

THE IMPACT OF CLIMATE CHANGE ON BUILDING MATERIALS: BIBLIOMETRIC ANALYSIS AND INNOVATIVE APPROACHES FOR SUSTAINABLE CONSTRUCTION SECTOR

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Abstract

In recent years, increasing population density and the associated rise in construction activity have intensified demand for building materials. This study aims to conduct a bibliometric analysis of research at the intersection of the concepts of “climate change” and “building materials” in the international literature, by examining innovative approaches to identifying the impacts of climate change on building materials. In September 2024, records in the Web of Science (WOS) database covering the years 2019–2024 were analyzed based on criteria such as title, abstract, and keywords. During the review process, various parameters including publication year, author information, subject headings, inter-institutional collaborations, countries, key concepts, and citation relationships were evaluated to create a comprehensive dataset. Data obtained from WOS was imported into the VOSviewer software to conduct co-authorship and co-occurrence analyses. The findings indicate that a significant portion of the studies were concentrated in the 2019–2024 period (394 publications) and that the highest number of publications appeared in journals published by Elsevier (256 publications). By country, Australia (31), Canada (34), and the United Kingdom (38) stand out as the leading countries. In September 2025, records from 2010–2025 in the Web of Science (WOS) database were updated and re-examined using the same method. Within this scope, publications were analyzed in terms of publication year, authors, subject categories, institutional affiliations, geographic origins, key terms, and references. The updated data were imported into VOSviewer, and “co-authorship” and “co-occurrence” analyses were repeated. According to the updated results, the most intensive research on climate change and participation was published between 2010 and 2025 (733 articles), and the largest number of publications (272) appeared in Elsevier sources. The leading countries were identified as the United States (105), China (92), and the United Kingdom (63). These comparative bibliometric analysis results covering 2024 and 2025 reveal the evolution of the international literature on climate change and building materials over time and provide a guiding framework for future studies. The bibliometric network analyses conducted aim to reveal trends in the development of the international literature on climate change and building materials, thereby providing a guiding framework for future research.

Keywords: Climate change, building materials, web of science, VOSviewer, Bibliometric Analysis

1. Introduction

Urban green areas play a crucial role in meeting the physical, mental, and social needs of city residents while also enhancing urban aesthetics and helping to reduce air pollution. In parallel with the social and

ecological importance of urban ecosystems, the ecosystem services approach makes the benefits provided by green spaces more visible [1].

Climate is defined as the average of all weather events observed and recorded over long periods of time in any region of the Earth, as well as the temporal distribution and characteristic features of these events. Climate, similar to weather conditions, can affect and shape people's lives, health, and daily activities in various ways. People try to meet their basic needs such as shelter, nutrition, clothing, and energy production by developing a lifestyle that is compatible with the climate and environmental conditions of the region they live in [2].

Climate change refers to changes in climate observed over specific time periods that result from human activities directly or indirectly affecting the composition of the global atmosphere, and the long-term effects created by these changes [3]. In other words, statistically significant and continuous climate changes over long periods explain the phenomenon of climate change [2]. Continuous and rapid increases in human-induced greenhouse gas emissions are considered the main cause of frequent changes in climate, which gives rise to the concept of "global climate change." In this context, climate change is related to natural meteorological factors, whereas global climate change refers to the comprehensive effects of human activities on climate and the permanent changes these effects create [4].

Climate change is a comprehensive and complex environmental phenomenon that refers to long-term and permanent changes observed in global temperatures and weather patterns. These atmospheric changes profoundly affect the delicate balances of the Earth's climate system, producing significant consequences in many areas, from ecosystems to biodiversity. These changes in our planet's climate can occur due to natural and cosmological causes such as periodic changes in solar cycles, large-scale volcanic activities, and fluctuations in Earth's orbital movements, as well as human-induced activities like intensive use of fossil fuels, extensive deforestation activities, and uncontrolled industrial production. In both cases, the observed effects of these climatic changes on the world ecosystem are quite extensive and long-term. These effects will significantly shape the living conditions not only of today but also of future generations [5].

Throughout the long process since humanity's existence, the Earth's geographical features have undergone several fundamental and irreversible changes. The vast majority of these changes are an inevitable result of natural processes, and these processes have led to significant and permanent changes in the Earth's climate systems over time. In particular, the disruption of the delicate natural balance on Earth due to various internal and external causes during certain periods has triggered and accelerated changes in climate. While the comprehensive effects of these changes on the natural environment can be visibly observed, it is a scientific reality that these processes have had a substantial and multifaceted impact on the human environment. Especially since the 19th century, with the acceleration of industrialization and urbanization, the human factor's contribution to climate change has increased markedly, causing climate change to become more rapid and pronounced [6].

Throughout history, climate change has persisted as a natural process. Although various climatic changes have occurred during different periods of human history, the effects of this phenomenon have become much more pronounced and concerning, especially after the industrial revolution. Following the industrial revolution that began in the middle of the eighteenth century, the increasing and uncontrolled consumption of fossil fuels, particularly resources such as oil, coal, and natural gas, has raised awareness about climate change and led to a more comprehensive and systematic examination of climate change [7]. In this context, one of the most important and direct causes of climate change is greenhouse gas emissions accumulating in the atmosphere. Greenhouse gases cause serious climate changes by triggering global warming due to their ability to trap and retain heat in the atmosphere. In particular, the continuous increase in the atmospheric concentration of gases such as carbon dioxide (CO₂), methane (CH₄), and nitrogen oxides (N₂O) strengthens the greenhouse effect, raising the average temperature of the earth's

surface, which seriously disrupts the delicate balance of the climate [8]. This complex process creates long-term, widespread, and often irreversible effects on both natural ecosystems and human communities. Among the most prominent examples of these effects are the continuous rise in global sea levels, the increase in frequency and intensity of extreme weather events such as severe storms and floods, and irreversible changes in natural ecosystems. These dramatic changes directly affect the construction industry, seriously challenging the performance, durability, and long-term sustainability of building materials. The study emphasizes the importance of using local materials and passive climate-control techniques for durability and energy efficiency in the face of rising temperatures, heavy rainfall/flooding, and wind-related impacts [9].

One of the most important and critical causes of climate change, global warming, and the continuous increase in global temperature is the dramatic rise in carbon emissions in the atmosphere [8]. Looking at societies and scientific communities worldwide regarding this concerning increase, serious and growing unease has emerged about the current levels and rate of increase of greenhouse gas emissions [10]. Particularly, the gradual depletion of limited natural resources such as fossil fuels, along with the high carbon emissions resulting from the intensive use of these finite resources, is causing irreversible and permanent damage to ecosystems and our planet's climate balance [11].

The preference for recycled materials stands out as an important sustainability strategy in the construction sector. Additionally, the use of organic materials such as wood and bamboo, which naturally capture and store carbon, minimizes environmental impacts. The selection of building materials produced and processed with low-carbon energy sources significantly reduces emissions generated during the production process. Furthermore, sourcing materials from local sources to minimize emissions from long-distance transportation is among the most effective and sustainable ways to reduce embodied carbon in buildings [12]. These comprehensive approaches not only reduce the carbon footprint but also contribute to environmental sustainability in multiple ways by strengthening the local economy, increasing employment opportunities, and optimizing resource efficiency.

The concrete effects of climate change, such as the increase in global average temperature, rapid melting of polar ice caps, and consequent continuous rise in sea levels, are causing significant and permanent changes in building materials. These changes can lead to both environmental and structural problems by negatively affecting the physical properties, performance, and long-term durability of materials. To cope with these challenging effects of climate change, the development and widespread use of sustainable, renewable, and low carbon footprint building materials is no longer a choice but a necessity.

