Table 2.** List of keywords with high co-occurrence frequency and centrality greater than 0

| Frequency | Degree centrality | Keywords |
|---|---|---|
| 228 | 0.07 | Performance |
| 141 | 0.08 | Design |
| 105 | 0.05 | Management |
| 62 | 0.04 | Built environment |
| 57 | 0.07 | Energy consumption |
| 53 | 0.09 | Consumption |
| 48 | 0.06 | Efficiency |
| 47 | 0.04 | LEED |
| 46 | 0.06 | Energy performance |
| 44 | 0.05 | Health |
| 42 | 0.01 | Technology |
| 35 | 0.02 | Policy |
| 18 | 0.06 | Cost |

Research in the field of green buildings focuses on optimizing building performance, innovative design, and resource efficiency. Key areas include reducing energy consumption and improving energy performance through energy-saving technologies and renewable energy. The design of green buildings emphasizes integration with the surrounding built environment to create eco-friendly spaces. Management research examines lifecycle management to effectively manage energy and resources.Health research in green buildings explores the impact of design on occupant well-being, such as air quality, lighting, and noise. LEED certification serves as a standard for sustainability, while policy studies aim to drive more sustainable construction practices. Cost research focuses on reducing initial investment and operational expenses while maximizing long-term benefits.Overall, green building research is interdisciplinary, combining technology, policy, and management to drive global sustainability in the construction industry.

### 3.3 Keyword Cluster Analysis

The LLR algorithm is employed in this study to perform cluster analysis based on keyword co-occurrence, aiming to identify the focal issues and structural characteristics within the research field. In this clustering analysis, 16 clusters were identified, as shown in Figure 3. The parameters of the map include a modularity value (Modularity Q) of 0.8118 and a mean silhouette value (Mean Silhouette, S) of 0.928. The Q value is used to measure the stability of the generated clustering network, with a Q value greater than 0.3 generally indicating that the detected community structure is significant. The S value measures the similarity of nodes within a cluster, and a cluster S value greater than 0.5 is typically considered reasonable[3].

The LLR algorithm was used to extract all 16 clusters, where the cluster ID represents the position of the keyword, the cluster size indicates the number of keywords included, and the Silhouette value (S) reflects the clustering quality. The keywords with the highest S values in the map are listed in Table 3, which provides a detailed analysis of the clustering results. The S value is used to assess the clustering effectiveness, with higher values indicating better-defined and more cohesive clusters.

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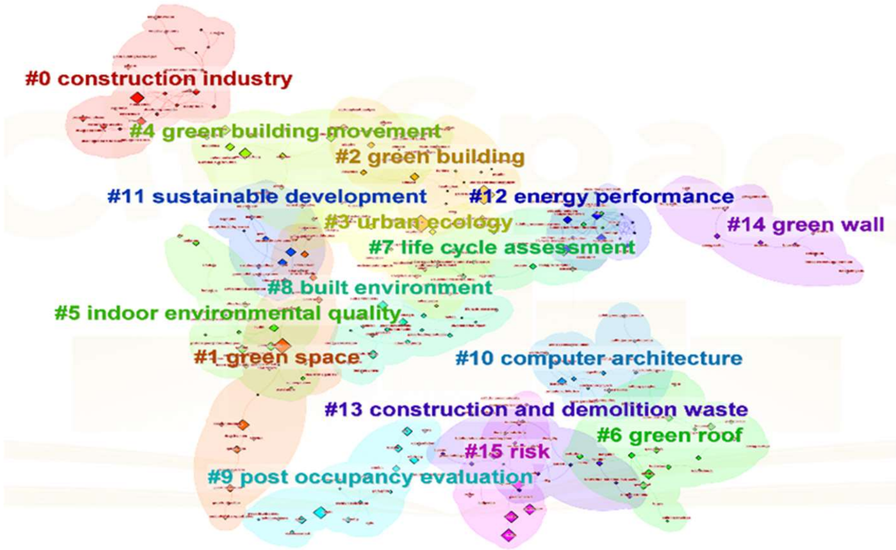


