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Bibliometric Analysis of Climate Action

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ABSTRACT

This study aims to map the intellectual structure, thematic development, and research trends in climate action using a bibliometric approach. Data were collected from a reputable scientific database and analyzed using VOSviewer to examine co-occurrence patterns of keywords, network relationships, and thematic evolution. The findings reveal that climate change serves as the central node connecting multiple research domains, indicating a highly integrated and multidisciplinary field. Three dominant thematic clusters emerge, namely mitigation-oriented research focusing on carbon emissions and energy transition, ecological studies emphasizing biodiversity and environmental protection, and adaptation and governance research highlighting resilience, risk assessment, and decision-making processes. The overlay visualization shows a temporal shift from impact-oriented studies toward more solution-driven themes such as sustainability, climate policy, and energy efficiency. Meanwhile, density analysis indicates that research remains concentrated on climate change and sustainable development, while adaptation and governance themes are still developing. This study contributes by providing a comprehensive overview of the structure and evolution of climate action research, as well as identifying potential directions for future studies, particularly in integrating mitigation, ecological, and governance perspectives into a more holistic framework.

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1. INTRODUCTION

Climate change has emerged as one of the most pressing global challenges of the twenty-first century, affecting environmental stability, economic development, and social well-being across the globe. Rising global temperatures, increasing frequency of extreme weather events, and shifting ecological systems have compelled governments, organizations, and communities to take coordinated actions to mitigate and adapt to these changes. The concept of climate action encompasses a broad range of initiatives, including emission reduction strategies, renewable energy adoption, sustainable resource management, and climate resilience planning. These efforts are increasingly reflected in academic research, which has grown significantly in

both volume and diversity over the past few decades [1].

The rapid expansion of scientific literature on climate action highlights the need for systematic methods to evaluate and synthesize existing knowledge. Bibliometric analysis provides a powerful approach to quantitatively assess research trends, influential publications, collaboration networks, and thematic evolution within a specific field. By utilizing statistical and computational tools, bibliometric studies enable researchers to map the intellectual structure of a discipline and identify key areas of development. In the context of climate action, such analysis is crucial for understanding how research priorities have shifted over time and which topics have gained prominence in response to global environmental challenges [2].

Over the years, climate action research has evolved from a focus on environmental science and policy to a more interdisciplinary domain that integrates economics, technology, social sciences, and governance. The emergence of concepts such as sustainable development, green innovation, and circular economy has further expanded the scope of climate-related studies. Moreover, international agreements such as the Paris Agreement have played a significant role in shaping research agendas, encouraging studies that explore pathways for achieving net-zero emissions and enhancing climate resilience. As a result, the body of literature on climate action has become increasingly complex and multifaceted [3].

Another important aspect of climate action research is the growing emphasis on collaboration across countries and institutions. Addressing climate change requires collective efforts that transcend national boundaries, leading to an increase in international research partnerships and knowledge sharing. Bibliometric analysis can reveal patterns of collaboration and highlight the contributions of different regions in advancing climate action research. Such insights are valuable for identifying gaps in global research participation and promoting more inclusive and equitable scientific engagement [4].

Despite the abundance of studies on climate action, there remains a lack of comprehensive synthesis that captures the overall structure and dynamics of the field. Many existing studies focus on specific aspects, such as renewable energy or carbon emissions, without providing a holistic overview of the broader research landscape. This fragmentation limits the ability of scholars and policymakers to fully understand the development of climate action research and to identify emerging trends and future directions. Therefore, a bibliometric analysis of climate action is essential to bridge this gap and provide a systematic overview of the field, enabling more informed decision-making and strategic research planning [5].

Although the volume of research on climate action has grown substantially, there is still limited understanding of the overall intellectual structure, key contributors, dominant themes, and evolving trends within this field. The absence of a comprehensive bibliometric assessment makes it difficult to identify research gaps, evaluate the impact of existing studies, and determine the direction of future research. Furthermore, the interdisciplinary nature of climate action research adds complexity, as knowledge is dispersed across multiple domains and publication outlets. This fragmentation hinders the development of a cohesive understanding of the field and reduces the effectiveness of research in informing policy and practice. Therefore, there is a critical need for a systematic bibliometric analysis that can map the landscape of climate action research and provide insights into its development and future trajectory. This study aims to conduct a comprehensive bibliometric analysis of climate action research in order to systematically map its intellectual structure, identify key trends and themes, and analyze patterns of collaboration and publication.

