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Bibliometric Analysis of Environmental Literacy in Sustainable Development: A Comprehensive Review Based on Scopus Data From 2013 to 2023

Ariyatun 

Universitas Negeri Semarang, INDONESIA

Sudarmin*

Universitas Negeri Semarang, INDONESIA

Sri Wardani 

Universitas Negeri Semarang, INDONESIA

Sigit Saptono 

Universitas Negeri Semarang, INDONESIA

Winarto 

Yogyakarta State University, INDONESIA

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Abstract: The review article presents an analysis of the literature on environmental literacy in sustainable development. By utilizing techniques to examine multiple documents published between 2013 and 2023, including citation analysis, co-authorship analysis, subject area analysis, and keyword analysis, this study aims to provide valuable information and insights into the research landscape surrounding environmental literacy and its contribution to promoting sustainable development. A systematic search was conducted to gather several scientific articles, conference papers, and publications from the Scopus database from 2013 to 2023. The findings of this analysis shed light on authors, influential institutions, and active research groups that contributed to the study of environmental literacy and sustainable development. This comprehensive review offers an understanding of the state of research in this field while identifying areas for further exploration and research gaps. The insights gained from this study can be highly beneficial for researchers, policymakers, and practitioners seeking to advance knowledge and take action toward promoting literacy's role in sustainable development. This analysis is a foundation for advancing our understanding of literacy's significance while emphasizing its vital role in sustainable development efforts.

Keywords: *Bibliometric analysis, environmental literacy, sustainable development.*

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Introduction

In today's world, where there is a growing concern for the environment and a pressing need for development, the importance of literacy cannot be overstated. It shapes decision-making processes, formulates policies, and fosters community action (Santiani et al., 2023; Tharasook et al., 2020). Environmental literacy helps individuals understand how human activities are interconnected with the environment, promoting sustainable development (Figueiredo et al., 2023; Kurupparachchi et al., 2021; Zheng et al., 2020). This knowledge equips people with the knowledge, skills, and attitudes to make choices and take responsible actions to address urgent environmental challenges (Alkahr & Goldman, 2018; Putra, 2022; Sasa et al., 2022). As the global recognition of development as a path to a resilient and equitable future grows stronger, so does the urgency of enhancing environmental literacy. Damage or degradation which brings environmental and welfare problems must be resolved immediately. Environmental damage can be overcome if society develops environmental literacy (Yang et al., 2021). Environmental literacy is defined as the product of several components of disposition, knowledge, competence, and behavioral responses to the environment that influence each other (Liang et al., 2018; Liu et al., 2015). Environmental literacy is assumed to display behavior that is responsive to environmental protection (Shamuganathan & Karpudewan, 2015). Knowledge about environment will change people's thought patterns, attitudes and behavior so that they care more about the environment. Environmental knowledge will also encourage conservation behavior.

*Corresponding author:

Sudarmin, Universitas Negeri Semarang, Indonesia. ✉ sudarmin@mail.unnes.ac.id

Environmental literacy encompasses competencies ranging from understanding principles to recognizing the socioeconomic consequences of environmental degradation; (Huang & Hsin, 2023; Martínez-Ventura et al., 2021; Örs, 2022). To gain insights into the landscape at the intersection of literacy and sustainable development, an in-depth analysis based on Scopus data provides a comprehensive overview of existing literature trends and thematic patterns. Research on increasing environmental literacy through sustainable education is the focus of analysis in this research. The results of this research obtained research on the environmental literacy gap through learning in higher education. This research paper provides an analysis of literacy in sustainable development using bibliometric analysis. By employing this method, we can identify patterns, trends, and knowledge gaps in the field. Our goal is to offer an overview of the research landscape surrounding literacy and its connection to sustainable development. We have analyzed articles, conference papers, and other relevant publications from systematic searches across various databases and academic platforms. The literature represents studies by experts from various disciplines, such as science, education, psychology, and sustainability.

To achieve our objectives, we utilized VOSviewer software for analysis. We first identified authors, institutions, and research groups contributing to environmental literacy and sustainable development. We gained insight into influence and collaborations within the research community by examining citation patterns and coauthoring networks. Our analysis examines how research in this field has evolved by tracking topic emergence and shifting trends. This analysis offers insights into the direction of research on literacy and how it relates to the ongoing discussions about sustainable development. Additionally, it aims to explore the literature framework by analyzing the network of keywords that appear together. Through this analysis, we can uncover the connections between concepts, themes, and research areas, thus revealing the nature of environmental literacy within the broader context of sustainable development.

As a result of synthesizing the findings of this comprehensive review, this research aims to contribute to existing knowledge about environmental literacy and sustainable development. Insights from this analysis will assist researchers, policymakers, and practitioners in understanding the current state of research, identifying research gaps, and guiding future directions for advancing environmental literacy as a catalyst for sustainable development. This comprehensive review provides a systematic and quantitative analysis of the literature on environmental literacy in sustainable development. Using bibliometric analysis, we aim to shed light on advances, trends, and knowledge gaps in this important subject area, ultimately contributing to the broader goal of promoting environmental literacy for a more sustainable future.

Literature Review

Understanding how the natural environment works and how humans protect and maintain it is known as environmental literacy (Figueiredo et al., 2023; Kharchenko et al., 2020; Kurupparachchi et al., 2021). Wardani et al., (2018) state that environmental literacy is "basic education for all individuals that provides basic knowledge, skills, and incentives related to environmental demands and contributions to sustainable development". Since 1969, the term environmental literacy in environmental education has been defined as "the ability to accept and interpret relatively balanced environmental systems and be able to take steps to maintain, restore, or improve these environmental conditions" (Aikowe & Mazancova, 2023; Husamah et al., 2022). Environmental literacy is one's ability, such as knowledge about ecological systems and attitudes toward the environment, which are important determinants of positive and negative environmental behavior (Aikowe & Mazancova, 2023; Huang & Hsin, 2023; McBride et al., 2013). The North American Association for Environmental Education (NAAEE) defines environmental literacy as including awareness and concern about the environment and related problems, knowledge, skills, and the desire to find new preventative measures and solutions to existing issues (Hollweg et al., 2011).

Understanding the importance of environmental literacy can help people develop the understanding, character, values, ethics, and skills necessary to prevent environmental problems and the motivation to preserve and enhance the environment for both the present and the future (Liu et al., 2015; Putra et al., 2021; Saribas, 2015). The four components of environmental literacy are knowledge, competence, disposition, and environmentally conscious conduct. This ability must be used to respond to environmental situations or problems so that appropriate actions can be taken to address them. In environmental education, environmental literacy is knowledge and concern for environmental problems that lead to students' engagement and positive attitudes toward the environment (McBride et al., 2013; Szczytko et al., 2019). Environmental literacy is knowledge about the natural environment's mechanisms and humans' role in preserving it (Ardyansyah & Rahayu, 2023; Kocak et al., 2023; Law et al., 2023). Environmental literacy has the objective of assessing the effectiveness of environmental education.