In recent years, numerous comprehensive international reports have been prepared that address in detail the effects of climate change on building materials, and important conferences focusing on this issue have been organized [13]. These reports and conferences have scrutinized the durability, sustainability, and environmental impacts of building materials. In this context, international meetings such as COP26 held in Glasgow in 2021, which began under the leadership of the United Nations in 1972, have encouraged the development of comprehensive strategies for the adaptation of building materials to climate change and raised awareness on this issue. However, it should not be overlooked that the main struggle takes place at the urban scale, namely through practices carried out by local governments and communities, and the success of these practices depends on their compatibility with local conditions [13]. When selecting building materials, they must be obtained from sustainable and renewable sources, not harm the environment and preserve ecological balance, while also maintaining their durability against the region's climate conditions, all weather events such as rain, snow, wind, and temperature changes for an extended period. These characteristics ensure the structure's longevity and keep maintenance costs low [14]. The foundation of sustainable housing consists of thinking long-term without cost concerns, preferring environmentally conscious renewable resources, and selecting building materials designed to consume less energy. With this approach, the conscious use and correct selection of construction materials

significantly reduces the natural resource usage burden of the construction sector and is critical for a sustainable future [15]. The aim of this study is to thoroughly examine the multifaceted effects of climate change on building materials through a systematic bibliometric analysis and comprehensively evaluate innovative approaches and solution proposals developed to effectively manage these impacts.

Bibliometric analysis is an effective method for revealing trends in a particular research field over time by quantitatively examining large datasets [16]. This method jointly encompasses performance analysis and science mapping techniques [17]. Performance analysis measures the contribution of research components such as journals [18], countries, authors, articles, and institutions to a given topic and, through various indicators, demonstrates the impact of these contributions [18-19-20]. Science mapping, on the other hand, aims to visualize the structure and dynamics of a scientific field by examining relationships among research components and making the field's structural and intellectual connections visible [19-20]. Within science mapping, methods such as bibliographic coupling, co-authorship, keyword co-occurrence, co-citation, and citation analyses are commonly used. When combined with network analysis, these techniques can reveal, in detail, both the bibliographic output of a field and its intellectual backbone. While the influence of a publication is largely based on its citation count [18], co-authorship analysis sheds light on the social structure of the field; keyword co-occurrence analysis highlights conceptual clusters and temporal trends; and co-citation analysis provides insights into the theoretical foundations of the field and the most influential studies [19-20-21-22]. In recent years, bibliometric analyses have been widely used to quantitatively evaluate the scientific production structure, trends, and development trajectory of specific research areas. For instance, a large-scale study examining the climate change literature analyzed approximately 120,000 publications between 2001 and 2018 and revealed how research themes evolved over time, their geographic distribution, and the main focal areas of the field [23].

Bibliometric studies conducted at the intersection of building materials and climate change emphasize the need for sustainable construction practices and the decisive role of environmental impacts in material selection. The study titled *A Bibliometric Analysis on Life Cycle Assessment of Bricks*, published in *Periodica Polytechnica Architecture* (2023), examined the environmental impacts of building materials through the life cycle assessment (LCA) of bricks and highlighted the importance of sustainable production approaches in reducing emissions [24]. Reviewed 1,827 publications on alternative building materials and demonstrated the importance of integrative approaches in the context of climate change and resource scarcity [25]. Zengin and Yamaçlı (2024) conducted a bibliometric analysis of international studies on climate change in architecture and showed that energy-efficient building design and the effective use of building materials are important for sustainable development [26]. In a bibliometric and content review on carbon emissions in building construction, identified knowledge gaps related to carbon reduction strategies and data statistics and discussed research trends across countries [27]. Li et al. (2025), in a comprehensive review of the environmental impacts of buildings from an LCA perspective, emphasized that research on sustainable building practices has increased markedly in recent years particularly in the United States and China and underlined the growing importance of interdisciplinary approaches [28]. Boros and Tózsér (2023) also bibliometrically demonstrated the rising role of plant-based building materials in combating climate change [29]. In addition, Sökmen Gürçam and Gürçam (2022) analyzed 343 articles published between 1993 and 2021 on climate change and sustainable development using the Scopus database and VOSviewer software, aiming to identify trends, prominent publications, and key authors in the field [30]. Although there is a substantial body of literature addressing the relationship between climate change and the building sector, a significant portion of these studies focuses on themes such as technical performance, energy efficiency, or carbon emissions. By contrast, studies that map this literature comprehensively and systematically using bibliometric methods remain limited. Unlike existing bibliometric analyses, the present study aims to fill this gap by addressing both long-term trends and current research dynamics together.

2. Materials and Methods

The core material of the research consists of international academic articles and detailed studies in the literature that include comprehensive work in the fields of climate change and building materials. These studies represent an extensive knowledge base examining sustainable building materials and the effects of climate change on the construction industry.

In September 2024, records from 2019-2024 in the Web of Science (WOS) database were meticulously examined and summarized with limitations to title, abstract, and keywords. The content of these studies was analyzed through a comprehensive dataset including factors such as publication year, authors, subject categories, institutional affiliations, geographical origins, key terms, and references. Data obtained from the (WOS) database was transferred to the VOSviewer program, and "co-authorship" and "co-occurrence" analyses were performed with the obtained data.

Within the methodological framework of the study, a comprehensive literature review was conducted in the Web of Science (WOS) database in September 2024. This review includes 23 articles selected for detailed examination, covering a five-year period between 2019-2024. In the systematic selection process of the articles, the keywords "climate change" and "building materials", which constitute the focus of the research, were used as the basis. As a result of the detailed search conducted in the Web of Science database, a comprehensive analysis of 394 articles containing the topics of "climate change" and "building materials" was performed. During this analysis process, various parameters such as the keywords of the articles, author profiles, distribution by years, classification of research topics, distribution of publishing institutions, and geographical distribution of the countries where they were published were examined in detail.

Within the scope of the study, a total of 733 articles published between 2010 and 2025 in the Web of Science (WoS) database were analyzed as of September 2025. The articles were retrieved using the keywords "climate change" and "building materials." Based on this search, bibliographic information was compiled for the 733 publications, including keywords, authors, yearly distribution, subject categories, institutions, countries, and sources (journals). Using these data, a bibliometric analysis was conducted, examining indicators such as number of publications, citation counts, keyword patterns, and research trends.

Bibliometric studies are characterized by the statistical analysis of academic literature [31]. Note that the number of articles and authors, as well as the productivity of authors, countries, and journals, constitute key indicators in bibliometric evaluation. To identify prominent subject areas and patterns, studies may also examine journal subject indexes using content analysis techniques [32]. In this study, VOSviewer (version 1.6.20) was employed to visualize relationships among countries, institutions, and author keywords through network structures, clusters, and linkages. In addition, complementary analyses and advanced statistical evaluations were performed using Bibliometrix (an R package). To assess research trends in the fields of climate change and building materials more comprehensively, two different time windows (2010-2025 and 2019-2024) were adopted. The 2010-2025 period was selected to reveal the long-term development, structural evolution, and overall growth trajectory of the WoS literature. This broad time span enables the identification of historical patterns, the analysis of overarching trends, and the tracking of changes in research intensity over time. In contrast, the 2019-2024 period was treated as a separate analytical window to examine current research dynamics in greater detail. This shorter interval allows a clearer assessment of rapid changes in publication output, emerging research themes, and potential disruptions that may influence scientific production. Using these two time scales together provides a multidimensional framework that enables the simultaneous analysis of macro-level long-term trends and micro-level recent developments. This approach facilitates cross-period comparisons, strengthens the analytical rigor of the study, and contributes to grounding the findings on a more robust basis.