2. METHODS

This study employs a bibliometric analysis approach to systematically evaluate the development and structure of climate action research. Bibliometric analysis is a quantitative method used to analyze academic literature through statistical techniques, enabling the identification of publication trends, influential works, and patterns of collaboration (Donthu et al., 2021). The data for this study were collected from a reputable scientific database, such as Scopus or Web of Science, which are widely recognized for their comprehensive coverage of peer-reviewed publications. A set of relevant keywords, including "climate action," "climate change mitigation," and "climate policy," was used to retrieve publications within a specified time frame. The inclusion criteria were limited to journal articles written in English to ensure consistency and quality, while conference papers, book chapters, and non-peer-reviewed documents were excluded. The retrieved data were then exported in compatible formats for further analysis.

3. RESULTS AND DISCUSSION

3.1 Network Visualization

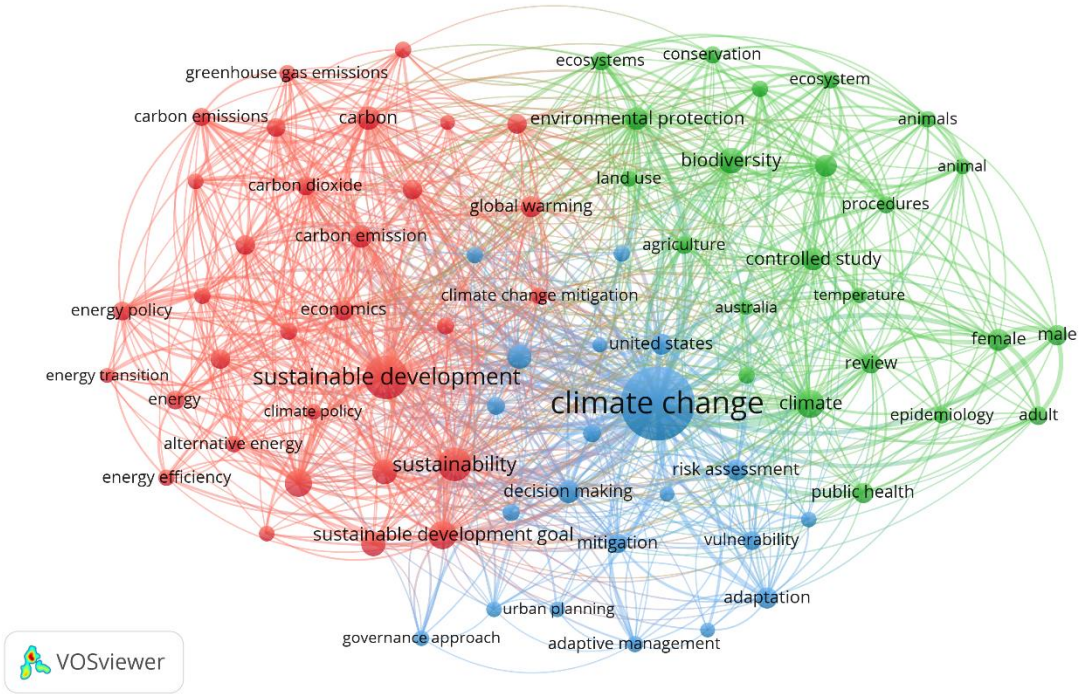

Figure 1. Network Visualization
Source: Data Analysis Result, 2025

Figure 1 reveals the intellectual structure of climate action research through three major thematic clusters, with "climate change" positioned as the central and most dominant node. This centrality indicates that climate change serves as the core integrating concept across diverse research streams. Its strong connections with multiple keywords across clusters suggest that the field is highly interdisciplinary, bridging environmental science, policy, health, and sustainability domains.

The red cluster represents a strong focus on sustainability, carbon emissions, and energy-related transitions. Keywords such as sustainable development, carbon emissions, energy policy, energy efficiency, and alternative energy indicate that a significant portion of the literature is oriented toward mitigation strategies. This cluster reflects the

economic and policy-driven discourse of climate action, emphasizing decarbonization, energy transition, and the role of sustainable development goals. The density of connections within this cluster suggests a mature and well-established research stream.

