GLOBAL RESEARCH MAPPING ON ENVIRONMENTAL AWARENESS IN EDUCATION: BIBLIOMETRIC ANALYSIS 2015-2025

Vika Puji Cahyani[1], Munawwarah[1]

[1]Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar, Makassar, Indonesia

Article Info	ABSTRACT
	The relationship between education and environmental awareness has been widely studied, but there are still several research gaps that need attention. For example, there is no comprehensive mapping that describes global research trends on environmental awareness in education. The urgency of this research lies in efforts to address gaps in academic literature, particularly the lack of research that systematically maps global research trends on environmental awareness in education. This study aims to analyse global trends in research on environmental awareness in education based on scientific publications during the period 2015-2025. This study uses a bibliometric approach. Research data were collected from the main database, namely Scopus. There are inclusion and exclusion criteria in this study. Environmental awareness in education is closely related to various aspects, including attitudes, behaviour, and sustainability policies. There are five main topics related to environmental awareness, namely Environmental Awareness and Environmental Education, Sustainability and Sustainable Development, Consumer Environmental Awareness and Pro-Environmental Behaviour, Environmental Attitudes and Environmental Performance, and Environmental Sustainability in Education. Enhancing environmental education is crucial for preparing future generations who are more concerned about the environment and ready to face sustainability challenges. By implementing the findings from this global research, Indonesia can develop more effective educational strategies to create a more environmentally conscious society and contribute to sustainable development. *This is an open access article under the CC BY-SA license.*

Corresponding Author:
Munawwarah
Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar, Makassar, Indonesia
Email: munawwarah@unm.ac.id

1. INTRODUCTION

Environmental awareness is a global issue that is gaining increasing attention, especially in the face of challenges such as climate change, environmental degradation, and natural resource sustainability (Gifford and Nilsson 2014; UNESCO 2021). In responding to these issues comprehensively, understanding the dimensions of environmental awareness is very important because it can influence people's attitudes and behaviour towards the environment. Environmental awareness itself is generally categorised into two main aspects, namely knowledge about the environment and concrete actions that reflect concern for sustainability (Kousar et al. 2022; Ali et

al. 2023). This categorisation reinforces the understanding that education has a strategic role in shaping pro-environmental behaviour through the strengthening of students' cognitive and affective aspects. Environmental knowledge gained through formal and informal education can shape critical awareness of ecological issues, while concrete actions reflect the application of these values in daily life. In this regard, Ali et al. (2023) and Jabbar (2015) emphasise the importance of integrating the dimensions of knowledge and action in building a holistic environmental awareness. Additionally, previous research indicates that value-based and experiential approaches are more effective in enhancing students' concern and participation in environmental issues. Therefore, the implementation of holistic and contextual environmental education is a relevant strategy for fostering a generation that is aware, critical, and committed to the sustainability of the Earth (Jabbar 2015; Ali et al. 2023).

Many studies highlight the crucial role of education in shaping environmental awareness. Environmental education has proven effective in enhancing children's knowledge and skills to face ecological challenges. Education plays a strategic role in shaping pro-environmental behaviour from an early age, which ultimately contributes to the creation of a more caring and responsible society towards environmental sustainability (Gifford and Nilsson 2014; Law et al. 2017; UÇAR ÇABUK and İŞAL 2023). In this context, integrating environmental issues into formal curricula is an important step toward strengthening this awareness. Education designed with a contextual and values-based approach has proven effective in internalising sustainable attitudes and behaviours among students. Educational transformation through curricula sensitive to environmental issues can accelerate the process of developing a generation resilient to ecological crises. Strengthening the cognitive, affective, and conative dimensions in environmental education is crucial to ensure that the awareness built does not stop at knowledge but is also manifested in concrete actions (Sola 2014; Zhongbin 2024). Therefore, it is important for educational institutions to design learning programmes that can fully integrate ecological insights into the learning process. This not only improves students' environmental literacy but also strengthens their capacity as agents of sustainable social change. Through a holistic approach to education, it is hoped that environmental awareness will be firmly embedded and produce long-term impacts for the sustainability of the earth.