The bibliometric analysis conducted using literature review results reveals current trends and developments in the research field. In this context, the Web of Science (WOS) database, which was preferred for bibliometric analysis, has been evaluated as a comprehensive and reliable source that meets the academic requirements and quality standards of the research [16]. The detailed bibliometric analysis provides a multidimensional evaluation that includes quantitative assessment of publications, citation performances, frequency of keyword usage, and changes in research trends over time. Advanced bibliometric analysis software such as VOSviewer was used for effective visual representation and trend analysis of research findings, thus making the data more comprehensible and interpretable. As shown in Figure 1, the flowchart of the bibliometric analysis using VOSviewer is presented.

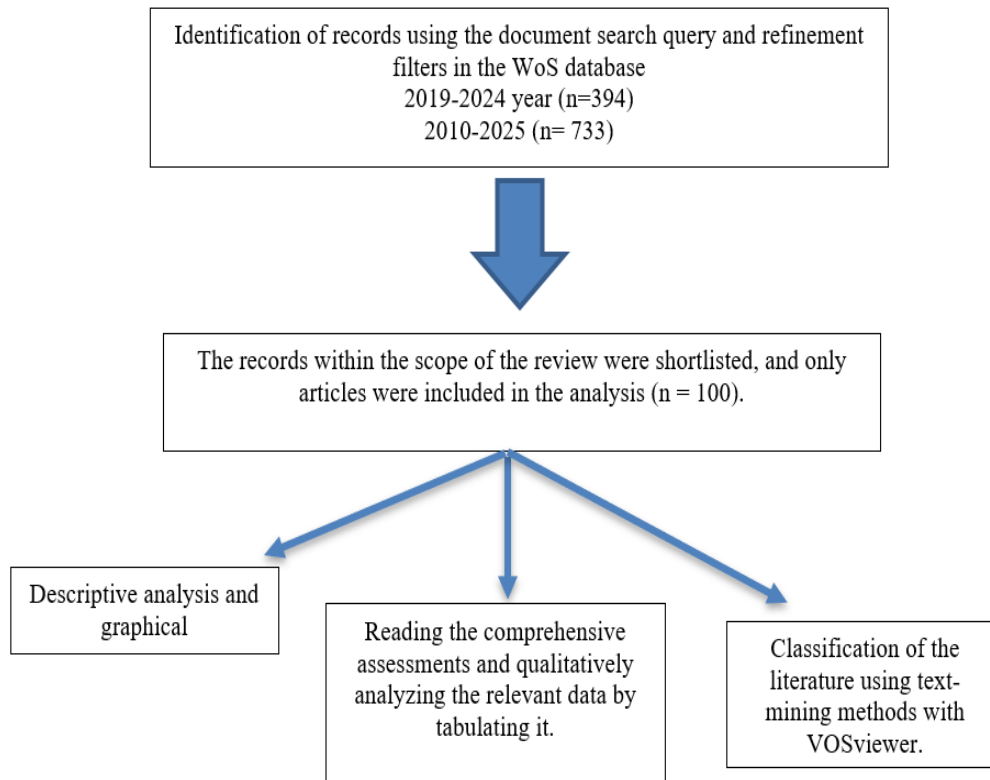


Figure 1. Flowchart of the bibliometric analysis using VOSviewer [22].

The total number of publications, most-cited articles, total citations, productive authors, countries, and universities were included in the performance analysis. Scientific mapping (network analysis) and VOSviewer were used to visualize co-citation networks. Bibliometric analysis is frequently used in conjunction with the network visualization application VOSviewer [18-33]. The flowchart of the entire process is illustrated in Figure 1.

2.1. Identification of Keywords

To find articles containing “climate change” in their titles and keywords, the original search used TITLE-ABS-KEY (“climate change” and “Building Materials”), PUBYEAR>2020, LIMIT-TO (LANGUAGE, “English”), and LIMIT TO (DOCTYPE, “article”) were set. The search strategy adopted by the researcher for the bibliometric analysis is presented in Table 1.

Accordingly, terms such as “climate change” and “Building Materials,” as well as “global warming,”

“concrete,” “steel,” “sustainable materials,” “climate crisis,” OR “construction material,” OR “concrete,” OR “steel,” OR “timber,” OR “sustainable material,” OR “low-carbon material” were also included. Consequently, the search string used in the titles and abstracts is as shown in Table 1.

Table 1. Search strategy adopted by the researcher for bibliometric analysis.

Stages	Inclusion criteria	Results obtained	Exclusion criteria
Stage 1	Search term: Database: Web of Science “climate change” and “Building Materials” Date: 6 March 2025	Number of documents = 733	No exclusions were applied at this stage.
Stage 2	2010-2025 (last 15 years)	Number of documents = 100	1996-2020
Stage 3	Source type: Journal article	Number of documents = 114	Book, book series, book chapter, conference proceeding
Stage 4	Keywords	Number of documents = 114	“climate change” and “Building Materials” “Global warming”, “concrete”, “steel”, “sustainable materials”, “climate crisis” OR “construction material” OR “concrete” OR “steel” OR “timber” OR “sustainable material” OR “low-carbon material”
Stage 5	Language: English	Number of documents = 720	French, Portuguese, Chinese, Czech

2.2. Initial Search

On September 6, 2025, at 17:53, data were retrieved from Web of Science by the researcher using the keywords “climate change” and “Building Materials,” applying the specified year range as well as the language and publication type filters. The initial search yielded 733 documents; these documents were then narrowed down according to the standards specified in the following sections.

2.3. Inclusion and Exclusion

Out of a total of 733 records, articles, conference papers, final papers, book reviews, book chapters, books, and notes were excluded. The initial results were published in the following languages: English (720), German (6), Spanish (3), Chinese (1), Korean (1), Portuguese (1), and Russian (1). Only articles written in English were included in the analysis. Using the applied method, 442 articles published between 2021 and 2025 were identified. Figure 2 presents the Web of Science interface as the research field.

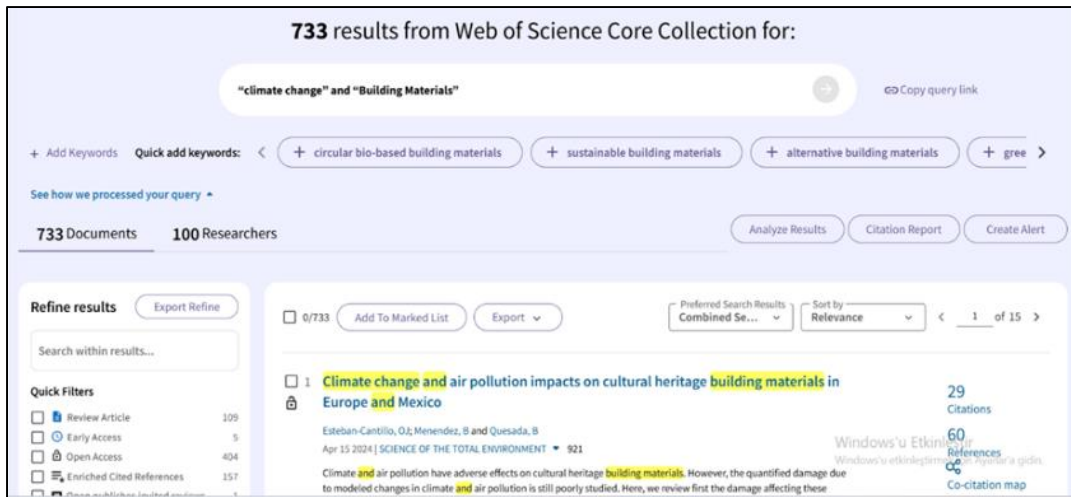


Figure 2. The Web of Science interface as the research domain.