The green cluster is primarily associated with environmental and ecological dimensions of climate action. Key terms such as biodiversity, ecosystems, conservation, environmental protection, and land use highlight the ecological consequences of climate change and the importance of preserving natural systems. The inclusion of terms like animals, epidemiology, and public health also suggests an intersection with biological and health sciences, indicating that climate action research increasingly incorporates ecosystem health and its implications for human well-being.

The blue cluster reflects themes related to adaptation, risk, and governance. Keywords such as adaptation, vulnerability, risk assessment, decision making, and adaptive management point to the growing importance of resilience-oriented approaches. This cluster is less dense compared to the red cluster, suggesting that adaptation research, while expanding, may still be developing relative to mitigation-focused studies. The presence of urban planning and governance approach further indicates a shift toward practical and policy-relevant applications of climate knowledge.

3.2 Overlay Visualization

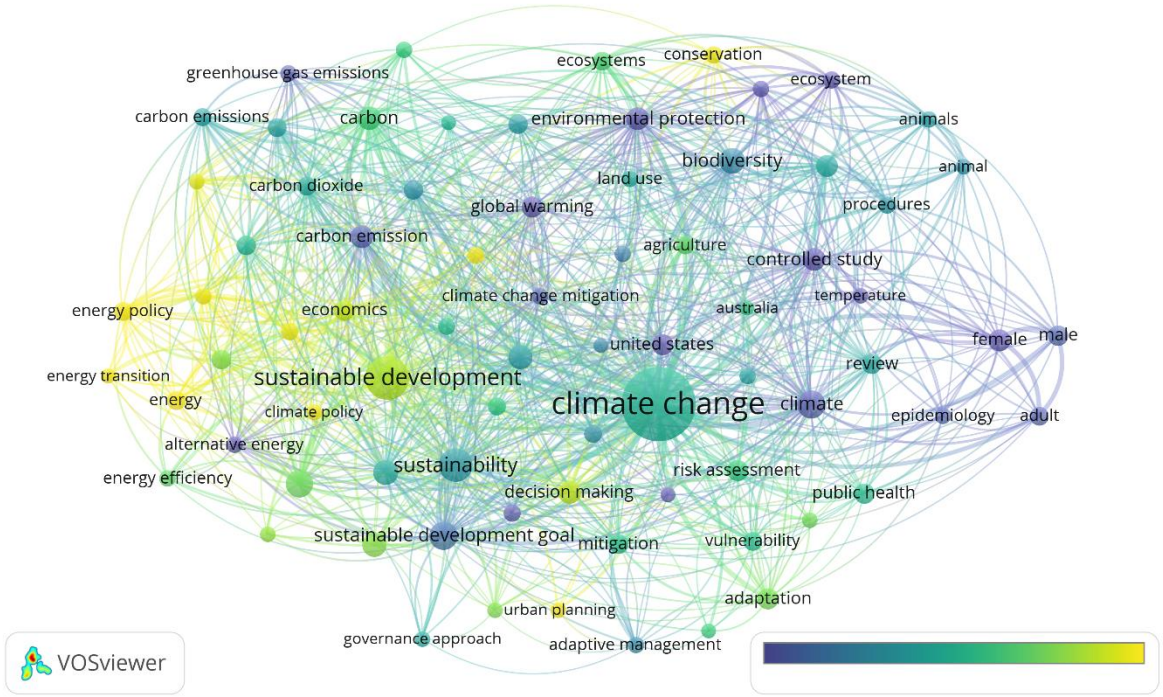

Figure 2. Overlay Visualization
Source: Data Analysis Result, 2025

Figure 2 highlights the temporal evolution of climate action research, where colors transition from earlier topics (blue/purple) to more recent ones (green–yellow). The keyword "climate change" remains the central anchor across time, indicating its sustained dominance as the core theme. However, the spread of colors across the network suggests that the field has evolved from foundational scientific and environmental concerns toward more

applied, policy-oriented, and sustainability-driven discussions.

Earlier research, represented by blue and purple tones, is concentrated around themes such as biodiversity, environmental protection, ecosystems, epidemiology, and controlled study. This indicates that initial scholarly attention focused on understanding the environmental and biological impacts of climate change, often grounded in natural sciences and health-related investigations. These foundational studies built the scientific basis for climate action by examining ecological disruption, species vulnerability, and the broader implications for human health.