The environmental crisis resulted from rapid population growth, industrialization, and increasing consumerism (Husamah et al., 2022; Lovren & Jablanovic, 2023). The same thing also happens in Indonesia, a developing country with the fourth-largest population in the world. Environmental problems are further complicated by human ignorance of the environment and selfishness. The government has much work to make its people ready to protect the environment, including educating them about bad environmental habits, such as throwing trash or waste into rivers, illegal logging, unrestricted fishing, and excessive consumption of water and energy (Figueiredo et al., 2023; Janoušková et al., 2020).

Environmental education strives to enhance the quality of life by empowering individuals to address and prevent environmental issues (Hollweg et al., 2011). Environmental education is highly prioritized to equip people to participate in creating a sustainable environment. Making students environmentally literate is a top priority for environmental education (Bonnert, 2013; McBride et al., 2013). Through implementing the sustainable development goals in education, research, and outreach, education must be a strategy to advance sustainable development (Husamah et al., 2022; Lovren & Jablanovic, 2023). A coherent long-term vision based on the foundations of human life and our environment is recognized as necessary for sustainability in higher education. Cognitive and emotional attitudes and awareness of important social, economic, and environmental issues can alter behavior.

Methodology

Research Design

Bibliometric analysis is one method used to evaluate a publication (Nugroho et al., 2022). The main concept of bibliometric analysis is the measurement of outputs, such as the number of citations in research and the impact of research with a particular theme. In order to facilitate the exploration of these patterns, it is essential to have data types. The researcher will then assess all the articles in the database using the following criteria: publication count, article source and publisher citation count, institutional affiliation, country of origin, language usage, and more. A systematic search was conducted to collect relevant scientific articles, conference papers, and other environmental literacy and sustainable development publications (Chen et al., 2023; Fayzullina et al., 2023; Husamah et al., 2023; Vásquez et al., 2023). The Scopus database is used to ensure comprehensive literature coverage. Search terms include variations of "environmental literacy," "sustainable development," and related keywords. The advantage of the Scopus database is that it can display a system of correlations or relationships between articles and publications and collaboration between authors. Collaboration is intended to involve more than one person or institution in a research or educational activity.

Sample and Data Collection

Data from 2013 to 2023 was collected from the Scopus database based on keywords and the year of publication, accessed on June 27, 2023. Several types of documents were collected, including articles (43 documents), conference papers (16 documents), book chapters (6 documents), and reviews (4 documents). However, this research used 59 articles and conference papers, consisting of 43 articles and 16 conference papers. The documents were stored in RIS, CSV, and BibTex formats. The research framework for data collection is described in Figure 1.

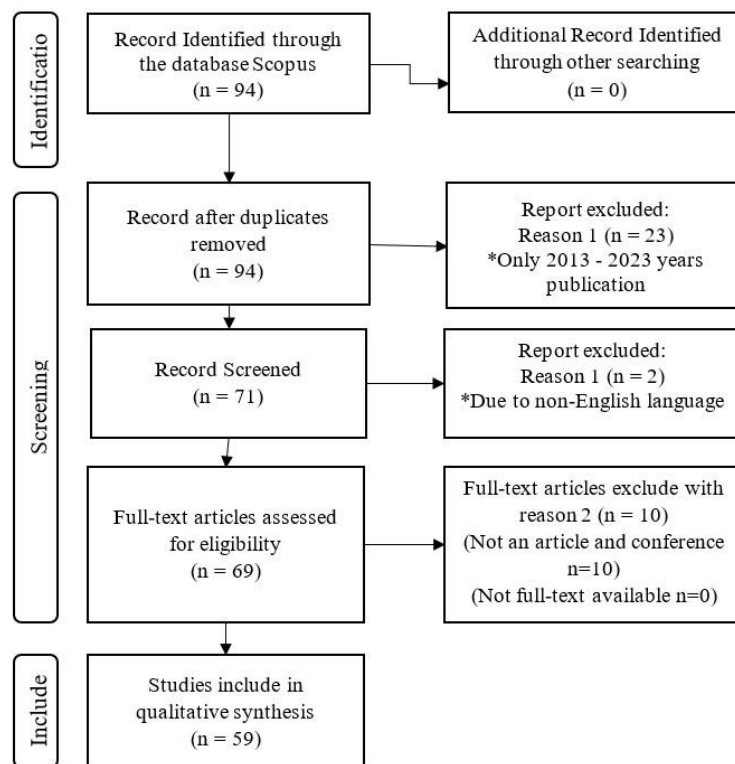


Figure 1. The Data Collection and Screening Process for the Bibliometric Analysis of Environmental Literacy in Sustainable Development

Analyzing of Data

An analysis was done through the "analyze results" dialog box on the Scopus database to analyze the number of publications, author productivity, and the most cited articles. Meanwhile, the relationship between topics and research

trends and the most frequently researched topics was analyzed using the VOSviewer applications. Several collected literature were screened based on predetermined inclusion and exclusion criteria. Inclusion criteria are publications focused on environmental literacy in sustainable development, written in English, and published between 2013 and 2023. Exclusion criteria are source, duplicate, and non-peer-reviewed publications that were not aligned with the study's objectives. Data exclusion was carried out by extracting relevant data from selected publications, including year of publication, title, journal/conference, affiliation, and abstract. In addition, the number of citations and references is recorded to facilitate citation analysis. Two methods are involved in analysis: performance analysis and science mapping (Cobo et al., 2011). Performance analysis assesses indicators, such as institutions, countries, authors, and similar information. It also helps evaluate the impact of these indicators using data (Henderson et al., 2009). On the other hand, science mapping depicts the dynamic aspects of scientific publications (Börner et al., 2003). This approach aids in creating a representation of how different disciplines and fields of knowledge are organized based on conceptual and intellectual foundations. This research used the performance analysis approach to illustrate indicators derived from bibliometric studies. The extracted data were analyzed using software or programming languages like VOSviewer. However, this analysis comprises the following components.

1. We examined the patterns of citations to uncover cited publications, influential authors, and noteworthy research groups. Through citation networks, we visualized the connections between articles and authors.
2. We constructed an authorship network to understand the relationships between authors and institutions. This analysis helps us identify authors, influential research groups, and collaboration patterns within the field.
3. We investigated the themes and concepts in the literature by analyzing co-occurring keywords. We carefully examined the frequency and occurrence of keywords to identify related terms and uncover the knowledge structure.
4. The insights from our analysis were interpreted to provide understanding. We discussed emerging trends, authors/institutions, and areas where further research concerning environmental literacy and sustainable development is needed. The results were synthesized to offer a view of the research landscape while guiding research directions.
5. It is important to acknowledge limitations when using analysis, such as excluding non-English publications or relying solely on available databases. These limitations were considered when interpreting our findings so that we maintained an understanding of the research landscape.