3. Findings

Within the framework of a comprehensive keyword distribution analysis conducted in Web of Science, scientific studies forming the intersection of the concepts of “climate change” and “building materials” among the research indexed in Web of Science database's academic indices have been examined in detail. This examination includes a systematic evaluation of these studies in terms of various parameters such as publication year, author profile, institutional distribution, citation count, and subject areas. These parameters include the chronological development of publications, researchers' contributions, thematic focuses of studies, institutional outputs, international distributions, and source diversity. This analysis reveals the research trends and scientific productivity in the field in detail.

In the first phase, the chronological distribution analysis showing the development and change over time of research in the fields of “climate change” and “building materials” indexed in the Web of Science database indexes is presented in detail in Figure 3.

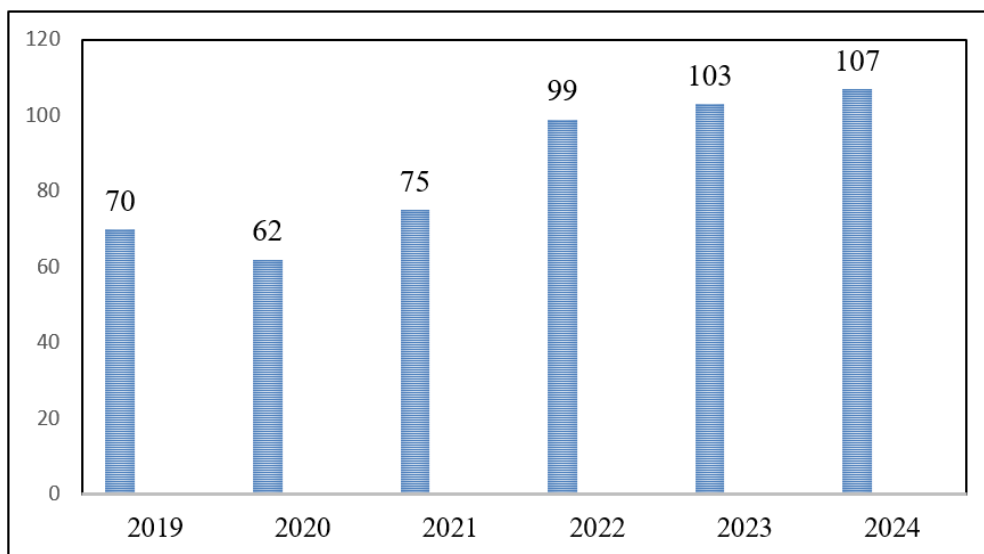


Figure 3. Distribution of publications by years (Web of Science between 2019-2024).

Figure 3 presents a detailed distribution of academic publications in the Web of Science database that address both climate change and building materials. When examining the publication distribution by year, the data in international literature clearly reveals the scope, intensity, and interrelationships of research activities across different periods. Particularly during the period between 2019-2024, the change and development process in research performance creates a notable graph. Detailed data analysis shows that research activity, which recorded an initial value of 70 units in 2019, unexpectedly declined to 62 in 2020. Subsequently, it entered a sustainable and stable upward trend starting from 2021. Various factors are thought to have contributed to this decline observed in 2020, including global environmental conditions, economic fluctuations, or sectoral challenges. However, the measurement value of 75 recorded in 2021 was a clear indication that a strong recovery and renewal process had begun in the research field. This positive development continued gaining momentum, and the number of research publications rose to 99 in 2022. This increase represents an impressive growth rate of 32% compared to the previous year, which clearly demonstrates the research dynamism and intensity of academic interest in the field. Although the growth rate relatively moderated to more modest levels in the following period, research numbers reaching 103 in 2023 and 107 in 2024 have been a strong indicator of sustainable progress and continuity of academic studies in the field.

Upon general examination, it is clearly evident that the graph shows a stable and continuous growth trend, except for the temporary decline period experienced in 2020. This positive trajectory clearly demonstrates that the evaluated indicator has successfully overcome the negative effects of the crisis period and completed its recovery process by entering a sustainable growth trend thereafter. However, upon careful assessment, it is observed that the growth rate has shown a significant slowdown in 2023 and 2024. This slowdown trend raises some questions about the sustainability of growth in the upcoming periods and indicates the necessity of comprehensively addressing potential limiting factors. In this context, a detailed analysis study will make significant contributions to understanding the fundamental dynamics of the relevant sector or field more deeply and establishing future projections on a more solid foundation.

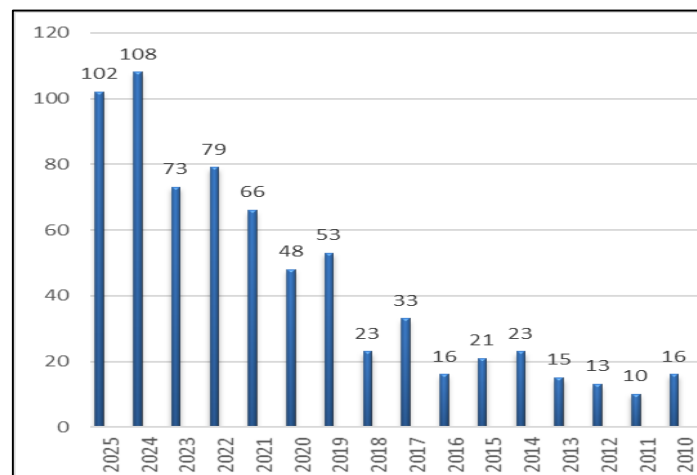


Figure 4. Distribution of Publications by Year (Web of Science, 2010-2025).

Figure 4 shows the distribution of publications in the Web of Science database for studies addressing both Climate Change and Construction Materials between 2010 and 2025. An examination of the distribution by year reveals that the data in the international literature highlights the intensity and proportions of research activities across different years. The year 2024 accounts for the highest share, comprising 14.734% of the total studies. This indicates a significant increase in research activity or a publication surge in 2024. The year 2025, with a 13.915% share, hosted 102 studies; this indicates that the

year also had high research activity but showed a limited decline compared to 2024. The years 2018 and 2014 each accounted for 23 studies, representing a 3.138% share; this indicates that these years were also active in terms of research, though they did not reach as high a share as 2024 and 2025. In 2011, however, only 10 studies were observed, representing a rate of 1.364%; this indicates that the year represented a notably low level of research activity.

When the annual publication performance covering the 2019-2024 period is evaluated alongside the overall distribution for the 2010-2025 period, it becomes clear that academic output in the fields of climate change and construction materials exhibits dynamic short-term fluctuations but shows a distinct upward trend in the long term. When these two periods are considered together, it is observed that research output, which was relatively low at the beginning of the 2010s, has increased over time and gained momentum particularly after 2020. The rapid increase during the 2019-2024 period confirms that the field has attracted more academic interest in recent years, reflecting the general trend of the 2010-2025 period.

However, when the slowing growth rate in 2023 and 2024 is evaluated alongside the partial decline in 2025, it is suggested that research output may be approaching a saturation point or that new research directions may be needed. In conclusion, when both datasets are considered together, it is evident that the field of climate change and building materials is a research area that is increasingly robust but has entered a more balanced growth trajectory in recent years.