More recent developments, shown in green to yellow tones, shift toward topics like sustainable development, energy transition, energy efficiency, climate policy, and decision making. This reflects a clear transition from problem identification to solution-oriented and policy-driven research. The increasing prominence of terms related to sustainability and energy systems suggests that the field is now emphasizing actionable strategies, governance, and integrated approaches to mitigation and adaptation. This evolution highlights a maturing research landscape, where climate action is no longer only about understanding impacts but also about designing and implementing transformative solutions.

Table 1. The Most Impactful Literatures

Citations	Authors and year	Title
5160	[6]	Bounding the role of black carbon in the climate system: A scientific assessment
4857	[7]	Vulnerability
4722	[8]	Coral reefs under rapid climate change and ocean acidification.
4310	[9]	Travel and the built environment
4170	[10]	High-resolution mapping of global surface water and its long-term changes
3666	[11]	Behavioral intention formation in knowledge sharing: Examining the roles of extrinsic motivators, social-psychological forces, and organizational climate
3575	[12]	Antibiotic resistance-the need for global solutions
3015	[13]	Status and ecological effects of the world's largest carnivores
2991	[14]	Regime shifts, resilience, and biodiversity in ecosystem management
2898	[15]	Paris Agreement climate proposals need a boost to keep warming well below 2 °c

