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# Unveiling research landscapes on climate change education and curriculum reform for SDGs

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**ABSTRACT**

This study maps the global research landscape on climate change education and curriculum reform within the SDGs framework using a bibliometric approach. A total of 133 articles indexed in Scopus (2015-2025) were analyzed with VOSviewer to identify publication trends, key authors and institutions, collaboration networks, thematic clusters, and co-citation patterns. The findings show a sharp growth in publications during 2020-2025, reflecting increasing academic attention to the nexus of climate change, education, and sustainability. Research output is dominated by the United Kingdom, the United States, and Australia, although contributions from the Global South, such as Indonesia and South Africa, are emerging. Manchester Metropolitan University and Walter Leal Filho were identified as central actors. Thematic mapping revealed five main clusters: climate change education, curriculum reform, sustainable development, environmental education, and policy. Co-citation analysis highlights two intellectual pillars: education for sustainable development and theories of pro-environmental behavior. This study provides a comprehensive overview of how climate change education is linked to curriculum reform and SDGs. Academically, it advances knowledge of research trends and intellectual foundations. In practice, it offers policymakers and curriculum developers, particularly in the Global South, insights for designing inclusive, context-specific climate change education strategies.

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***ABSTRAK***

*Penelitian ini memetakan lanskap penelitian global mengenai climate change education dan reformasi kurikulum dalam kerangka Sustainable Development Goals (SDGs) dengan pendekatan bibliometrik. Sebanyak 133 artikel terindeks Scopus periode 2015-2025 dianalisis menggunakan VOSviewer untuk mengidentifikasi tren publikasi, penulis dan institusi kunci, jaringan kolaborasi, kluster tematik, serta pola ko-sitasi. Hasil analisis menunjukkan pertumbuhan publikasi yang tajam pada periode 2020-2025, menandakan meningkatnya perhatian akademik terhadap nexus perubahan iklim, pendidikan, dan keberlanjutan. Publikasi didominasi oleh Inggris, Amerika Serikat, dan Australia, meskipun kontribusi dari Global South, termasuk Indonesia dan Afrika Selatan, mulai muncul. Manchester Metropolitan University dan Walter Leal Filho teridentifikasi sebagai aktor sentral. Pemetaan tematik mengungkap lima kluster utama, yaitu climate change education, curriculum reform, sustainable development, environmental education, dan policy. Analisis ko-sitasi menyoroti dua pilar literatur utama, yaitu education for sustainable development dan teori perilaku pro-lingkungan. Penelitian ini memberikan gambaran komprehensif mengenai keterkaitan pendidikan iklim, reformasi kurikulum, dan SDGs. Secara akademis, penelitian ini memperkaya pengetahuan tentang tren dan fondasi intelektual riset. Secara praktis, hasilnya dapat menjadi acuan bagi pembuat kebijakan dan pengembang kurikulum, khususnya di Global South, untuk merancang strategi pendidikan iklim yang inklusif dan kontekstual.*

***Kata Kunci:*** *pendidikan perubahan iklim; reformasi kurikulum; SDGs; sustainable development goals*

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## INTRODUCTION

Climate change is an increasingly urgent global issue that must be addressed through various cross-sectoral strategies, including education. The Intergovernmental Panel on Climate Change (IPCC) reported in 2023 that a rise of 1.1 °C in global temperature relative to the pre-industrial period has increased the frequency of hydrometeorological disasters, threatening food security, public health, and ecosystems. Recent global syntheses confirm that climate change education (CCE) research has expanded significantly over the past decade, driven by the increasing urgency of climate impacts and the growing recognition of education as a strategic pathway for adaptation and mitigation. Similarly, a scoping review reveals that CCE scholarship has evolved from fragmented thematic studies into a more coherent field, with expanding attention to teacher capacity, curriculum integration, and justice-oriented approaches (Muccione et al., 2025). Data from the United Nations Office for Disaster Risk Reduction (UNDRR, 2022) indicate that, over the past two decades, climate-related disasters have increased by more than 80% compared to the previous period. This condition underscores the urgency of climate change education in equipping younger generations with climate literacy, critical awareness, and the competencies needed to engage in mitigation and adaptation efforts (Monroe et al., 2019). Some countries have taken concrete steps—for instance, Finland has integrated climate education across all levels of primary schooling. At the same time, Japan has incorporated disaster and climate mitigation into the secondary school curriculum (Mochizuki & Bryan, 2015). Nevertheless, such initiatives are not yet widespread globally.

Following the adoption of the Sustainable Development Goals (SDGs) in 2015, particularly target 4.7, many studies have emphasized the importance of integrating climate change into both formal and non-formal curricula. Education is no longer viewed solely as a cognitive process but also as a transformative one, linking scientific knowledge with social action and behavioral change (Filho et al., 2019). Preliminary analysis using the Scopus database indicates a significant increase in publications on climate change education after 2015, as mandated by the Paris Agreement. For example, the number of articles published in *Sustainability* and *Environmental Education Research* nearly doubled between 2016 and 2022. Moreover, recent reviews highlight that curriculum reform plays a pivotal role in translating global sustainability commitments into national policies and classroom practices, underscoring the need for systematic, transformative curriculum interventions (Reid et al., 2023). The majority of these publications originate from the United States, the United Kingdom, Australia, and China, reflecting the concentration of research in the Global North (Filho et al., 2019; Shepherd et al., 2023).

However, a significant gap remains in the Global South. Developing countries are the most vulnerable to the impacts of climate change, yet their research contributions remain limited (Mochizuki & Bryan, 2015). The notion of climate justice is particularly relevant here: Global South countries contribute less to carbon emissions but bear disproportionately greater consequences, including constraints in integrating climate issues into national curricula. In Indonesia, for example, despite the implementation of the *Merdeka Belajar* (Freedom to Learn) policy that allows for innovation, climate curriculum integration remains partial, often limited to incidental programs rather than systemic reforms. This gap highlights the need for



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more substantive curriculum reform to ensure that education genuinely contributes to achieving the 2030 SDG targets.

Existing bibliometric studies have primarily focused on education for sustainable development or environmental literacy but have rarely examined the specific interconnections among climate change education, curriculum reform, and the SDGs (García-Álvarez & Moreno-Fernández, 2021; Shepherd et al., 2023). In addition, most previous research has emphasized systematic reviews or thematic analyses, without uncovering patterns of international collaboration, citation networks, or thematic evolution that can be revealed through a bibliometric approach. Leicht stated in his book that the curriculum is the main instrument for translating global agendas into learning at the national and local levels. Without curriculum reform that is responsive to climate change issues, education risks remaining only at the level of discourse.