Based on detailed analyses conducted in the Web of Science (WOS) database, significant findings have been obtained when examining the number of academic publications in the fields of “climate change” and “building materials”. In this comprehensive evaluation, it is observed that researcher Caldas Lucas Rogerio, who works at the Federal University of Rio de Janeiro, one of Brazil's leading academic institutions, has achieved significant success. Rogerio stands out as the most productive researcher with 6 academic publications in this field and makes important contributions to the literature Figure 5 and Figure 6.

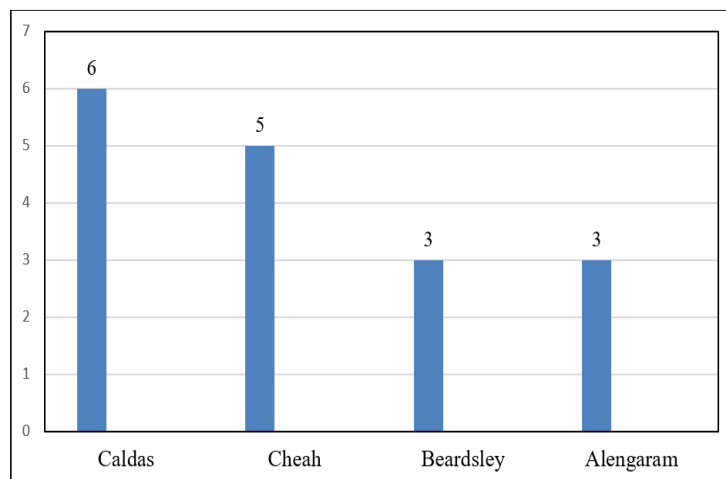


Figure 5. Distribution of publications by authors (Web of Science between 2019-2024).

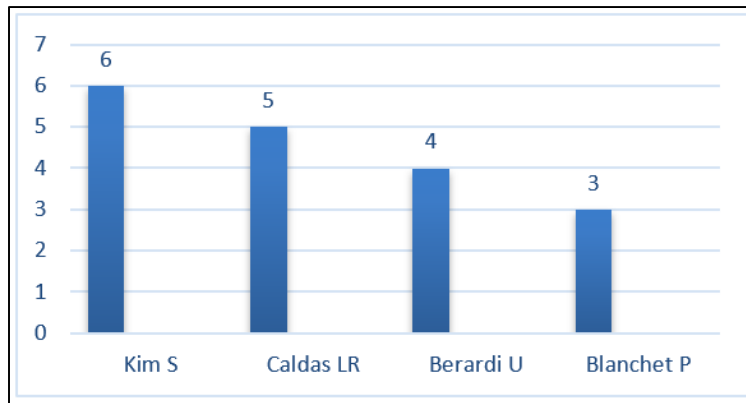


Figure 6. Distribution of publications by authors (Web of Science between 2010-2025).

When studies using the concepts “Climate Change and Construction Materials” together were evaluated based on the number of publications using data from indices indexed in the WOS database, it was found that Sumin Kim, who is affiliated with Yonsei University at the Institute for Basic Science - Korea (IBS), ranked first with 6 studies.

In the detailed data obtained from academic indices comprehensively scanned in the Web of Science database, scientific studies that jointly address the concepts of “climate change” and “building materials” have been systematically examined and categorized according to research areas. This categorization demonstrates the intensity of use of these concepts across different disciplines and their distribution in academic studies. The distribution of publications by research areas is given in Figure 7 (Web of Science, 2019–2024).

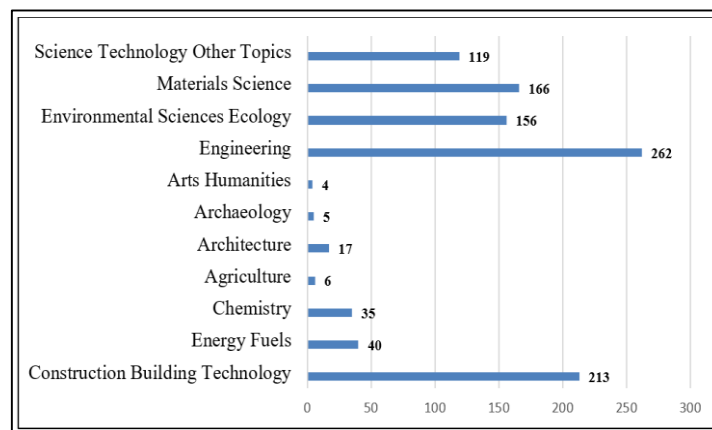


Figure 7. Distribution of publications by research areas (2019-2024 Web of Science).

The above data shows the detailed distribution rates of publications by disciplines for a specific academic institution or field and how this distribution shapes the institution's research profile. Engineering has the highest publication rate with a total of 262 publications and an impressive share of 50.775%. This ratio clearly demonstrates that more than half of the institution's research activities are concentrated in the engineering discipline, where it has developed strong expertise. Construction Building Technology ranks second with 213 publications and a significant proportion of 41.279%, holding a strong position in the institution's research portfolio. While Materials Science ranks third with a notable rate of 32.171%, Environmental Sciences Ecology demonstrates the institution's substantial academic contribution to sustainability and environmental issues with a rate of 30.233%. Looking at more specific

fields with relatively lower publication rates, basic sciences such as Energy Fuels at 7.752%, Chemistry at 6.783%, and Physics at 4.264% stand out. Although these fields occupy a more limited space in the institution's research portfolio, they provide an important foundation for interdisciplinary studies. While the field of Architecture makes a more modest contribution with a rate of 3.295%, the limited publication output in fields such as Agriculture (0.969%), Archaeology (0.969%), and Arts-Humanities (0.775%) indicates that the institution still has development potential in these areas. This comprehensive distribution analysis clearly shows that the institution's research priorities are largely concentrated in applied and technological fields such as engineering, construction technology, and environmental sciences. Although the relatively low number of publications in basic sciences and social sciences shows that the institution has limited academic output in these areas, this situation also presents an important opportunity for establishing interdisciplinary balance and expanding the research portfolio. Future strategic investments and collaborations in these areas could further enrich the institution's academic profile and increase its research impact. Figure 8 shows the distribution of publications by research areas for the 2010-2025 period based on Web of Science data.

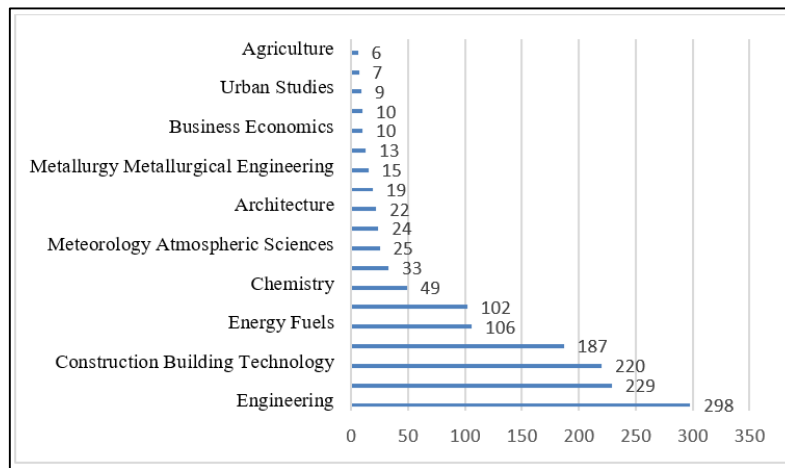


Figure 8. Distribution of publications by research areas (2010-2025 Web of Science).