The approaches mentioned earlier describe a method used to analyze the literature on environmental literacy concerning sustainable development. This approach enables an exploration of the field, offering insights into research patterns, influential authors/institutions, and the fundamental knowledge framework. Ultimately, this contributes to conducting a review of the literature.

Findings/Results

Based on the bibliometric analysis of research publications on environmental literacy in sustainable development, the following findings are obtained:

Publication Trends

The analysis reveals a steady increase in environmental literacy and sustainable development publications over the last decade. It shows the growing interest in and recognition of the importance of environmental literacy in achieving sustainable development goals.

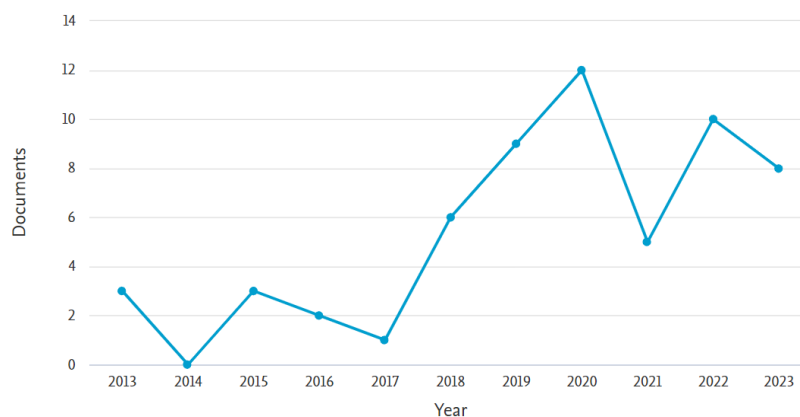


Figure 2. Publication Document by Year on Scopus Data 2023

Figure 2 explains that the highest year of article publication was 2020, with 12 documents on Scopus data; the second highest number was 2022 (10 documents), and the third was 2023 (8 documents). A significant increase is seen from

2017 to 2020 and a significant decrease (70%) from 2020 to 2021. There are five top journals in the document search: Sustainability Switzerland (26 documents), Water Switzerland (7 documents), International Journal of Environmental Research and Public Health (5 documents), International Journal of Sustainability in Higher Education (5 documents), and Environmental Educational Research (4 documents). Of the five journals, Sustainability Switzerland has the highest stability in publishing articles related to environmental literacy and sustainable development from 2015 to 2023. The data analysis is presented in Figure 3.

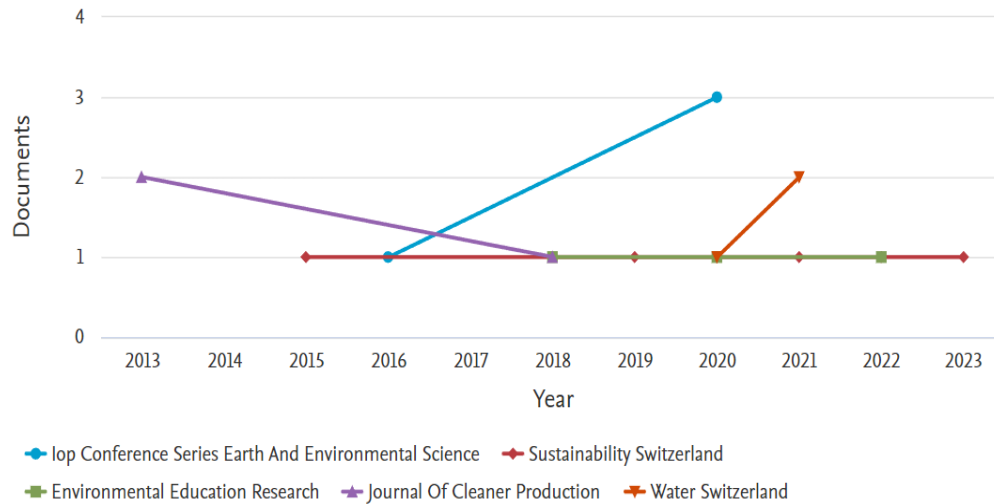


Figure 3. Publication Documents per Year by Source

Based on the analysis results of the scope and focus of the journals, they have the highest number of publications with the themes of environmental literacy and sustainable development. These journals have scope and focus related to sustainability and the environment. From 2015 to 2023, Sustainability Switzerland had a CiteScore of 5.8 SJR 0.664 SNIP 1.198. Sustainability is an international, cross-disciplinary, scholarly, peer-reviewed, and open-access journal on human beings' environmental, cultural, economic, and social sustainability. Sustainability, for example, focuses on themes such as environmental science, social science, and energy (sustainability and environment) in its publications. The second position is the IOP Conference Series: Earth and Environmental Science (EES), an "open access" proceedings journal providing fast, versatile, and cost-effective proceeding publication services. From 2016 to 2020, EES had a CiteScore of 0.8 SJR 0.197 SNIP 0.255. The third position is Environmental Education Research, which had a CiteScore of 7.1 SJR 1.122 SNIP 1.871. Environmental Education Research prioritizes research-based and scientific understanding of environmental education and sustainability. This journal publishes peer-reviewed research on all aspects of environmental education from around the world and from diverse schools of thought and practice in inquiry. Journal of Cleaner Production is ranked fourth with CiteScore 18.5 SJR 1.981 SNIP 2.379 from 2013 to 2018. The fifth is Water Switzerland with CiteScore 5.5 SJR 0.723 SNIP 1.063 from 2020 to 2021. The results of this analysis illustrate that the focus and scope of journals affect authors' selection of journal targets and the level of acceptance.

The trend of environmental literacy research in sustainable development is also based on a comparative analysis of documents from several countries. The top 10 countries are presented in Figure 4.