Therefore, this study seeks to unveil the global research landscape through a Scopus-based bibliometric analysis covering the period 2010-2025. The analysis includes publication growth trends, citation patterns, collaboration among countries and institutions, and dominant and emerging research themes. The novelty of this study lies in its explicit focus on the nexus among climate change education, curriculum reform, and the SDGs. Thus, this research not only maps the development of scientific knowledge but also identifies research gaps and future directions to strengthen the capacity of developing countries to build transformative curricula.

The objectives of this study are to: 1) map global publication trends related to climate change education and curriculum reform; 2) identify collaboration among countries, institutions, and researchers; and 3) analyze future research directions that support the achievement of the SDGs 2030. The results of this study are expected not only to enrich the global literature but also to provide practical contributions to policymakers and curriculum developers, particularly in developing countries, for designing climate change education strategies that are more contextually grounded, fair, inclusive, and oriented toward long-term sustainability.

## LITERATURE REVIEW

To affirm the novelty of this research, a systematic literature review is required. The following literature review section presents the development of global research on climate change education, curriculum reform, and their relationship with the SDGs agenda, which simultaneously serves as the basis for the bibliometric mapping in this study.

### Climate Change Education: A Global Perspective

Climate change poses a serious global threat, demanding comprehensive research on both environmental hazards and societal vulnerabilities (Birkmann et al., 2022). Climate change education (CCE) has emerged as a critical field in the twenty-first century, responding to the escalating impacts of climate disruption on ecosystems, health, and society. The urgency of CCE is reflected in international reports, which emphasize that climate literacy is a prerequisite for fostering adaptation and mitigation capacities among younger generations (Monroe et al., 2019). Systematic reviews of climate change education confirm that effective


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approaches must integrate three essential dimensions: accurate scientific knowledge, critical thinking skills, and opportunities for learners to engage in practical action (Monroe et al., 2019). This dual function—providing scientific literacy and enabling social engagement—positions CCE as a transformative educational domain rather than a purely cognitive one.

Empirical evidence further underscores its importance. Demonstrated that exposure to climate change education can significantly reduce an individual's lifetime carbon footprint, translating educational interventions into measurable environmental outcomes (Cordero et al., 2020). Such findings highlight the direct link between classroom pedagogy and long-term behavioral change. Anderson expanded this perspective by assessing sustainability and climate literacy across diverse educational systems, concluding that literacy levels remain inconsistent and require more systematic curricular reforms to ensure equitable access to knowledge (Anderson, 2024).

Global implementation of CCE, however, varies considerably between regions. In the Global North, integration has often been systematic, embedded in school curricula at multiple levels. For example, in the United Kingdom, climate topics are embedded across subjects such as geography and science, while in Finland, sustainability themes permeate the entire national curriculum (Mochizuki & Bryan, 2015). In contrast, countries in the Global South face significant barriers, including limited teacher capacity, fragmented policy support, and resource constraints (Mochizuki & Bryan, 2015). As a result, climate education initiatives in these regions often appear sporadic, delivered through pilot projects or non-governmental programs rather than being institutionalized within formal curricula. This imbalance exacerbates the global inequity in climate literacy, leaving those most vulnerable to climate impacts with the least access to structured educational responses.

Recent empirical studies further reinforce the centrality of curriculum reform in addressing these disparities. Studies found that climate and sustainability literacy in secondary schools is closely linked to the extent of curriculum integration, with countries employing comprehensive curricular frameworks achieving significantly higher levels of student engagement and understanding (Anderson, 2024). Additionally, argue that curriculum futures in the context of the climate crisis must foreground justice, interdisciplinarity, and action-oriented learning to ensure that learners can respond to climate challenges in both local and global contexts (Reid et al., 2023).

Climate literacy is central to CCE. The National Oceanic and Atmospheric Administration defines climate literacy as the ability to understand climate systems, communicate knowledge effectively, and make responsible decisions regarding mitigation and adaptation strategies. Research demonstrates that individuals with higher levels of climate literacy exhibit stronger environmental concern and a greater likelihood of engaging in pro-environmental actions. These findings support the need for formal curricula that not only transmit knowledge but also nurture behavioral change and collective action.

CCE is also strongly connected to broader global policy frameworks, such as the Paris Agreement in 2015 and UNESCO's Education for Sustainable Development (ESD) Roadmap in 2021. Both emphasize that education must not only transfer scientific knowledge but also cultivate values and competencies for sustainability. This elevates CCE beyond environmental science, framing it as an interdisciplinary and justice-oriented practice that links climate, society, and equity. Recent studies argue that CCE should adopt participatory approaches



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that empower learners to engage with local communities and policy debates, thereby connecting classroom learning with civic engagement. Without such approaches, climate education risks remaining abstract and disconnected from students' lived realities.

## Curriculum Reform and the Sustainable Development Goals

The curriculum is widely recognized as the heart of educational systems, acting as a vehicle for transmitting knowledge, values, and competencies to learners. In the context of the Sustainable Development Goals (SDGs), particularly target 4.7, the curriculum is expected to integrate principles of sustainable development, global citizenship, and climate change education. UNESCO has explicitly stated that education for sustainable development (ESD) should transform learning environments into spaces that promote social transformation, critical awareness, and sustainability-oriented action.

Empirical studies support this assertion. Conducted a bibliometric mapping analysis and found a significant increase in research linking SDGs with education, but they also noted that the integration of these goals into national curricula remains uneven and often rhetorical rather than practical (Prieto-Jiménez et al., 2021). Extended this line of inquiry by reviewing ESD research from 1992 to 2022, revealing rapid expansion after 2015 but also highlighting the predominance of contributions from Global North institutions (Yang et al., 2023). Reinforced this observation, showing that scholarly output in sustainability education is disproportionately concentrated in the Global North, raising concerns about epistemic justice and inclusivity (Gorski et al., 2023).

In higher education, researchers have documented the growing prevalence of sustainability-oriented curricula and noted universities' role as laboratories for innovation in pedagogy and policy (Filho et al., 2021). Despite this progress, challenges remain. Teachers and lecturers often lack the necessary capacity to integrate sustainability themes effectively, leading to partial or inconsistent adoption (Shepherd et al., 2023). Furthermore, institutional inertia and resistance to change hinder the mainstreaming of climate issues into core curricula.

The Indonesian context vividly illustrates these challenges. Although the Merdeka Belajar (Freedom to Learn) policy has provided space for pedagogical innovation, the integration of climate change into national curricula has remained fragmented and largely dependent on individual initiatives. This demonstrates the gap between national policy rhetoric and practical curriculum reform, highlighting the need for systemic transformation rather than incremental adjustments.