It was found that the highest share belonged to the field of Engineering (n = 298), while the lowest shares were observed in Agriculture, Archaeology, and Arts & Humanities Other Topics (n = 6 for each). Comparing the 2019-2024 data with the 2010-2025 period shows that Engineering sits at the center of the research profile in both time intervals. In 2019-2024, Engineering had a more dominant weight; in 2010-2025, although it maintained its leadership in terms of publication count, the relative intensity appeared to be distributed somewhat more evenly. Similarly, the fact that Construction & Building Technology and Environmental Sciences & Ecology rank highly in both periods indicates that the field continues to follow an applied, sustainability-oriented research trajectory. The increased visibility of areas such as Materials Science and energy in the long-term dataset also suggests that research themes have diversified over time.

Based on a comprehensive literature review conducted in the Web of Science database, the global distribution of academic studies using the keywords "climate change" and "building materials" together has been examined in detail. The data showing the intensity and geographical distribution of these studies across different countries have been systematically analyzed, and the results are visually presented in Figure 9. This distribution clearly demonstrates the importance of the subject in international academic literature and the research contributions of different countries in this field.

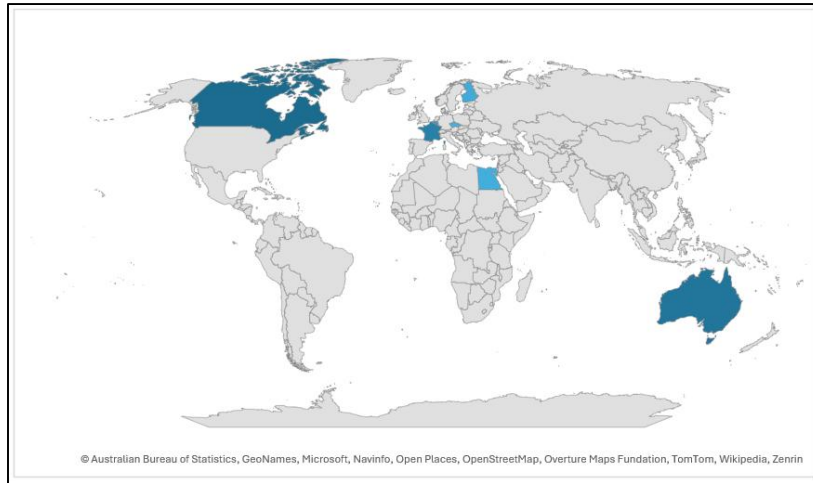


Figure 9. Distribution of publications by countries (Web of Science between 2019-2024).

The map provides a detailed geographical distribution of scientific and academic publication activities across countries worldwide. Countries marked in blue tones represent the major regions that are significant in terms of publication numbers and included in the analysis. According to the results based on comprehensive data analysis, among the countries with the highest publication numbers, the United Kingdom (38 publications), Canada (34 publications), and Australia (31 publications) stand out remarkably. The advanced research infrastructure, modern laboratory facilities, and strong international collaboration networks possessed by these countries are considered as the key determinants of these high publication numbers.

In the European continent, countries with well-established academic traditions, particularly Germany (29 publications) and France (27 publications), provide significant and sustainable contributions to the continent's scientific output. However, countries such as Belgium (17 publications), Finland (13 publications), and the Czech Republic (11 publications) produce publications at lower levels. Nevertheless, this distribution reflects an expected and reasonable pattern when considering these countries' geographical sizes, population densities, and existing research capacities.

From developing regions, countries such as Brazil (16 publications) in South America and Egypt (12 publications) in Africa have also been evaluated, and these countries are making significant contributions to the increase in scientific production and diversification of academic studies in their respective regions. This detailed mapping study effectively and clearly visualizes the global distribution of publication numbers, distinctly revealing the geographical diversity of scientific publications and the regions where academic production is concentrated.

The differences in publication numbers between countries directly reflect each country's scientific research capacity, available economic resources, technological infrastructure, and level of access to international collaborations. When making a general assessment, as shown by the map data, research and publication production activities are primarily concentrated in developed countries, however, it is observed that developing regions are making increasingly substantial and higher quality contributions to scientific production. The distribution of journals publishing academic articles in the field of building materials and climate change is given Figure 10.

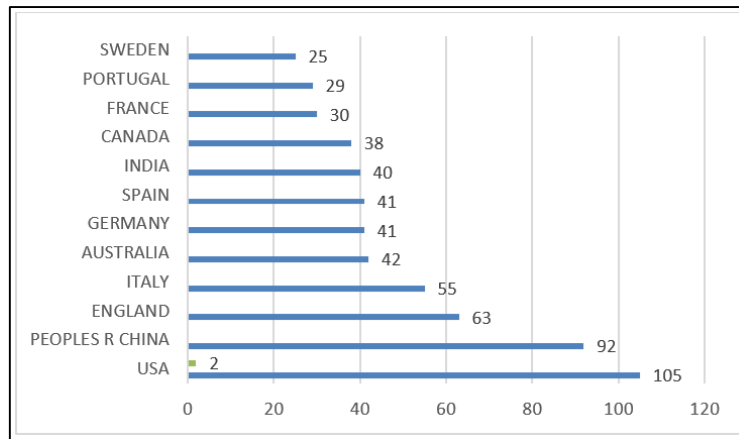


Figure 10. Distribution of journals publishing academic articles in the field of building materials and climate change.

Bibliometric analyses reveal the geographical distribution of scientific output in the relevant field. Among countries, the United States provides the highest research contribution, accounting for 14.33% of total publications. It is followed by the People's Republic of China (12.55%), the United Kingdom (8.60%), and Italy (7.50%). These findings indicate that these countries make substantial scientific contributions to the building materials literature in the context of climate change and sustainable development and occupy a leading position in the field's research output. By contrast, countries with the lowest publication contributions include Norway (1.91%) and Saudi Arabia (1.77%), whose shares of total output remain limited. Overall, the distribution suggests that scientific output is not geographically balanced and that the influence of certain countries on the field is more pronounced.

A comparison of the 2010-2025 and 2019-2024 periods shows that the share of North American and Asian countries in global academic production has increased. While countries such as the United Kingdom, Canada, and Australia were relatively more visible in the earlier period, the overall assessment for 2010-2025 indicates that the leadership of the United States and China has strengthened, whereas the contribution of European countries has remained stable. At the same time, a modest increase in the publication share of developing countries points to the role of improvements in research infrastructure and international collaboration networks in shaping scientific output.

Based on comprehensive research conducted in the Web of Science database, the institutional distribution of scientific studies using the keywords "climate change" and "building materials" together in academic literature has been analyzed in detail. The results of this analysis are visually presented in Figure 11 to show the contributions and research intensity of different research institutions. This distribution clearly demonstrates which institutions take a leading role in this research field and the extent of institutional interest in the subject. The distribution of publications by publishing institutions is given Figure 11 (Web of Science between 2019-2024).

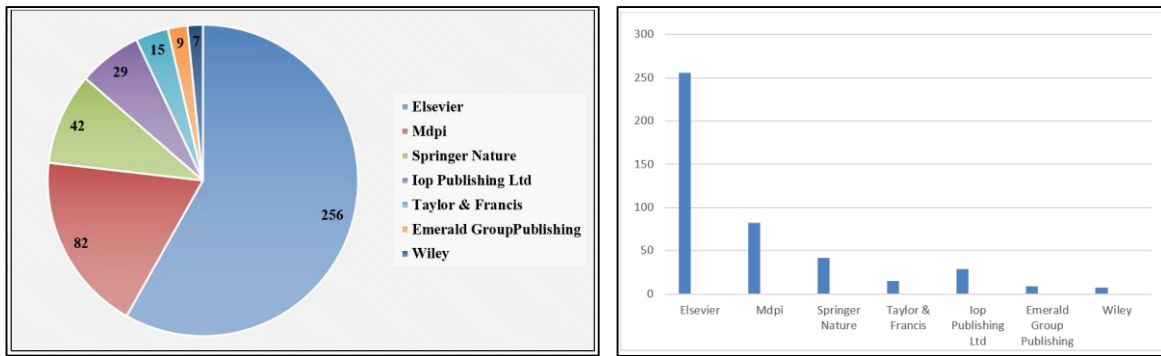


Figure 11. Distribution of publications by publishing institutions (Web of Science between 2019-2024).