Source: Scopus, 2026

3.3 Density Visualization

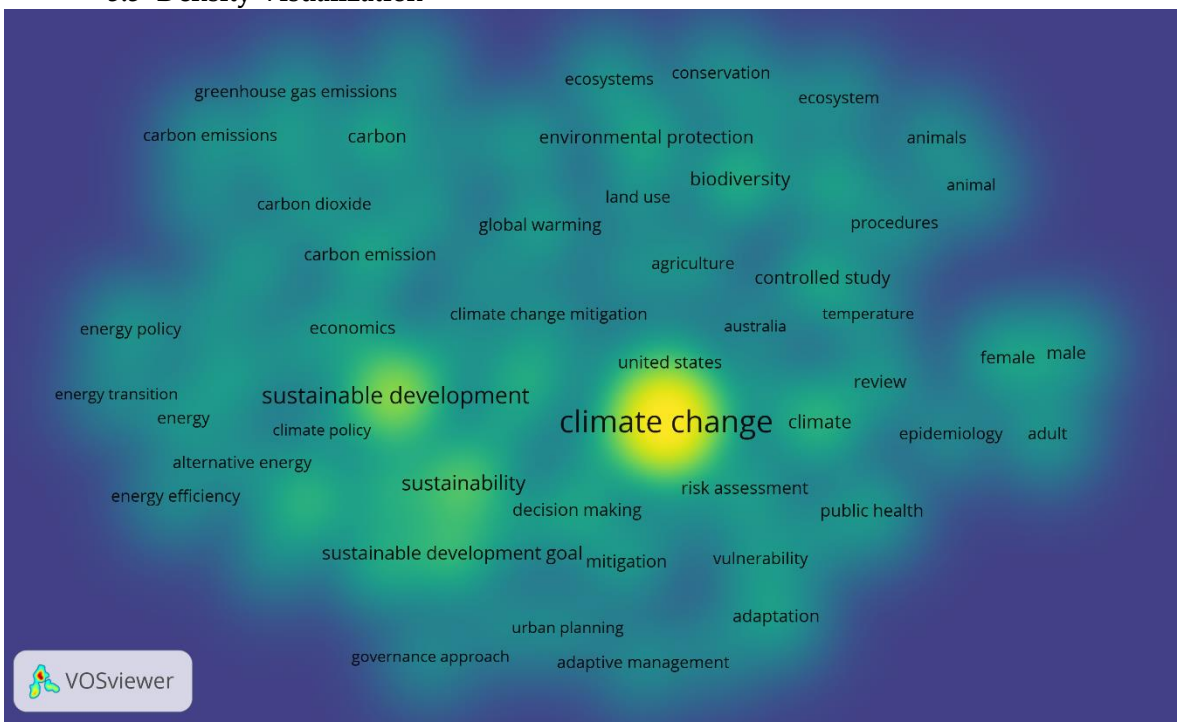

Figure 3. Density Visualization

Source: Data Analysis Result, 2025

Figure 3 shows that "climate change" is the most prominent and highly concentrated research topic, indicated by the brightest (yellow) area at the center of the map. This suggests that it serves as the primary focal point of the entire knowledge structure. Closely surrounding it are terms such as climate, risk assessment, mitigation, and sustainability, which also appear in relatively dense areas, indicating strong research attention and frequent co-occurrence. The presence of "sustainable development" as another high-density node confirms that climate action research is strongly anchored in broader sustainability discourse, linking environmental concerns with economic and policy considerations.

Beyond the central core, the density gradually decreases toward more specialized or emerging themes. Topics such as adaptation, vulnerability, governance approach, urban planning, and public health appear in moderately dense zones, reflecting growing but less dominant attention. Meanwhile, more peripheral areas like biodiversity, ecosystems, and energy policy are still relevant but show lower intensity, suggesting either niche specialization or less integrated positioning within the broader network.

Discussions

The findings of this bibliometric analysis reveal that climate action research is structured around a highly interconnected knowledge base, with climate change serving as the central organizing concept. The dominance of this keyword across network, overlay, and density visualizations indicates that the field has evolved into a cohesive yet multidisciplinary domain. Rather than being fragmented, climate action research integrates perspectives from environmental science, economics, public policy, and social systems. This centrality also reflects how climate change functions not only as a scientific issue but as a unifying framework that connects diverse research agendas under a shared global challenge.

The cluster analysis further demonstrates that the literature is organized

into three major thematic orientations: mitigation, ecological systems, and adaptation/governance. The mitigation-oriented cluster, characterized by terms such as carbon emissions, energy policy, and sustainable development, appears as the most mature and densely connected domain. This suggests that earlier research efforts have strongly emphasized reducing emissions and transitioning energy systems. In contrast, the ecological cluster highlights the importance of biodiversity, conservation, and environmental protection, indicating that climate action is deeply rooted in preserving natural systems. Meanwhile, the adaptation and governance cluster reflects a growing recognition of resilience, decision-making, and institutional responses, pointing toward a more applied and policy-relevant direction.

The temporal evolution captured in the overlay visualization provides further insight into how the field has progressed. Earlier studies were largely concentrated on understanding environmental impacts and ecological consequences, as reflected in themes such as ecosystems, biodiversity, and epidemiology. Over time, however, the focus has shifted toward more solution-oriented topics, including sustainability, energy transition, and climate policy. This transition suggests that climate action research has moved beyond problem identification toward the development of strategic responses. The increasing prominence of decision-making and policy-related terms indicates that the field is becoming more engaged with real-world implementation and governance challenges.

The density visualization reinforces this interpretation by showing that research attention remains heavily concentrated around climate change and sustainable development, while other themes are more dispersed. Topics such as adaptation, vulnerability, and governance appear in moderately dense areas, suggesting that although these areas are gaining traction, they have not yet reached the same level of integration as mitigation-focused research. This imbalance highlights an important gap in the literature, where adaptive capacity and governance mechanisms may require deeper exploration and stronger conceptual integration with existing sustainability frameworks.

These findings suggest that climate action research is undergoing a phase of consolidation and expansion. While mitigation and sustainability remain dominant pillars, there is a clear shift toward integrating ecological understanding and adaptive governance into a more holistic framework. Future research could benefit from bridging these domains more explicitly, particularly by linking technological and policy innovations with social resilience and institutional capacity. Such integration would not only advance theoretical development but also enhance the practical relevance of climate action research in addressing complex, real-world challenges.

4. CONCLUSION

This study provides a comprehensive bibliometric mapping of climate action research, revealing a field that is both highly interconnected and increasingly oriented toward practical solutions. The findings show that climate change remains the central anchor, supported by three main thematic pillars: mitigation, ecological systems, and adaptation/governance. While the literature has been historically dominated by mitigation-focused studies, recent developments indicate a gradual shift toward sustainability integration, policy engagement, and adaptive capacity. However, the uneven density across themes suggests that adaptation and governance aspects still require deeper exploration and stronger integration within the broader research framework.

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