Power dynamics and global inequalities also shape curriculum reform. Studies reveal that curricular models in the Global South are often imported from the Global North, leading to mismatches with local socio-cultural and ecological contexts. For instance, while European models of sustainability education emphasize energy transition, countries in the Global South often face more immediate challenges, such as food security and disaster preparedness. Thus, curriculum reform must be locally grounded, integrating indigenous knowledge and community-based practices alongside global scientific insights. Moreover, aligning curriculum reform with SDGs requires not only content adjustments but also changes in pedagogy, teacher training, and assessment strategies, making reform a multidimensional process rather than a technical exercise.


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## Model and Approaches in Climate Change Education

Several scholars have advanced conceptual models to improve the design and delivery of CCE. Tang proposed a behavioral climate change education model for higher education that addresses the well-documented gap between knowledge and behavior, emphasizing the cultivation of agency and sustained pro-environmental practices (Tang, 2022). This model shifts the focus of education from awareness alone to behavioral change, aligning with the goals of transformative education.

Eilam critically examined the risks of fragmenting climate change education by removing it from disciplinary contexts, cautioning that such approaches could undermine learning coherence. Instead, Eilam recommended a curriculum design that maintains disciplinary rigor while promoting interdisciplinary connections, ensuring both depth and breadth in learners' understanding (Eilam, 2022). Similarly, Anderson argued that climate literacy must be integrated across disciplines rather than confined to environmental science, requiring comprehensive curriculum reform that embeds sustainability into multiple subject areas (Anderson, 2024).

These perspectives align with the transformative education paradigm, which emphasizes integrating the cognitive, affective, and behavioral domains. Shepherd et al. argued that transformative education must empower learners as agents of change, capable of linking global challenges with local solutions through project-based and community-based learning (Shepherd et al., 2023). Provided empirical support for this claim, demonstrating that curricula which engage students in experiential learning can significantly reduce their carbon emissions (Cordero et al., 2020).

More recent models expand CCE beyond classrooms, incorporating digital technologies, simulation tools, and gamification strategies to enhance engagement. For example, interactive climate simulations have been shown to improve both conceptual understanding and motivation, particularly among younger learners. Other approaches emphasize systems thinking, encouraging students to explore the interconnectedness of ecological, economic, and social dimensions of climate change. Such models argue that climate change cannot be addressed in isolation but must be framed as part of complex socio-ecological systems. Furthermore, community-based participatory models highlight the importance of linking schools with local actors—such as NGOs, policymakers, and indigenous communities—to make climate education both locally relevant and globally connected. These approaches represent a paradigm shift from traditional content delivery toward dynamic, participatory, and action-oriented learning.

## Bibliometric Studies in Education and Sustainability

Bibliometric research has become an increasingly valuable method for mapping the intellectual landscape of education and sustainability. By examining publication trends, collaboration networks, and citation patterns, bibliometric studies provide insights into the evolution of scientific discourse and the identification of research gaps. Conducted a bibliometric analysis of education for sustainable development, revealing a surge in publications between 2015 and 2020 but noting that much of the literature remained general



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in scope, lacking specific focus on climate change education or curriculum reform (Filho et al., 2021).

More recent bibliometric efforts have addressed this limitation. Provided a comprehensive mapping of climate change education, highlighting the dominance of Global North authors and institutions while calling for greater inclusion of Global South perspectives (Wang et al., 2024). Offered updated insights into climate education literature, showing that while thematic clusters such as environmental literacy and sustainability dominate, few studies explicitly address the nexus of CCE, curriculum reform, and SDGs (Westphal et al., 2025).

Bibliometric approaches are particularly useful for capturing macro-level patterns that are difficult to observe in traditional literature reviews. For example, keyword co-occurrence analysis can reveal the evolution of themes such as "climate literacy," "curriculum innovation," or "sustainable pedagogy," demonstrating how research interests shift over time. Similarly, co-authorship networks reveal the dominance of a small group of prolific scholars, often concentrated in the Global North, raising questions about inclusivity and diversity in knowledge production. Co-citation analysis, meanwhile, helps identify intellectual foundations, such as theories of pro-environmental behavior or transformative learning frameworks, that anchor much of the discourse on CCE and sustainability.

At the same time, bibliometric studies have their limitations. Reliance on a single database, such as Scopus, risks excluding important contributions from regional or non-English journals. This limitation is particularly problematic for Global South contexts, where locally relevant research may not be indexed in major databases. Therefore, while bibliometric mapping provides a powerful tool for analyzing global research trends, it must be complemented by critical reflection on whose voices and perspectives are included—or excluded—in the analysis.

These findings emphasize the novelty of the present study. While previous bibliometric analyses have examined education for sustainable development broadly or climate education in isolation, few have explicitly linked CCE with curriculum reform and the SDGs. This research gap provides a strong rationale for a focused bibliometric analysis that highlights the interconnections among these domains, particularly in the context of contributions from the Global South.

## Challenges and Gaps in Climate Curriculum Reform

Despite significant progress in climate change education, several persistent challenges hinder its integration into formal curricula. First, there is often a gap between policy frameworks and local realities. National strategies may endorse sustainability education, but classroom implementation remains fragmented (Mochizuki & Bryan, 2015). Second, teacher capacity is frequently inadequate, with educators lacking both the content knowledge and pedagogical tools to teach climate issues effectively (Shepherd et al., 2023). Third, cultural and socio-economic contexts shape the reception of climate education, requiring curricula that are locally relevant and inclusive.

Emphasized that successful implementation depends not only on curricular content but also on systemic support, including professional development, institutional commitment, and


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cross-sectoral collaboration (Ben-Zvi Assaraf et al., 2025). Without these enabling conditions, climate education risks remaining peripheral rather than transformative.

Another challenge lies in addressing the inequities of global knowledge production. As bibliometric evidence shows, Global North institutions dominate the literature, leaving Global South perspectives marginalized (Gorski et al., 2023; Wang et al., 2024). However, it is precisely in the Global South that climate vulnerabilities are most acute. Addressing this imbalance requires both increased scholarly contributions from developing countries and a recognition of the value of local knowledge in curriculum reform.

In addition to structural and systemic barriers, curriculum reform is often hindered by political and ideological resistance. Climate change remains a contested issue in some contexts, where skepticism or denial influences policy decisions and educational priorities. This politicization of climate education creates barriers to mainstreaming climate issues in national curricula. Moreover, the pressure of standardized testing in many educational systems discourages innovation, as teachers are compelled to prioritize exam content over sustainability topics. Another overlooked challenge is the lack of appropriate assessment models. Traditional testing methods are ill-suited to measure competencies such as systems thinking, collaborative problem-solving, and sustainability values, all of which are central to CCE. Developing new forms of assessment, such as portfolio or project-based evaluation, is therefore essential to ensuring that curriculum reform translates into meaningful learning outcomes.