The data comprehensively shows the detailed distribution of academic publications across different publishers and their contribution rates to the total scientific literature. In light of the analyzed data, Elsevier provides the largest and most notable contribution, constituting nearly half (49.612%) of total publications; this significant proportion clearly demonstrates that the publisher is the most preferred and trusted platform by researchers and academics. MDPI, ranking second in the publishing market, maintains its presence with a notable rate of 15.891%, while Springer Nature, with its well-established history, maintains its third position with an 8.140% share. Other significant actors in the academic publishing ecosystem include prestigious institutions such as IOP Publishing Ltd (5.620%), the well-established academic publisher Taylor & Francis (2.907%), Emerald Group Publishing, which stands out in management and business (1.743%), and the multidisciplinary publisher Wiley (1.356%). This comprehensive distribution analysis clearly shows that large and established publishers like Elsevier are undisputedly the dominant choice for research articles and that such institutional publishers make a very significant contribution to global scientific literature. While leading publishers like MDPI and Springer Nature also provide notable and sustainable contributions to scientific publishing, the relatively lower rates of other publishers indicate that academic publications have a relatively limited volume on these platforms. In conclusion, this diversity and differentiation shown by publishers clearly emphasizes that today's research activities have a multidisciplinary, dynamic, and global structure; however, the marked dominance of large and institutional publishers unequivocally demonstrates the effectiveness and market dominance of certain publishers in the academic world. The distribution of journals publishing academic articles in the fields of construction materials and climate change is given Figure 12.

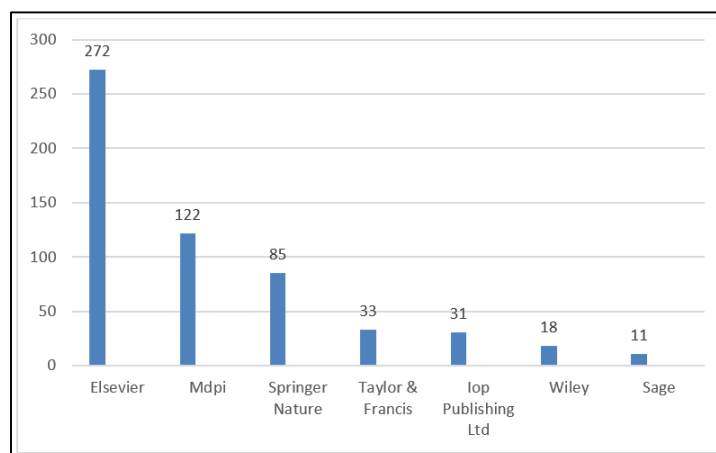


Figure 12. Distribution of journals publishing academic articles in the fields of construction materials and climate change.

Bibliometric analyses also reveal the distribution of journals in which academic publications in the fields of building materials and climate change are published. The data indicate that Elsevier is by far the leading publisher (272 publications, 37.11%), followed by major publishers such as MDPI (122 publications, 16.64%) and Springer Nature (85 publications, 11.60%). Publishers with a moderate level of contribution include Taylor & Francis (33 publications, 4.50%), IOP Publishing Ltd (31 publications, 4.23%), and Wiley (18 publications, 2.46%). In addition, Emerald Group Publishing (12 publications, 1.64%), Sage (11 publications, 1.50%), and other smaller publishers account for a relatively small share of the total number of publications. Overall, this distribution clearly demonstrates the dominant position and influence of major publishers in academic production, while also indicating that smaller publishers' contributions remain limited but still support diversity in the literature.

A comparison of the 2010-2025 and 2019-2024 periods shows that the share of North American and Asian countries in global academic output has increased, with the United States and China assuming leading positions, while European countries have maintained their contributions in a relatively stable manner. In terms of publishers, Elsevier, MDPI, and Springer Nature continue to retain their dominant positions, whereas the share of small and mid-sized publishers remains limited. These findings suggest that academic production is becoming more geographically diversified worldwide, yet major countries and large corporate publishers still play a central role in shaping the field.

4. Visualization of Studies on “Climate Change” And “Building Materials” In The Web of Science Database Using Vos viewer Mapping Technique

Comprehensive research conducted on the Web of Science database focuses particularly on “climate change” and “building materials” topics, enabling detailed analysis and visual presentation of commonly used keywords in these fields through the VOSviewer program. As shown in detail in Figure 13, the complex network map created using VOSviewer software clearly reveals the co-occurrences, connections, and relationship levels of keywords with each other. In this comprehensive analysis, keywords have been divided into 6 different main clusters based on their relationships with each other, with the importance and weight of each cluster represented by circles of different sizes in the visual map. As a result of detailed examinations, it has been observed that there is an intensive accumulation of academic studies on climate change as the main focus of research, and it has been determined that particularly the keywords "climate change" and "life cycle assessment" stand out as the most frequently referenced and highest-interaction keywords of publication distribution by keywords for climate change and building materials research is given in Figure 13. in the literature with a remarkable connection strength of 337. The bibliometric network analysis

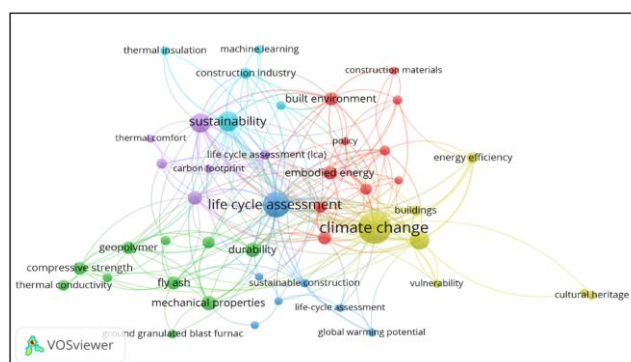


Figure 13. Bibliometric network analysis of publication distribution by keywords for climate change and building materials research.

Keyword analysis reveals thematic trends in the research field, indicating that concepts such as “sustainable materials,” “carbon emissions,” and “energy efficiency” have become increasingly prominent in recent years. It also notes a relative decline in studies focusing on traditional building materials. Overall, the temporal analysis shows that the research focus is progressively shifting toward sustainability and low-carbon materials. The bibliometric network analysis of the publication distribution by country for climate change and building materials research is given Figure 14.

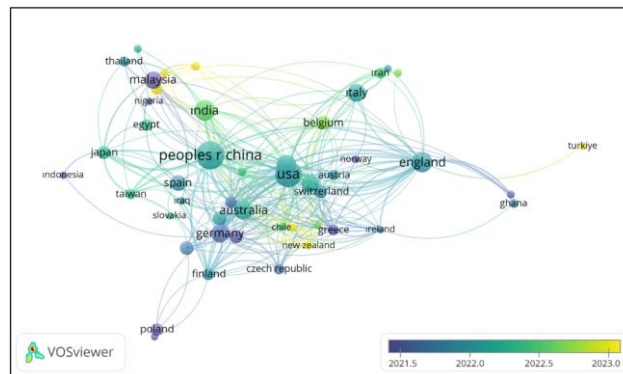


Figure 14. Bibliometric network analysis of the publication distribution by country for climate change and building materials research.