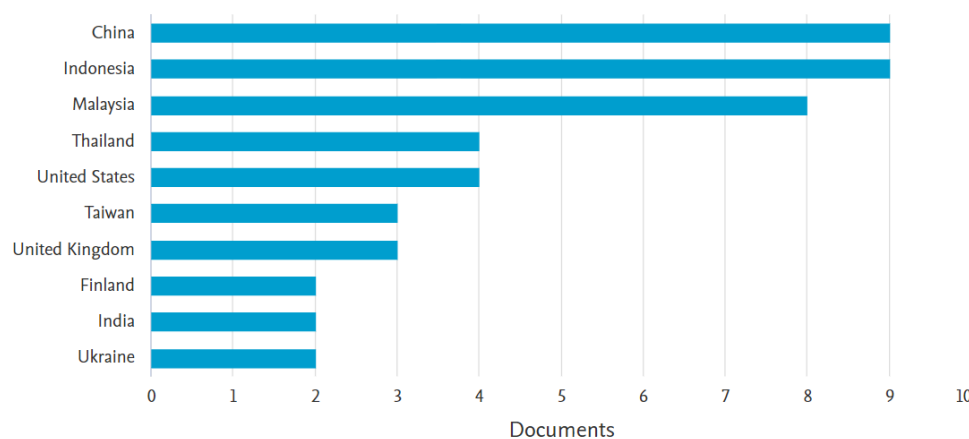


Figure 4. Publication of Documents by Country or Territory

The study results explain that the top five countries producing the most documents related to environmental literacy in sustainable development from 2013 to 2023 are China, Indonesia, Malaysia, Thailand, and the United States, with 9, 9, 8, 7, and 6 documents, respectively. The sixth to tenth place are Taiwan, United Kingdom, Finland, India, and Ukraine with 4, 3, 2, 2, and 2 documents respectively. The number of documents related to environmental literacy in sustainable development has increased significantly from 2018 to 2023, as displayed in Figure 4 by the VOS viewer software.

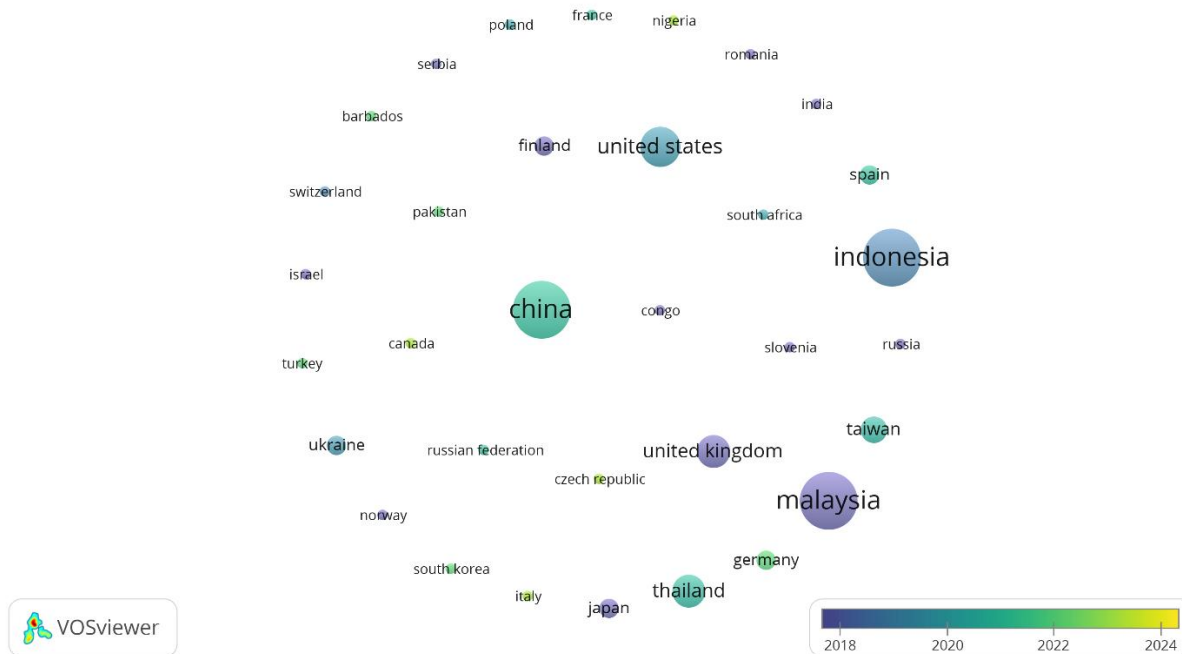


Figure 5. Collaboration Network by Country on Environmental Literacy and Sustainable Development Research Trends

The results of the visualization analysis of the overlay domain environmental literacy and sustainable development through the VOSviewer software also show the same results as the Scopus data. Several countries with the most significant clusters show an increasing number of documents produced: China, Malaysia, Indonesia, the United Kingdom, Thailand, Taiwan, Finland, and Ukraine.

Key Research Themes

This analysis identifies several main research themes in environmental literacy and sustainable development. It includes environmental education programs and strategies, assessment of environmental knowledge and attitudes, the role of technology in promoting environmental literacy, community involvement and participation, and the development of policies to integrate environmental literacy into the education curriculum to achieve sustainable development.

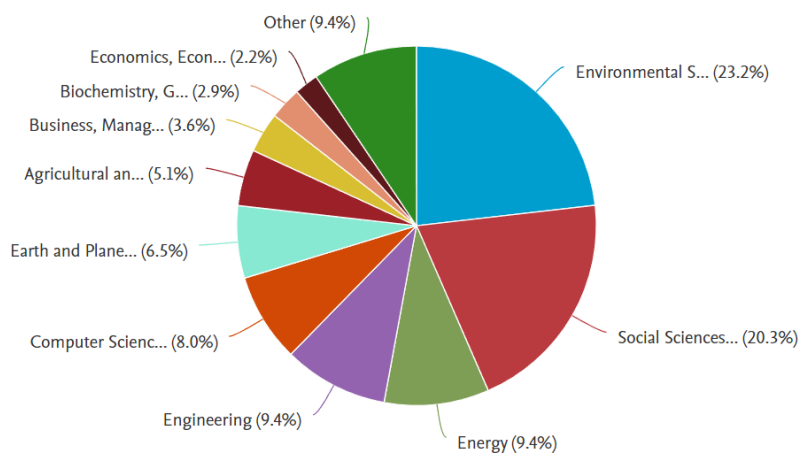


Figure 6. Documents by Subject Area Based on Scopus Data

The most searched theme is environmental science, with 32 documents (23.2%). The second is Social Science with 28 documents (20.3%), followed by Energy with 13 documents (9.4%), Engineering with 13 documents (9.45%), and Computer Science with 11 documents (8.0%). Environmental literacy transcends the boundaries of traditional education, extending its influence into policy-making, business strategy, and everyday choices. It includes a multifaceted understanding of ecological systems, the consequences of human action on these systems, and potential pathways for mitigating and adapting to the impacts of environmental change. This research theme explores the important role of environmental literacy in sustainable development, revealing its significance as a catalyst to promote harmonious coexistence between humans and the planet we call home.

Citation Analysis

The analysis examines citation patterns, identifying highly cited papers and influential sources. It indicates the original work and influential publications that significantly shaped environmental literacy and sustainable development discourse. Figure 7 describes the development of document citations from 2013 to 2023.