Furthermore, disparities between urban and rural schools create another gap in climate education. Urban schools may have better access to digital resources and extracurricular initiatives, while rural schools—often located in climate-vulnerable regions—may lack both infrastructure and trained personnel. Bridging this urban-rural divide is crucial for equitable climate literacy. The integration of indigenous and local knowledge also remains underutilized, despite its potential to enrich formal curricula with contextually relevant sustainability practices.

## METHODS

This study employs a bibliometric approach, namely a quantitative analysis that utilizes publication data to map the knowledge landscape, thematic trends, and collaboration networks within a scientific field. This method is considered effective for exploring research developments and identifying open research gaps (Donthu et al., 2021; Aria & Cuccurullo, 2017). Accordingly, the bibliometric approach was chosen to comprehensively understand global research developments in climate change education and curriculum reform within the Sustainable Development Goals (SDGs) framework.

The research data were obtained from the Scopus database, which was downloaded on September 18, 2025. The search was conducted using keywords combined with Boolean operators, namely “climate change education” OR “climate literacy” OR “climate education” OR “climate change learning” AND “curriculum reform” OR “curriculum development” OR “curriculum innovation” OR “curriculum change” OR “education reform” AND “Sustainable Development Goals” OR “SDGs” OR “sustainability education” OR “ESD” OR “education for


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sustainable development." The search was limited to the TITLE-ABS-KEY fields to ensure retrieved articles were more relevant to the study's focus.

The screening criteria were set for the publication period 2010-2025, document type (articles and reviews), publication language (English), and subject areas including Social Sciences, Environmental Science, and Education. From the search results, 133 articles relevant to the research topic were identified. The analysis stage used a bibliometric approach, including descriptive analysis and network mapping. The descriptive analysis examined the growth in the number of publications per year, the distribution of articles by journal, and the most productive authors and institutions. The network mapping analysis was carried out to examine the interconnections among authors (co-authorship), among articles (co-citation), and among keywords (co-occurrence).

All bibliometric analyses and network visualizations were conducted using VOSviewer, a widely used software for generating intuitive, easily interpretable network maps (Eck & Waltman, 2010). Using this software, network visualization was performed to show the relationships among research entities, and overlay visualization was used to identify the evolution of themes throughout the study period.

The limitation of this study lies in the use of a single database, namely Scopus. Consequently, publications not indexed in Scopus, such as articles in Web of Science, ERIC, or non-indexed national journals, were excluded from the analysis. Nevertheless, Scopus was selected because it has broad multidisciplinary coverage and comprehensive metadata, and therefore is still considered representative for bibliometric studies (Mongeon & Paul-Hus, 2016).

## RESULTS AND DISCUSSION

The bibliometric analysis yielded several important findings about the global research landscape on climate change education and curriculum reform within the SDGs framework. The following section presents the research results in several main categories: publication trends, geographical distribution, key actors, and thematic mapping. These findings are then discussed to illustrate how this study expands understanding and fills gaps in the literature.

### Publication Trends per Year

The analysis shows fluctuating developments in the early phase, followed by a significant increase over the past five years. Publications in the 2015-2017 period remained relatively low, totaling only six articles, indicating that climate change education and curriculum reform in the context of the SDGs had not yet become a primary concern. In 2018, no publications were recorded, reflecting a pause in research productivity. Starting in 2019, the trend began to rise again, with five articles in 2019, followed by 6 in 2020.

A significant leap occurred in 2021 and 2022, each recording 15 publications. This coincided with global momentum in the post-COVID-19 era, when issues of resilience and sustainability began to be more intensively discussed in the context of education. The year 2023 remained relatively stable, with 13 publications, but a sharp increase was observed in 2024 (27 publications), which peaked in 2025 with 46 publications. The more than threefold increase within just two years underscores that this topic has become a primary focus in global


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education research, while also marking a shift in academic discourse toward integrating climate, curriculum, and the SDGs.

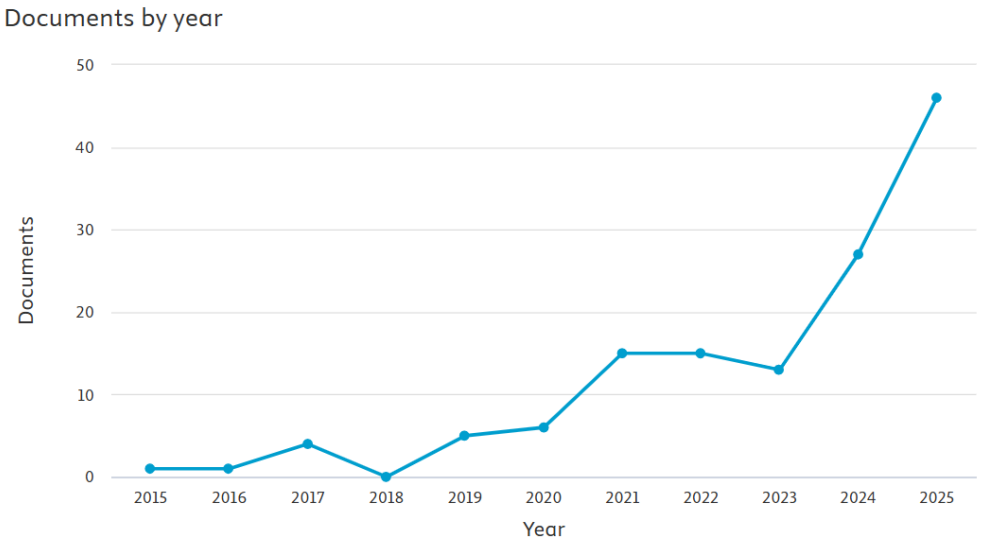


**Figure 1.** Annual publication trends (2015-2025)
*Sources: Research 2025*

## Distribution of Publications by Country

The analysis of country contributions reveals the strong dominance of Global North countries. The United Kingdom ranked first with 25 publications, followed by the United States (21) and Australia (16). These three countries accounted for more than one-third of total publications, demonstrating the concentration of research in regions with stronger educational infrastructure and research funding. Spain (12 publications) and Germany (10 publications) also emerged as important contributors, indicating a strong academic base in Western Europe.

Meanwhile, contributions from the Global South remain limited. South Africa contributed eight publications, while Indonesia and the Netherlands each contributed 7. Although the numbers are smaller than in developed countries, the presence of developing countries such as Indonesia indicates the beginning of active involvement in the global discourse. These findings highlight a geographical gap in knowledge production, with patterns still dominated by the Global North but increasingly shaped by the participation of developing countries.