As a result of comprehensive research on climate change and building materials, a detailed network map showing global academic collaborations and research relationships has been created (Figure 7). In this visual analysis, circles representing different countries are used, where each circle's color represents a specific country group, and circles of the same color indicate countries belonging to the same research cluster. The map reflects in detail the academic interactions, citation relationships, number of joint publications, and levels of collaboration between countries. In creating the dataset, criteria were established requiring a minimum of 2 academic studies and at least 2 citations for each country. This comprehensive network map provides an in-depth analysis of international collaborations in the field of climate change and building materials and reveals the structure of academic relationships between countries. The connections created between circles demonstrate the intensity of academic citations between countries and the scope of joint research projects. The color coding serves as an important visual guide in grouping countries with similar research approaches and methodologies. Through this detailed visual analysis, global research trends, collaborations, and the structure of academic networks in the field of climate change can be understood more clearly.

A total of 95 countries meeting the research criteria have been identified and grouped under three main clusters. The leading members of the first cluster, marked in dark green, include the USA, Canada, and Switzerland. The second cluster, shown in purple, includes important research centers such as Germany, Greece, and Malaysia. The third cluster, represented in yellow, includes actively researching countries such as Turkey, New Zealand, Pakistan, and Saudi Arabia. The most striking feature on the map, the large green ring, clearly demonstrates the USA's dominant role in this field and its extensive cooperation network with other countries. This detailed visual analysis effectively visualizes the intensity of global academic collaborations and the complex network of relationships.

Climate change is causing various environmental changes worldwide by affecting weather patterns, including temperature increases, extreme weather conditions, sea level rise, and drought. In this context, construction materials used in the building sector are being re-evaluated in terms of sustainability and environmental impacts, and the resilience of these materials against climate change is being enhanced.

Recent bibliometric analyses examine trends in the literature aimed at minimizing the environmental impacts of building materials, showing that a significant portion of research in this field focuses on energy efficiency, low carbon footprint, and the use of recyclable materials. Additionally, tools like VOSviewer enable us to better understand global efforts toward developing more environmentally friendly and climate-resilient materials for buildings by mapping these research trends in academic literature. These analyses play a critical role in designing structures and selecting materials in a way that will contribute to the fight against climate change.

5. Conclusion

Bibliometric analysis studies reveal in detail the multifaceted effects of climate change on building materials and the critical research topics in this field. This study aims to make a concrete contribution to sustainable construction goals by providing comprehensive knowledge and systematic guidance on building materials and implementation strategies to effectively combat the challenges posed by global climate change. The main objective of the study is to contribute to the development of solutions that will support environmental sustainability in the construction sector. In this context, the study aims to conduct a detailed bibliometric analysis of academic studies at the intersection of “climate change” and “building materials” concepts in international literature and to reveal research trends in this field.

Based on the comprehensive literature review, it is observed that various innovative approaches have been developed to enhance the durability of construction materials and ensure environmental sustainability, and these approaches are gaining increasing importance. In particular, research focuses on topics such as smart building materials that can dynamically adapt to changing climate conditions, recyclable materials that minimize environmental impact, and efficient building systems that optimize energy consumption. It is emphasized that future research should prioritize comprehensively evaluating the performance of these innovative technological solutions under different climate scenarios and transforming the findings into industrially scalable solutions.

The data obtained from the study presents various factors related to academic publishing in a comprehensive and systematic manner. Upon detailed examination, the analyses conducted over the years clearly reveal a remarkable and continuous upward trend from 2019 to 2024. The process in question began with 70 academic publications in 2019, showing a steady increase in subsequent years to reach 107 publications in 2024, thus recording a significant growth of 52% over the five-year period. This noteworthy upward trend serves as a concrete indicator of intensive research activities and academic production, particularly in applied sciences such as Engineering and Construction Technology. Looking at the 2024 data, it is clearly evident that this upward trend continues to strengthen, indicating that academic production has gained sustainable momentum and is expected to maintain this momentum in future periods.

In detailed country-based assessments, it is clearly evident that certain countries demonstrate significant superiority in terms of academic publication output. Countries with advanced research ecosystems, particularly Australia, Canada, the United Kingdom, and France, exhibit remarkable performance in both quantity and quality. Among these countries, Australia and Canada stand out as the most influential actors in the field, each with over 30 high-quality publications, demonstrating sustainable academic production capacity. The United Kingdom and France make significant contributions to scientific literature through their research infrastructure supported by well-established universities, modern research centers, and strong academic traditions. On the other hand, countries with developing academic systems such as Brazil, Egypt, the Czech Republic, and Argentina maintain more limited publication numbers, indicating that these countries' current academic production capacities and research

opportunities are relatively lower. The expansion and support of research activities in these countries is important for achieving a more balanced distribution of global academic production.

When conducting a detailed analysis in terms of disciplines, technical and applied fields such as Engineering, Construction Technology, Materials Science, and Environmental Sciences stand out as the main research areas that constitute the majority of academic publications. When these disciplines are evaluated both quantitatively and qualitatively, they make up a significant portion of total publications and represent an important part of research output. The concentration in these fields is particularly notable in terms of industrial applications and technological developments. In contrast, studies in more specific and basic sciences such as Chemistry, Physics, and Energy have a relatively limited share within the total research volume. This characteristic distribution clearly demonstrates that scientific research is predominantly concentrated in application-oriented and technology-related fields, emphasizing the tendency of academic studies towards practical applications. When examined from the perspective of publishers, large publishing houses like Elsevier show a notable dominance in the academic publishing sector. These publishers maintain their leading positions in the sector by producing approximately half of all academic publications. Other significant publishers such as MDPI and Springer Nature also stand out with their remarkable market shares; MDPI ranks second with a rate of 15.891%, while Springer Nature holds third place with 8.140%. Despite the strong performance shown by these two publishers, the contributions and spheres of influence of smaller-scale publishers continue to remain relatively limited in the sector. In light of these data, it is clearly evident that the academic publishing industry is largely under the control of certain major publishers. However, it has been observed that alternative publishers have begun to take on an increasingly active and effective role in the academic publishing ecosystem in recent years.

During the 2010-2025 period, academic output in the field of building materials and climate change exhibits a clear differentiation in terms of both geography and publishers. At the global scale, the United States and China stand out as leading countries, while European countries have sustained their contributions steadily. Developing countries, meanwhile, account for a limited yet increasing share. In terms of publisher distribution, Elsevier, MDPI, and Springer Nature maintain their dominant positions, whereas the share of small- and medium-sized publishers remains relatively limited. These findings indicate that academic production is becoming increasingly globalized and gaining interdisciplinary diversity; however, they also show that major countries and institutional publishers continue to play central and decisive roles in the scientific literature. The results further suggest that there are several important research gaps in the literature. In particular, studies conducted in Africa and parts of Asia appear to be limited. Moreover, research focusing on traditional building materials and local solutions has not been adequately addressed. Future studies that concentrate on these underexplored areas would contribute to a more balanced and inclusive body of literature.

In conclusion, the comprehensive data obtained through detailed analyses clearly demonstrates that academic publications have shown a steady and significant upward trend in recent years, certain important disciplines have gained particularly noteworthy positions in academic literature, and leading major publishers continue to maintain their decisive roles and dominance in the sector. It is clearly observed that research production is particularly intensive in engineering and technology fields, while research in other important disciplines such as social sciences, basic sciences, and health sciences continues to progress and develop consistently. Furthermore, the increasing diversity and number of publishers in the academic publishing world is considered an important indicator that the academic world is becoming increasingly globalized and that the power dynamics in this dynamic field may be reshaped over time.

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