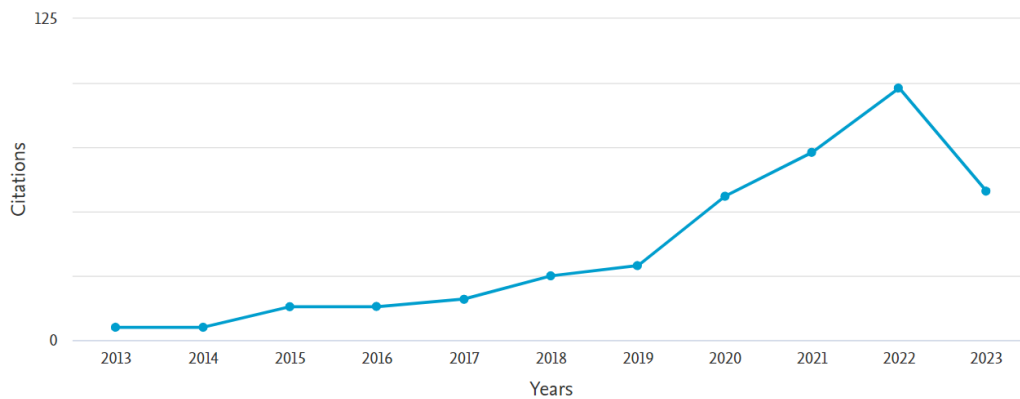


Figure 7. Overview of Citations for the Documents

There are 125 total citations, with more and more developments from 2013 to 2023. 2013 and 2014 had five citations each, and 2015 and 2016 had 13. There were 16 citations in 2017, 25 in 2018, 29 in 2019, 56 in 2020, 73 in 2021, and 98 in 2022. In 2023, there are 58 citations.

Table 1. Top 10 Citations in Scopus Data

No	Author	Journal	Total Citations	TC per year	Normalized TC
1	Foo (2013)	Journal of Cleaner Production	83	7,55	2,37
2	Goldman et al. (2018)	Journal of Cleaner Production	43	7,17	4,78
3	Lukman et al. (2013)	Journal of Cleaner Production	43	3,91	1,23
4	Lin et al. (2021)	International Journal of Environmental Research and Public Health	31	10,33	3,65
5	Ashley et al. (2019)	Frontiers in Marine Science	22	4,40	4,30
6	Shen et al. (2020)	Water (Switzerland)	19	4,75	4,49
7	Juntunen & Aksela (2013)	Center for Educational Policy Studies Journal	14	1,27	0,40
8	Nikezic & Markovic (2015)	Sustainability	14	1,56	1,68
9	Witoszek (2017)	Environmental Education Research	10	1,67	1,11
10	Asteria et al. (2016)	IOP Conference Series: Earth and Environmental Science	10	1,25	1,00

Based on article sources and authors, there are 10 top rankings with the most citations on environmental literacy in sustainable development. Journal of Cleaner Production occupies the top three rankings for the most citations with the collaboration of authors Foo (2013), Goldman et al. (2018), and Lukman et al. (2013), respectively, with 83, 43, and 43 citations. The fourth is the International Journal of Environmental Research and Public Health, with 31 yearly citations. Fifth to tenth place, respectively, are occupied by Frontiers in Marine Science, Water (Switzerland), Center for Educational Policy Studies Journal, Sustainability, Environmental Education Research, and IOP Conference Series: Earth and Environmental Science, with a total number of 22.19 citations each, 14, 14, 10, and 10.

Authorship Networks and Institutional Collaborations

The mapping of authorship networks and institutional collaboration reveals clusters of researchers, institutions, and regions that actively contribute to environmental literacy studies in sustainable development. Such networks provide insight into knowledge diffusion, collaborative dynamics, and interdisciplinary engagement. The analysis highlights the collaborative nature of the field, emphasizing the need for an interdisciplinary approach to address complex sustainability challenges.

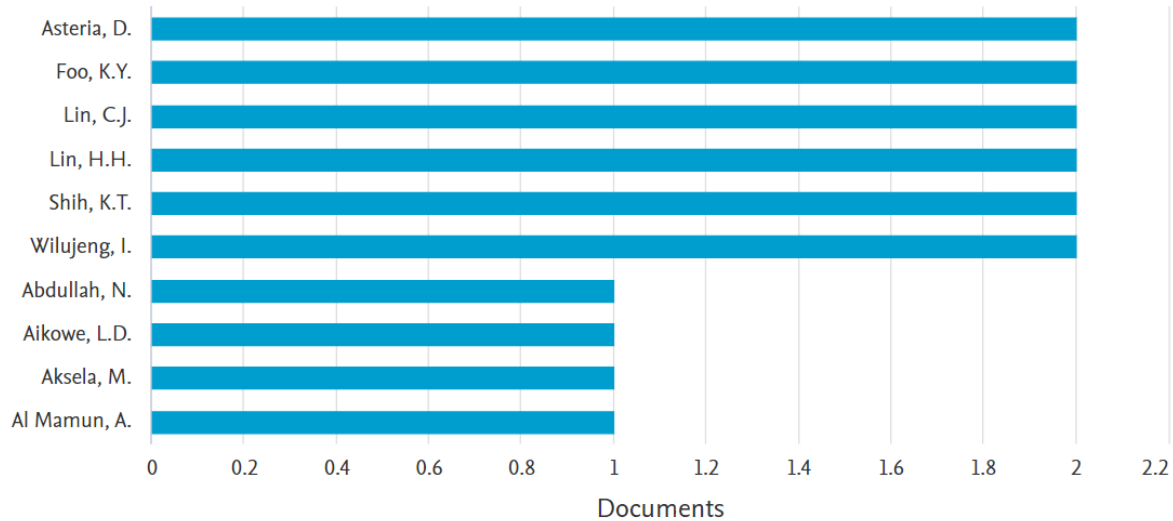


Figure 8. Comparison of the Document Counts for up to 10 Authors based on Scopus Data Overview of Citations for the Documents

This analysis identifies influential authors and institutions in environmental literacy in sustainable development. Renowned authors with a significant number of publications and many citations are identified, demonstrating their expertise and influence in the field. Likewise, institutions that produced significant research in this area are recognized as major contributors to the literature.

Table 2. Influential Authors and Institutions Based on Scopus Data Overview of Citations for the Documents

No	Author	Institutions	Total Citations in Scopus Data	H-index
1	Asteria, D.	Universitas Indonesia	67	5
2	Foo, K.Y.	Universitas Sains Malaysia	12.146	45
3	Lin, Jaochuan	National Kaohsiung University of Science and Technology, Taiwan	44	3
4	Lin, Hsiaohsien	Jiazing University, Meizho, China	321	11
5	Shih, Kuo Tung	Krirk University, Thailand	1	1
6	Wilujeng, Insih.	Universitas Negeri Yogyakarta	366	8
7	Abdullah, Nabilah Ooi	University Technology MARA, Malaysia	85	4
8	Aikowe, Loveth Daisy	Czech University of Life Sciences Prague	5	1
9	Aksela, Maija Katariina	Helsingin Yliopisto, Helsinki Finland	638	16
10	Mamun, Abdullah Al	UKM-Graduate School of Business Malaysia	1.719	22

The analysis results in Figure 9 display ten affiliates with the highest number of document producers on environmental literacy in sustainable development from 2013 to 2023. The top rank is Krirk University affiliation with three documents. Next are the top nine affiliations with a total of 2 documents each: Nanning Normal University, Universiti Sains Malaysia, Helsingin Yliopisto, National Chin-Yi University of Technology, Universiti Teknologi Malaysia, Universiti Malaya, Universiti Sains Malaysia (Health Campus), Universitas Indonesia, and Universitas Negeri Yogyakarta.