**Table 1.** Distribution of Publications by Country

| No | Country | Number of Documents |
|---|---|---|
| 1 | United Kingdom | 25 |
| 2 | United States | 16 |
| 3 | Australia | 16 |
| 4 | Spain | 12 |
| 5 | Germany | 10 |
| 6 | Canada | 8 |
| 7 | South Africa | 8 |


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| No | Country | Number of Documents |
|---|---|---|
| 8 | Indonesia | 7 |
| 9 | Netherlands | 7 |
| 10 | Austria | 6 |

*Sources: Research 2025*

## Distribution by Institutional Affiliation

The analysis by institutional affiliation shows that publication production remains concentrated among a few universities. Manchester Metropolitan University emerges as the most productive institution with seven publications, followed by Hochschule für Angewandte Wissenschaften Hamburg (5 publications). These two institutions highlight the important role of European universities in developing research on climate education and curriculum.

Another notable institution is The University of the West Indies, with four publications, which is significant as it demonstrates contributions from the Caribbean region. Meanwhile, universities such as The University of Manchester, Nottingham Trent University, Victoria University, Universidade Fernando Pessoa, and the University of Melbourne each contributed three publications. Universitas Pendidikan Indonesia (UPI) from Southeast Asia is also included in the list, with three publications, indicating the involvement of institutions in this region in global research. These findings suggest that, while institutions dominate in Europe and Australia, contributions from other regions are beginning to emerge, albeit in smaller numbers.

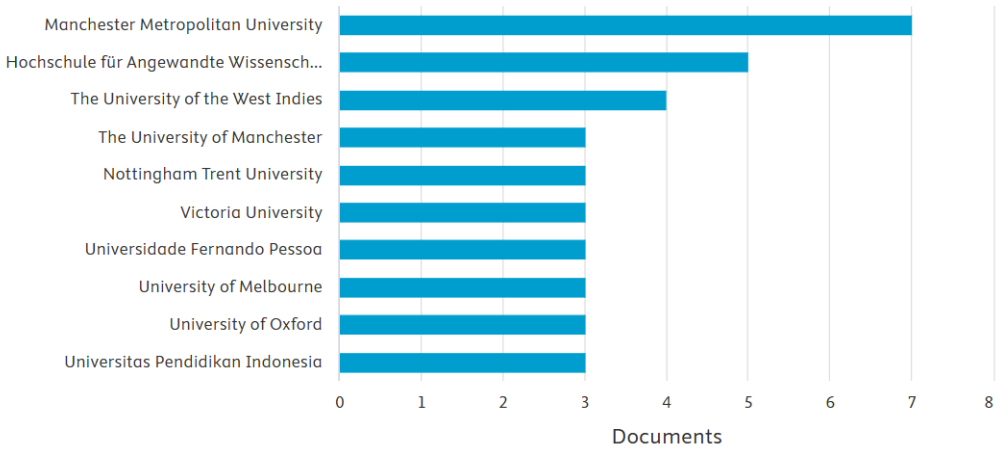


**Figure 2.** Distribution of publications by institution
*Sources: Research 2025*

## Author Contributions

The analysis of author productivity reveals a small group of researchers who serve as central actors in this corpus. Ferguson, T., and Leal Filho, W. occupy the top positions, each with four publications. The name Leal Filho is particularly significant, as he is recognized as one of the most prolific authors in the field of education for sustainable development. Therefore, his consistent focus on climate change education and curriculum is not surprising.


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In addition, authors such as Eilam, E., and Hurlimann, A. each produced three publications, demonstrating consistent engagement in multidisciplinary research that connects education, environment, and policy. Several other authors, such as Akdemir, K., Ali, M., Bush, J., Cobbinnah, P.B., and Dinis, M.A.P., contributed two publications each. Although the individual contributions outside the core group are relatively small, this pattern indicates a core group of scholars driving research in this field, with collaborations spanning multiple institutions and countries.

**Table 2.** Most Productive Authors

| No | Authors | Number of Documents |
|---|---|---|
| 1 | Ferguson, T | 4 |
| 2 | Leal Filho, W | 4 |
| 3 | Eilam, E. | 3 |
| 4 | Hurlimann, A | 3 |
| 5 | Akdemir, K. | 2 |
| 6 | Ali, M. | 2 |
| 7 | Bush, J. | 2 |
| 8 | Cobbinnah, P.B. | 2 |
| 9 | Dinis, M.A.P. | 2 |
| 10 | Eames, C. | 2 |

*Sources: Research 2025*

## Distribution of Research Fields

The analysis of research fields indicates that studies on climate change education and curriculum reform within the SDGs framework are multidisciplinary. Most of the articles fall within the domain of Social Sciences, totaling 120 publications (47.4%), reflecting the dominance of educational, policy, and sociological approaches to this issue. The field of Environmental Science follows with 43 publications (17.0%), demonstrating the close relationship between education and environmental science studies.

In addition, the field of Energy contributed 23 publications (9.1%), signaling particular attention to issues of energy transition and sustainable energy literacy in education. Computer Science also made a significant contribution with 18 publications (7.1%), highlighting the connection between digital technology, data literacy, and the integration of climate issues into technology-based curricula. Meanwhile, contributions from other fields, such as Business, Management, and Accounting (9 publications), Psychology (8 publications), and Arts and Humanities (7 publications), underscore that this research has expanded across various disciplines. Overall, these findings indicate that climate change education is not merely a pedagogical issue, but also involves environmental, technological, psychological, and managerial dimensions.



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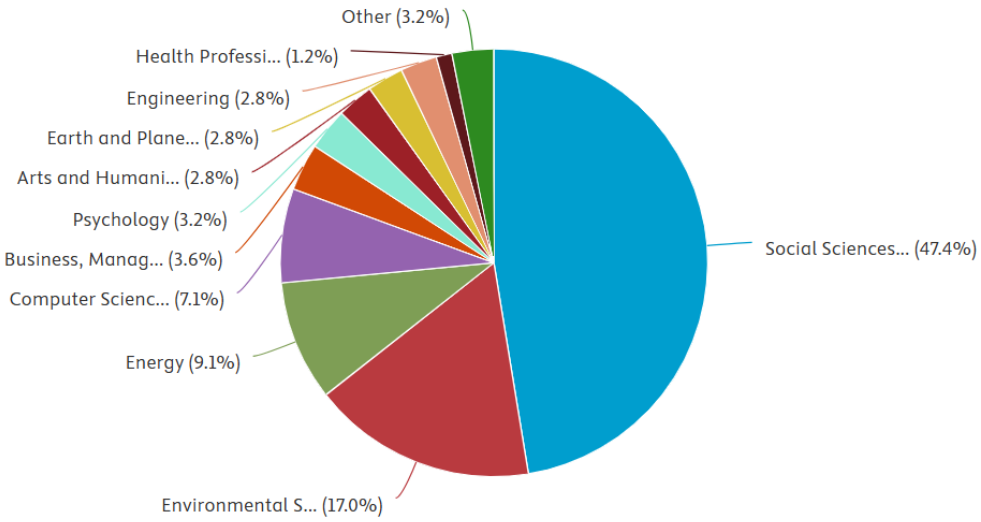