**Figure 3.** WOS Database Keyword Clustering Graph

**Table 3.** WOS Keyword Clustering Statistics Table

| Cluster ID | Cluster Size | Silhouette Value | LLR Algorithm Extracted Keywords |
|---|---|---|---|
| 0 | 25 | 0.934 | construction industry; developing countries; green innovation; barriers; influencing factors |
| 1 | 22 | 0.951 | green space; green buildings; air pollution; multi-objective optimization; built environment |
| 2 | 22 | 0.978 | green building; waste management; wood; recycling; malaysia |
| 3 | 19 | 0.937 | urban ecology; green buildings; environmental sustainability; residential building; double skin facade |
| 4 | 19 | 0.948 | green building movement; university building; green building technologies; occupant behaviors; risk management |
| 5 | 19 | 0.894 | indoor environmental quality; indoor environmental quality; thermal comfort; post-occupancy evaluation; occupant satisfaction |
| 6 | 19 | 0.944 | green roof; green building; urban heat island; green roofs; green facade |
| 7 | 17 | 0.692 | life cycle assessment; sensitivity analysis; triple bottom line; uncertainty analysis; raw-wood assortments |
| 8 | 17 | 0.981 | built environment; green infrastructure; climate change; human health; green building |
| 9 | 17 | 1 | post occupancy evaluation; post-occupancy evaluation; occupant satisfaction; construction view index; segnet |
| 10 | 15 | 0.908 | computer architecture; green computing; green products; cloud computing; environmental monitoring |
| 11 | 14 | 0.944 | sustainable development; green building rating systems; leed; prospect theory; sustainable buildings |
| 12 | 14 | 0.972 | energy performance; energy consumption; energy simulation; green building rating system; BP neural network |

Based on the keyword clustering map and the extracted keywords analysis, it can be concluded that the content under different clustering labels varies significantly. However, from an overall analysis, the results show a strong correlation with the research clusters identified by keyword co-occurrence analysis. By combining the keywords extracted using the LLR algorithm and referencing the literature with high co-citation frequencies listed in Table 3, the factors influencing the development of green buildings are summarized in Table 4.

**Table 4.** Influencing Factors of Green Building Development in WOS Database

| Category | Influencing Factors |
|---|---|
| Government Function Level | Government financial support |
| | Government planning and approval support |
| | Degree of standard and regulation improvement |
| | Government supervision strength |
| | Policy completeness |
| | Government incentives and penalties |
| | Government promotional and guidance efforts |
| Market Environment Level | Economic benefits of green buildings |
| | Supply of green building materials and equipment |
| | Public environmental awareness |
| | Public purchase intent |
| | Competitiveness of construction companies |
| | Market demand |
| | Maturity of the green finance system |
| | Enterprise awareness of green buildings |
| | GDP |
| Construction Implementation Phase | Level of standardized green building design |
| | Level of green construction management |
| | Level of green construction technology |
| | Incremental construction cost for green buildings |
| Building Operation Phase | Energy usage efficiency |
| | Operation and maintenance costs |
| | Building comfort |
| | Operation management level |
| | Green building quality and performance level |

## 4. Conclusion

This study utilizes CiteSpace software to construct a knowledge map based on green building-related literature from the Web of Science database published between 2013 and 2023. The analysis is conducted from three aspects: publication volume, research directions, and research hotspots. Based on the keywords extracted using the LLR algorithm, 25 influencing factors are summarized and

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categorized into four dimensions: government functions, market environment, construction implementation phase, and building operation phase, in conjunction with relevant literature. Currently, various aspects of green building research are covered, but some research topics and areas have yet to be explored in depth, and the mechanism framework remains imperfect. Therefore, there is still room for further development and research in the future.

## References

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