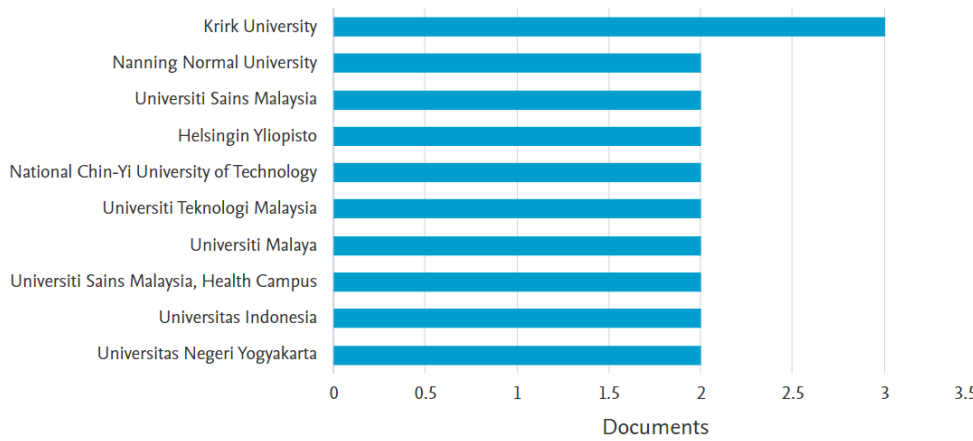


Figure 9. Comparison of the Document Count for up to 10 Affiliations based on Scopus Data

Patterns of collaboration among researchers of environmental literacy in sustainable development were analyzed in this paper. The analysis reveals collaborative patterns of co-authorship networks indicating collaboration between individuals, institutions, and countries, demonstrating the formation of research communities and the importance of collaborative efforts in advancing knowledge in this field. The citation analysis results on environmental literacy in sustainable development are also visualized in Figure 10 and Figure 11.

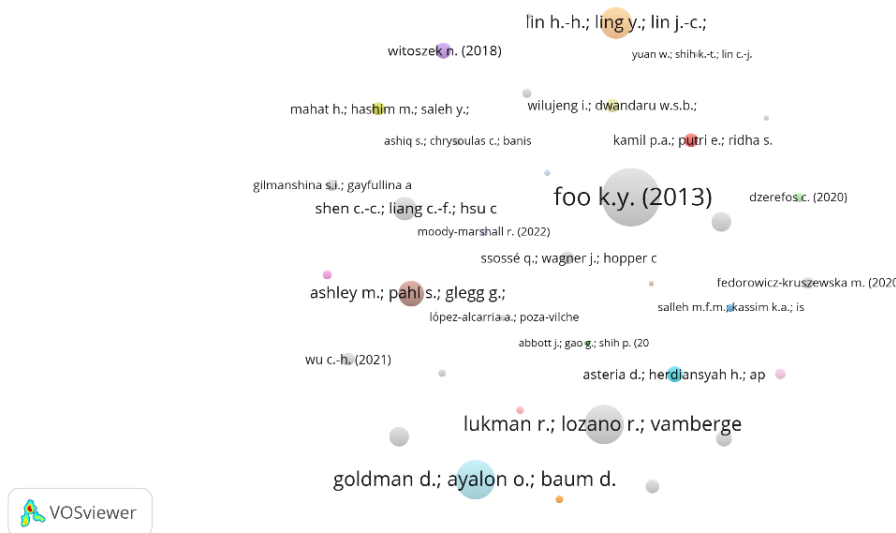


Figure 10. Network Visualization Citations by Co-Authorship

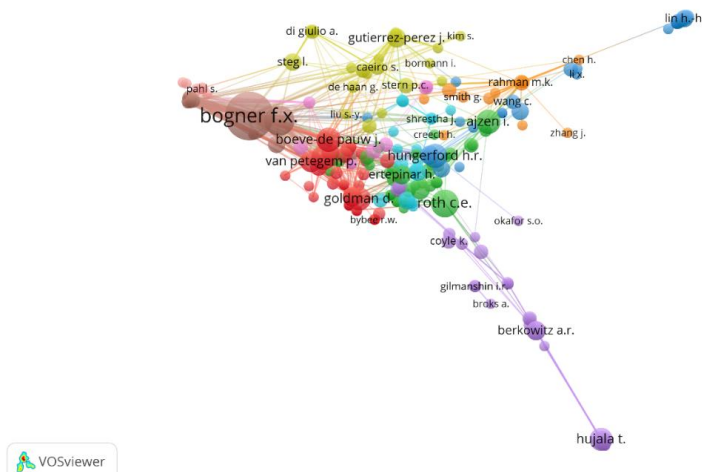


Figure 11. Network Visualization Co-Citation by Authors

There are 10 clusters in the visualization of co-citations by the Author, indicating a collaborative network between several authors from several affiliations and countries. It shows the formation of research communities and collaborations on environmental literacy research in sustainable development. The largest cluster in brown indicates the most collaborations of several authors, with six other clusters in red, yellow, green, blue, orange, and light purple.

Emerging Research Directions

This analysis also highlights emerging research directions and gaps in the literature. It covers areas such as the impact of environmental literacy on sustainable behavior change, the role of social media and online platforms in promoting environmental literacy, integrating indigenous knowledge and perspectives into environmental education, and evaluating the long-term results of environmental literacy programs.