**Figure 3.** Distribution of subject areas
*Sources: Research 2025*

## Analysis of Author Collaboration Networks

The visualization of author collaboration networks in VOSviewer shows several clusters of closely connected researchers. The largest cluster is led by Leal Filho, W., who maintains extensive networks with authors from Europe, North America, and Asia. This cluster illustrates the dominance of researchers who have long been active in the field of education for sustainable development and are now expanding their research into issues of climate change education.

Another cluster is formed around Ferguson, T., who collaborates with authors from multiple countries on research related to curriculum policy and climate literacy. Eilam, E., and Hurlimann, A. also lead an active cluster, with a research focus on pedagogical approaches and the integration of climate issues into formal education. Although there are connections between clusters, the overall pattern reveals fragmentation within the author networks, with some research groups working relatively independently within their regional or disciplinary contexts. This indicates that, although there is global collaboration, research still tends to center on a few key figures.


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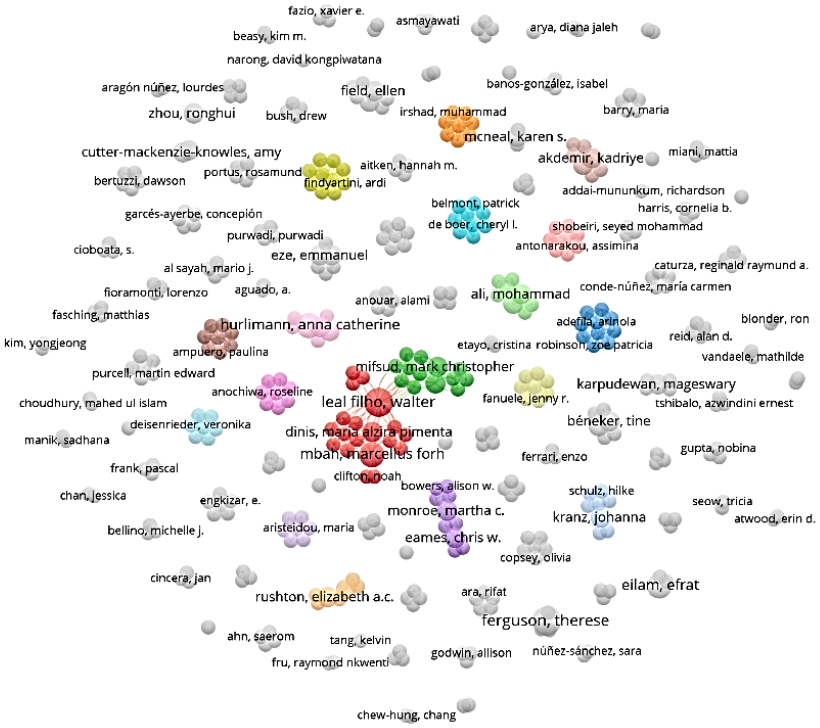


**Figure 4.** Author collaboration network
*Sources: Research 2025*

## Keyword Analysis

The analysis of keyword co-occurrence yielded five main clusters that reflect the research's thematic mapping. The first cluster centers on the term *"climate change education"*, which is closely associated with keywords such as *climate literacy*, *teacher training*, and *professional development*. This cluster illustrates the research focus on strengthening teacher capacity and students' climate literacy.

The second cluster focuses on *"curriculum"*, with strong connections to keywords such as *curriculum reform*, *educational development*, and *higher education*. This theme demonstrates a shift in research from merely addressing climate literacy toward curriculum transformation as a key instrument for implementing the SDGs. The third cluster emphasizes *"sustainable development"* and *SDGs*, highlighting the integration of sustainability issues across educational levels. The fourth cluster centers on *"environmental education"*, which is linked to *pro-environmental behavior* and *planetary health*, illustrating the focus on behavioral impacts and environmental awareness. The final cluster relates to *"policy"* and educational policy, underscoring the regulatory dimension as an important component in advancing the integration of climate issues. Thus, this pattern shows that research emphasizes not only the cognitive aspect, but also structural and policy dimensions.



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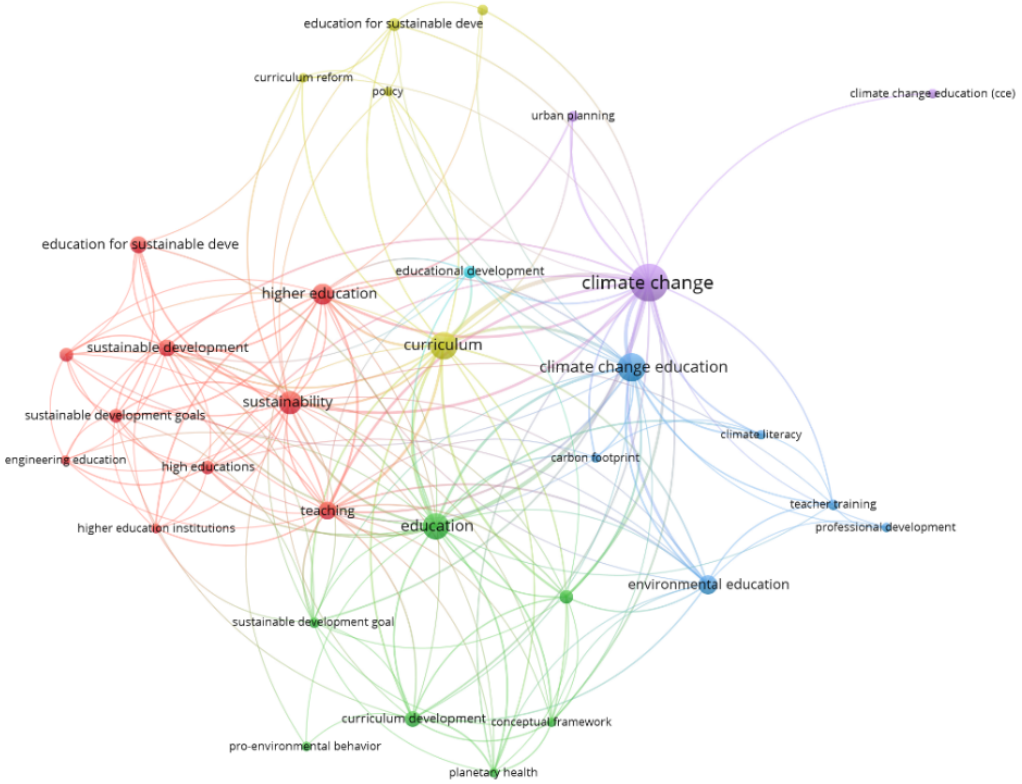


**Figure 5.** Keyword co-occurrence map
*Sources: Research 2025*

## Co-citation Map (Cited References/Sources)

The co-citation map generated in VOSviewer illustrates the intellectual structure that underpins research on this topic. Nodes with larger sizes indicate references or journals that are most frequently co-cited, while colors represent thematic clusters.

The results show that the *Journal of Education for Sustainable Development* occupies a central position as the dominant source within the ESD cluster, affirming its role as a primary basis of literature. Another cluster centers on behavioral change theory, with classical works such as Ajzen's *Theory of Planned Behavior* and Bamberg's *Pro-environmental Behavior* emerging as central nodes. This finding indicates that psychological foundations of human behavior remain a primary reference in climate change education research.

In addition, clusters related to pedagogical practices and environmental education also appear, with names such as Boyes and Bofferding highlighting climate learning at the school level. A policy-related cluster is also visible, with links to themes such as *policy*, *curriculum reform*, and *conceptual framework*. Interestingly, there are also regionally based clusters, such as the *Caribbean Journal of Education* and authors from the Caribbean region (e.g., Bynoe, Cantell), which demonstrate distinctive contributions from specific local contexts.


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Overall, this co-citation map shows that research within this corpus rests on two main pillars: (i) the literature on education for sustainable development (ESD) and sustainability education journals, and (ii) literature on theories of pro-environmental behavior. These two pillars are then connected with themes of pedagogy, curriculum reform, and educational policy, forming a complementary knowledge network.

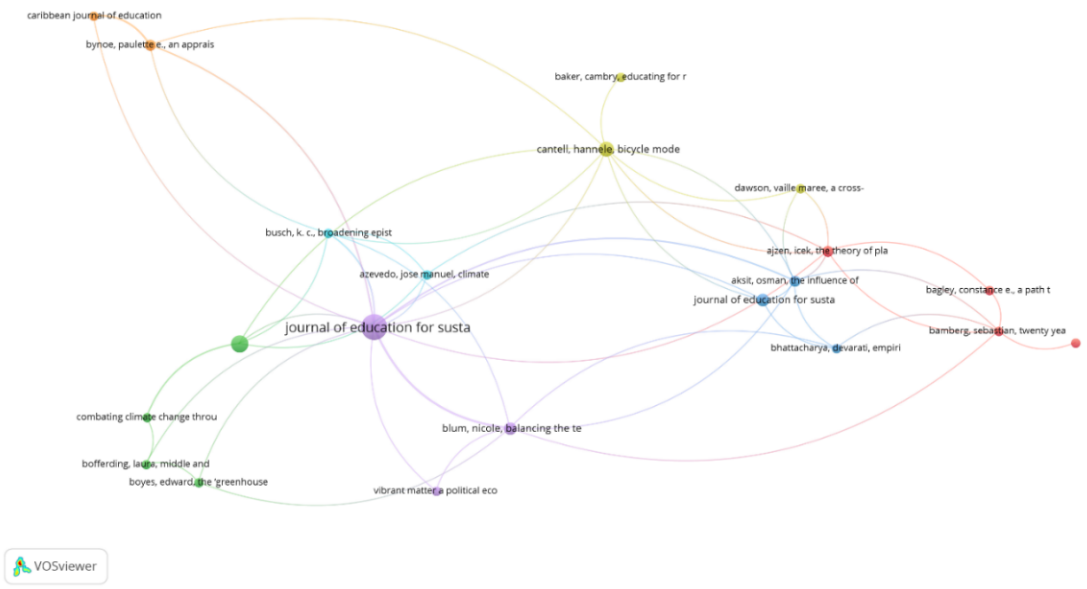


**Figure 6.** Co-citation reference map
*Sources: Research 2025*

## Discussion

The bibliometric analysis conducted in this study reveals a significant increase in publications related to climate change education (CCE), curriculum reform, and the Sustainable Development Goals (SDGs) over the past decade. This upward trend aligns with recent global reviews showing that scholarly output on CCE has expanded rapidly, reflecting growing international awareness of sustainability issues and the recognition of education as a strategic response to the climate crisis (Muccione et al., 2025). Despite this growth, the geographic distribution of research remains highly uneven, with research overwhelmingly concentrated in the Global North—particularly the United States, the United Kingdom, and other English-speaking countries. In the digital age, when information is complex and change is rapid, the significance of CCE is increasingly recognized. Require a high degree of flexibility. In response, CCE made technology knowledge and digital literacy crucial elements of its methodology (Hadiapurwa et al., 2024).

Such a pattern is consistent with bibliometric evidence indicating that knowledge production in CCE remains dominated by Global North institutions. At the same time, contributions from the Global South remain limited and underrepresented (Wang et al., 2024). This phenomenon is consistent with broader concerns raised in recent scholarship. A high-impact global analysis demonstrates that climate-related research remains heavily dominated by


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institutions in the Global North, resulting in significant epistemic inequality that marginalizes scholars, institutions, and knowledge systems from the Global South (Virgüez et al., 2024). This imbalance reflects structural disparities in research funding, access to publications, and international collaboration networks, reaffirming the need for more inclusive and equitable knowledge production in CCE. This persistent imbalance underscores the urgency of strengthening research capacity and visibility in developing countries to foster more equitable and contextually relevant climate education scholarship.

When compared with earlier bibliometric studies, the novelty of this research becomes evident. Prior analyses mapped general trends in education for sustainable development but did not specifically address the intersection of CCE, curriculum reform, and the SDGs (Prieto-Jiménez et al., 2021; Yang et al., 2023). By explicitly focusing on this nexus, the present study offers a more targeted perspective that situates curriculum reform as a crucial link between global agendas and local educational practices.