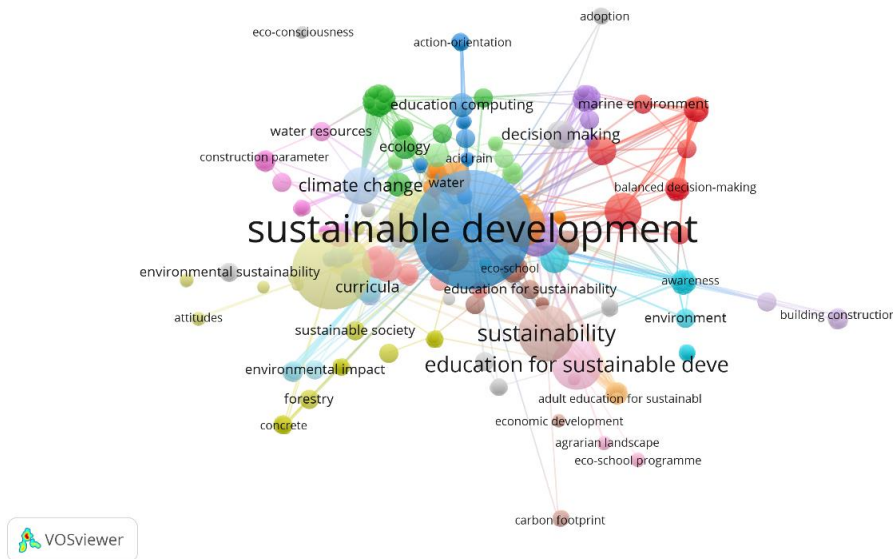


Figure 12. Network Visualization of Several Studies in the Overall Environmental Literacy and Sustainable Development Domain from 2013-2023 based on Scopus Data

The results of network visualization mapping show that the latest research themes are very closely related: sustainable development, environmental literacy, environmental education, Sustainability, Literacy, and Educational for Sustainable Development. Based on Figure 6. 68 journal articles in this study are grouped into 24 clusters, and in this research analysis, the six largest clusters are taken. Each cluster can be identified from the color difference. Cluster 1 is the largest blue cluster in the center of the map, which is directly related to the most prominent clusters around it: environmental literacy, sustainability, education for sustainable development, ecology, literacy, climate change, environmental protection, conservation, and environmental awareness. Cluster 2, in light yellow, is on the left side of the map, covering themes related to environmental literacy: attitudes, sustainable society, competencies for sustainable development, environmental impact, forestry, and creativity. Cluster 3 is shown in light brown, which includes themes related to sustainability: sustainable development, education for sustainable development, environmental literacy, economic development, carbon footprint, and climate change. The fourth largest cluster is the theme educational for sustainable development, which is closely related to sustainable development, environmental literacy, sustainability, and academic performance.

Analysis of the thematic content of the identified articles uncovers dominant research themes, emerging topics, and gaps in the literature. This analysis explores multiple dimensions of environmental literacy, from formal education and public awareness campaigns to sustainability practices and global environmental governance. By identifying emerging themes, this study offers a glimpse into priorities and evolving directions in environmental literacy and sustainable development. These findings give us an understanding of the research status regarding environmental literacy in the sustainable development context. They provide insights into trends in research, influential contributors, collaborative networks, and areas that still need exploration. These findings can guide future research efforts, policy development, and educational initiatives to increase environmental literacy and promote sustainable development.

Synthesis of Environmental Literacy for Sustainable Development

The bibliometric analysis conducted on the Scopus data set highlighted several important research themes at the intersection of environmental literacy and sustainable development. These themes collectively contribute to a

comprehensive understanding of the complex relationship between human knowledge, behavior, and the environment, highlighting environmental literacy's important role in driving a sustainable future.

1. *Education and Awareness*

A significant focus of research revolves around the importance of informal education in promoting literacy, particularly starting from a young age. Studies within this area explore the development of curriculum with different teaching methods and the effectiveness of environmental education programs in enhancing individuals' comprehension of ecological systems, resource management, and sustainable practices (Asteria et al., 2016; Mahat et al., 2020; Moody-Marshall, 2023; Santiani et al., 2023).

2. *Public Engagement and Behavior Change*

Researchers have extensively studied the impact of knowledge on how people perceive, think, and act (Andersson-Bakken et al., 2020; Fine & Furtak, 2020; Fung, 2020; Hanley et al., 2020; Lee et al., 2020). This topic highlights the significance of making informed decisions and changing our behavior to address challenges. Research explores factors influencing environmental actions, the media's role in this context, and effective communication strategies that encourage sustainable behaviors among different groups of people.

3. *Corporate Sustainability and Green Practices*

Businesses that prioritize literacy are becoming increasingly significant. They are dedicated to incorporating practices in their day-to-day operations and across their supply chains and decision-making processes (Cherian & Jacob, 2012; Lei et al., 2019; Tan et al., 2019). This particular focus revolves around the impact of literacy on driving social responsibility, promoting sustainable innovation, and aligning business strategies with environmental objectives.

4. *Policy and Governance*

Another crucial area of research focuses on the influence of awareness on policy development and governance systems. Researchers delve into how public knowledge and engagement shape policies that foster participatory decision-making and advance sustainable development objectives at various levels local, national, or global (Asteria et al., 2016).

5. *Interdisciplinary and Cross-sectoral Approaches*

The analysis highlights the importance of research in literacy, emphasizing the collaboration between academia, government, industry, and civil society (Lin et al., 2021; Onuki & An, 2013). This theme emphasizes the necessity of an approach that connects fields to address complex sustainability problems.

6. *Global Cooperation and Sustainable Development Goals*

According to Farida et al., (2023), adopting an approach that integrates disciplines to address complex sustainability challenges is essential. The current research landscape demonstrates a growing focus on collaboration and the significance of literacy in attaining the United Nations Sustainable Development Goals (SDGs), as highlighted by Tharasook et al., (2020) and Takala et al., (2023). Research indicates a need for solutions that consider perspectives and promote cooperation across various fields.

7. *Indigenous Knowledge and Cultural Perspectives*

Understanding the importance of knowledge and cultural viewpoints, researchers explore how environmental literacy contributes to the preservation of ecological knowledge, the development of cultural resilience, and the promotion of sustainable practices that are deeply rooted in local wisdom (Santiani et al., 2023; Sudarmin et al., 2020, 2023).

8. *Technological Innovation and Environmental Literacy*

The key focus of this theme delves into the convergence of advancements, digital proficiency, and ecological awareness. It encompasses the significance of platforms, reality, and data visualization in enhancing public comprehension of intricate environmental concerns.

Discussion

Findings from bibliometric analyses of research publications on environmental literacy in the context of sustainable development offer several points for discussion and reflection. The increasing number of publications on environmental literacy and sustainable development shows a growing awareness of the importance of environmental literacy in addressing environmental challenges. This shows a positive trend to integrate education and environmental awareness into sustainable development initiatives (Ariyatun et al., 2022; Szczytko et al., 2019). The network of collaborations identified among researchers demonstrates the interdisciplinary nature of environmental literacy research (Alkaher & Goldman, 2018). Collaboration among researchers from different disciplines, such as environmental science, education,

psychology, and policy, is essential to address different aspects of environmental literacy. This collaboration can lead to a more comprehensive and holistic approach to promoting environmental literacy.