Critical scholarship further supports this interpretation. Sustainability education must be framed critically, not merely imparting factual knowledge but empowering learners to engage in transformative social action (Alam, 2022; Dhanaraj et al., 2024; Uthman, 2023). This is consistent with the bibliometric evidence from this study, which shows that terms such as *climate literacy*, *sustainable pedagogy*, and *transformative learning* recur prominently. Thus, the study not only maps trends but also reaffirms the conceptual trajectory of climate change education toward transformative paradigms. These insights underscore the need to strengthen curriculum models that bridge scientific knowledge with action-oriented and justice-centered approaches. Emphasize that climate education must integrate cognitive, affective, and behavioral dimensions, while highlighting the emergence of transformative pedagogies that prioritize agency, participation, and community engagement (Muccione et al., 2025). Together, these studies support the argument that climate-responsive curriculum reform must be systemic, interdisciplinary, and contextually grounded.

The findings also highlight that teacher capacity remains a key challenge. A significant barrier to embedding sustainability in education lies in teachers' limited preparedness, which aligns with the lack of publications focused on strategies to equip teachers to integrate CCE into classroom practice (Evans et al., 2019). In other words, while the theoretical discourse on sustainable curricula continues to expand, its translation into practical pedagogy remains constrained by insufficient professional development and institutional support.

This complements the bibliometric finding that keywords such as *participation* and *youth engagement* are becoming increasingly prominent in recent CCE literature. Such evidence suggests that climate curriculum reform is not only about adding new content but also about designing pedagogical spaces where learners can engage critically and collaboratively in envisioning future pathways. Instead of addressing climate change from a policy perspective that leaves governments solely in charge of developing adaptation strategies, it is time to actively explore knowledge production and skill development through education (Apollo & Mbah, 2021).

In terms of contribution, this study provides a comprehensive overview of the global research landscape by explicitly linking three domains: climate change education, curriculum reform, and the SDGs. The SDGs formalized the objective of guaranteeing that every child has access to high-quality education that fosters lifelong learning. According to some academics and


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decision-makers, the most essential of the 17 SDGs is education for sustainable development. In a way, the secret to achieving all the SDGs lies in education that helps the next generation of global citizens develop sustainable values, attitudes, and actions (Hallinger & Chatpinyakoop, 2019). By identifying this gap, the present study contributes to critical debates on *knowledge justice* in sustainability education.

The practical implications of these findings can be observed at three levels. At the policy level, governments are urged to embed CCE systematically into national curricula, aligned with SDG targets. At the institutional level, schools and universities should foster transformative learning environments through interdisciplinary collaboration, project-based learning, and student-led initiatives. At the practitioner level, teachers require continuous professional development and training to implement climate-responsive curricula effectively (Evans et al., 2019).

The theoretical implications reinforce two key frameworks: transformative learning and critical sustainability education. Bibliometric evidence confirms that pedagogical approaches emphasizing critical reflection, collective action, and learner empowerment are gaining prominence in the field (Dara & Kesavan, 2025; Ural & Özdemir, 2025). This shift indicates that CCE's trajectory is moving away from traditional instructional paradigms toward participatory and emancipatory models that position learners as active change agents. Most importantly, CCE can encourage students and communities to consider pertinent climate change adaptation measures or to positively alter their attitudes toward climate action (Mbah et al., 2022). Nevertheless, this study is not without limitations. As with most bibliometric research, reliance on a single database (Scopus) may exclude significant contributions published in regional or non-English journals (Gorski et al., 2023). Furthermore, bibliometric methods tend to prioritize quantitative indicators, such as citation counts or keyword frequencies, which may not capture the pedagogical depth or contextual nuances of climate education initiatives.

These limitations point to several promising directions for future research. Comparative analyses between Global North and Global South countries are needed to explore variations in curriculum implementation. Over the past ten years, there has been a progressive global trend away from a narrow focus on environmental protection in curricula toward broader objectives and innovative teaching techniques, as evidenced by the literature on climate change and sustainability in higher education (Filho et al., 2021). Empirical studies in schools and universities should investigate how CCE strategies are applied in practice, including the development of new assessment models suited to sustainability competencies. Action research involving teachers and students could provide more contextually grounded insights into how curricula can be co-created to address local climate challenges. Additionally, future research should embrace interdisciplinary approaches. Critical frameworks are essential for fostering transformative action (Nautiyal, 2024; Uthman, 2023). Combining these perspectives may yield more holistic and innovative curriculum models. This underscores the need for curriculum designs that incorporate local knowledge, cultural contexts, and community practices into global sustainability education frameworks.



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Overall, this study affirms that CCE and curriculum reform must be understood as inseparable from the global SDG agenda while remaining sensitive to local realities and epistemic justice. The increase in publication output in recent years is a positive sign of growing scholarly engagement. However, challenges related to global imbalances, teacher preparedness, and the need for transformative pedagogy remain pressing. By providing a comprehensive mapping of the research landscape and identifying critical gaps, this study contributes, both theoretically and practically, to advancing climate-responsive curriculum reform. It is hoped that these insights will inform policymakers, practitioners, and researchers seeking to design more inclusive, equitable, and transformative approaches to climate change education.

## CONCLUSION

This study maps the global research landscape on climate change education and curriculum reform within the Sustainable Development Goals (SDGs) framework using a bibliometric analysis of the Scopus database. The analysis reveals several key findings. First, publications have increased significantly since 2015, with a sharp surge during the 2020-2025 period, indicating growing academic attention to climate change education issues. Second, the distribution of publications remains dominated by Global North countries such as the United Kingdom, the United States, and Australia, although contributions from the Global South are beginning to emerge, including from Indonesia and South Africa. Third, the productivity of institutions and authors highlights the presence of central actors such as Manchester Metropolitan University and Walter Leal Filho, who play a driving role in advancing this field.

In addition, the analysis shows that the research is multidisciplinary, involving the social sciences, environmental science, energy, and technology. The collaboration map shows the formation of relatively strong author clusters, though fragmentation among research groups persists. Keyword analysis confirms the existence of five main thematic clusters, namely climate change education, curriculum reform, sustainable development, environmental education, and policy. Meanwhile, the co-citation map demonstrates that this body of research rests on two central intellectual pillars: education for sustainable development (ESD) and theories of pro-environmental behavior.

The contributions of this study are both academic and practical. Academically, it provides a comprehensive overview of the development, trends, and intellectual foundations within the nexus of climate change education, curriculum reform, and the SDGs, while also filling a gap in the literature that has been rarely explored in depth. In practice, the findings can serve as a reference for policymakers, curriculum developers, and education practitioners, particularly in developing countries, to design climate change education strategies that are more context-specific, inclusive, and long-term sustainability-oriented. Moving forward, further research is needed to strengthen the involvement of the Global South and expand cross-disciplinary collaboration to ensure that the integration of climate change education into curricula can be more evenly implemented worldwide.


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## AUTHOR'S NOTE

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