Analysis of bibliometric data described in Figure 1. provides significant insight into the publication trends of articles on environmental literacy and sustainable development. The increase in the number of publications from 2017 to the peak in 2020 reflects the increased interest and focus of researchers on this topic. These findings are able to reflect responses to increasingly pressing environmental issues, encouraging research and publication in an effort to understand and address sustainable development challenges (Kuruppuarachchi et al., 2021; Pan & Hsu, 2022). The significant decline of 70% from 2020 to 2021 attracted attention. This drastic decline may reflect several factors, such as changes in research focus, global events affecting research capacity, or even influences from external factors such as the COVID-19 pandemic. Further discussion and tracing of the causes of this decline can provide a deeper understanding of the dynamics of environmental literacy research.

The top four journals that publish the most articles on environmental literacy, Sustainability Switzerland is in the limelight. The stability of its publication level from 2015 to 2023 shows its consistency and continued contribution in disseminating knowledge on environmental literacy and sustainable development. Further analysis can consider what factors make this journal a favorite of researchers, such as editorial reputation, editorial policies, or the focus of the journal that fits the research trend. The high number of publications on environmental literacy and sustainable development provides a strong indication of the increasing awareness of the importance of environmental literacy in facing environmental challenges. These findings reflect a paradigm shift towards a deeper understanding of how environmental education can play a key role in supporting sustainable development. Previous studies by Farida et al. (2023), Figueiredo et al. (2023), Pan and Hsu (2022), and Rasis et al. (2023) also corroborate these claims, suggesting that environmental literacy is becoming an increasingly relevant and growing research topic in the scientific literature.

Thematic analyses of publications on environmental literacy in the context of sustainable development provide a rich overview of the focus of research in this field. The largest theme, environmental science, dominated with 23.2%, indicating that many researchers are interested in the relationship between environmental literacy and a deep understanding of ecological systems. The analysis of this section reflects awareness of the importance of environmental literacy in understanding and responding to increasingly complex environmental challenges (Husamah et al., 2022; Figueiredo et al., 2023). Overall, these findings confirm that environmental literacy has transcended the boundaries of traditional education. By involving various themes such as environmental science, social science, energy, engineering, and computer science, environmental literacy not only serves as knowledge, but also as a catalyst for interdisciplinary decision making and action. Awareness of human impacts on ecological systems and efforts to respond to them have made environmental literacy an integral element in promoting sustainable development, creating harmony between people and the earth as our home.

Thematic content analysis conducted on the identified articles provides a rich picture of the diversity of environmental literacy dimensions in the context of sustainable development. Emerging themes cover a wide range of aspects, from formal education to public awareness campaigns, as well as global sustainability and environmental governance practices. Thus, the analysis details that environmental literacy is not only limited to understanding ecology, but also includes aspects such as community participation, sustainability actions, and environmental management at the global level. The dominant research themes, as identified in the analysis, namely sustainable development, environmental literacy, environmental education, Sustainability, Literacy, and Educational for Sustainable Development provide an overview of the key issues that are the main focus of environmental literacy research. The emergence of formal education shows that understanding environmental literacy is being integrated into the formal education system as a step to increase people's awareness and knowledge of environmental issues. Public awareness campaigns also reflect efforts to bring environmental literacy into the public sphere, creating broader awareness and support. There are several important points from the synthesis of research results that are important to note, namely:

1. *Addressing Knowledge Gaps*: The analysis uncovers paths for research and areas where our understanding of literacy falls short. Future studies must concentrate on these aspects to deepen our knowledge. For instance, studying how effective environmental literacy programs are in encouraging change or examining the impact of technology on enhancing environmental education can offer valuable insights for practical application and policy formation.
2. *Policy and Practice Implications*: The results of this study have implications for individuals involved in education and sustainable development efforts. The authors and institutions that were found to be influential as their significant contributions can serve as a valuable resource for informing policy decisions and guiding the creation of effective environmental education programs. By understanding the patterns and areas lacking in the literature, practitioners can identify areas that warrant research and intervention.
3. *Global Perspective and Contextualization*: This analysis provides an overview of the outlook on research regarding literacy. It allows for the recognition of different approaches to environmental education and the contextual factors that impact the development of environmental literacy. This understanding is crucial for tailoring interventions and strategies to cultural and socioeconomic contexts.

4. *Long-Term Impact Assessment*: An area that stood out in this analysis was the necessity to evaluate the long-term consequences of environmental education efforts. It is crucial to comprehend how environmental literacy programs continue influencing individuals' knowledge, attitudes, and behavior to assess their effectiveness and guide interventions.

These findings offer insights into environmental literacy research in the development context. They highlight the progress made so far, identify areas where more knowledge is needed, and suggest avenues for further exploration. Discussing these findings can contribute to the conversation about education, policy creation, and promoting sustainable practices. Ultimately, this can lead to effective efforts in enhancing environmental literacy. The synthesis of the research themes emphasizes how multifaceted environmental literacy contributes to development. It encompasses education, behavior change, corporate practices, policy influences, and cultural perspectives all factors for fostering a resilient coexistence between humans and our environment. As scholars, policymakers, and practitioners delve deeper into these themes, we gain pathways toward a sustainable future. Informed decision-making, proactive engagement, and a profound understanding of our web of life on Earth drive us forward.

Conclusion

The analysis indicates an increasing number of publications on environmental literacy research, which shows a growing interest in this area. It suggests that people are becoming more aware of the importance of acquiring knowledge, attitudes, and behaviors that support sustainability. The research also emphasizes the need for collaboration across disciplines to address the challenges related to environmental literacy. We can gain a holistic understanding and develop effective strategies to promote environmental literacy by bringing together researchers from different fields. Additionally, identifying authors, institutions, and original work provides insights for policymakers, educators, and practitioners involved in environmental literacy initiatives. These findings can guide policy decisions, shape programs, and contribute to evidence-based practices. Lastly, the analysis sheds light on emerging research areas and identifies gaps in our knowledge. Ultimately, these findings emphasize the importance of environmental literacy as a critical component of sustainable development. Increasing environmental literacy can empower individuals to make decisions, adopt sustainable behaviors, and actively participate in addressing environmental challenges. The conclusions from this bibliometric analysis provide valuable insights for researchers, policymakers, educators, and practitioners. They contribute to ongoing efforts to promote environmental literacy and advance sustainable development goals, ultimately driving a more environmentally conscious and sustainable society.

Recommendations

This research discusses Environmental Literacy Analysis in Sustainable Development: A Comprehensive Review Based on Scopus Data from 2013 to 2023. Future research will increase the number of articles analyzed from WOS data based sources. Further research will carry out bibliometric analysis of environmental literacy studies in primary and secondary education. This was done to review the relationship of education to increase environmental literacy from primary education to high education. Suggestions for teachers, managers, educators, parents to support education that increases awareness of the environment so that it can increase our children's environmental literacy.

Limitations

This article only discusses sustainable development and Scopus data based on the 2013-2023 period

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Conflict of Interest

The authors declare no potential conflicts of interest.

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