As the urgency of the environmental crisis increases, various studies have been conducted to understand how education can contribute to raising environmental awareness. Education not only strengthens knowledge but also shapes positive attitudes and behaviours towards nature conservation. Collaborative learning experiences can enhance understanding of the interconnections between humans and the environment, which is an important foundation for promoting pro-environmental actions (Flanagan et al. 2019; Kousar et al. 2022). Increased environmental knowledge has a positive relationship with the formation of better environmental attitudes, although there are still challenges in its implementation, especially in developing countries (Debrah et al. 2021). Locally relevant learning experiences are more effective in internalising environmental awareness. Furthermore, educational approaches that integrate social, cultural, and ecological contexts can enhance the relevance of learning and strengthen students' motivation to engage in environmental action (Ardoin et al. 2018; Monroe et al. 2019). Thus, education must be positioned not only as a means of knowledge transfer but also as a transformative tool for shaping environmentally conscious generations ready to face global sustainability challenges. Holistic interventions encompassing cognitive, affective, and conative

aspects are key to creating long-term impact in building environmental awareness and concern (Khoiri et al. 2021; UNESCO 2021). Therefore, collaboration between educational institutions, communities, and policymakers is essential to create an educational system that supports sustainable behavioural change.

Many studies have discussed the relationship between education and environmental awareness, there are still several gaps in research that need to be addressed. First, there is no comprehensive mapping that describes global research trends on environmental awareness in education, in terms of the number of publications, collaboration between researchers, and the main topics that have developed over the past decade. Such mapping is important for understanding the dynamics of scientific developments and the direction of global environmental education policies. Second, it is not yet known to what extent the results of global research can be adapted and applied in the context of education in Indonesia, which has different social, cultural, and geographical characteristics. This poses a particular challenge in formulating effective and relevant educational approaches. Furthermore, most studies are still theoretical and lack exploration of real-world implementation at the school or university level, particularly in developing countries. Thus, a study is needed that not only systematically maps the literature but also identifies gaps and opportunities for collaboration to develop contextual environmental education strategies. Research using a bibliometric approach can be a solution to fill this gap, as it provides a quantitative overview of the existing scientific landscape. Through this approach, education policies in Indonesia can be formulated in a more targeted and evidence-based manner.

Given the importance of a deeper understanding of global research trends in this field, this study uses a bibliometric analysis approach to trace the development of environmental awareness research in education during the period 2015-2025. This analysis will provide an overview of research patterns, the relationship between key concepts, and identify research areas that have received insufficient attention (Auliah and Cahyani 2024; Cahyani et al. 2024a; Cahyani et al. 2024b; Cahyani and Fadly 2024; Cahyani and Romadin 2024). According to Jumini et al. (2022), the integration of science, technology, and entrepreneurship in science education, through bibliometric analysis, plays a crucial role in understanding the intersection of various disciplines, which can also enrich the development of environmental awareness education. The urgency of this research lies in the attempt to address the gaps in academic literature, especially the lack of studies that systematically map global research trends on environmental awareness in education. As global environmental challenges continue to escalate, a comprehensive understanding of how environmental awareness is taught and instilled in various education systems becomes paramount. This study aims to fill the gap identified by Jumini et al. (2022), where the application of bibliometric analysis could help in tracking the evolution of environmental awareness research, contributing to the global discourse on sustainable education practices (Jumini et al. 2022).

The study entitled 'Global Research Mapping on Environmental Awareness in Education: Bibliometric Analysis 2015-2025' offers a novel approach to identifying global research trends related to environmental awareness in education, using a bibliometric approach to map the development of literature from 2015 to 2025. Unlike previous studies, which were mostly qualitative and focused on case studies at the national or regional level, this study provides a comprehensive global overview of the relationship between key concepts and research areas that have not received sufficient attention (Auliah and Cahyani 2024; Cahyani et al. 2024a; Cahyani and Fadly 2024; Cahyani and Romadin 2024). While studies such as those conducted by Flanagan

et al. (2019) focus on the influence of collaborative experiences on environmental awareness among young people, this study broadens the scope by mapping the contributions of various disciplines to environmental education at the global level. In addition, research by Debrah et al. (2021) demonstrate the link between increased environmental knowledge and pro-environmental attitudes, but do not discuss how these research developments interact in the context of global education. This study provides deeper insights into the development of research areas that have received little attention and areas that are rapidly developing in the international environmental education literature. Using bibliometric analysis, this study is able to map broader research patterns and provide a more holistic view of the impact of education on environmental awareness. This makes this study important for understanding how environmental education can be more effectively integrated into education curricula in various countries (Debrah et al. 2021).

This study aims to analyse global trends in research on environmental awareness in education based on scientific publications during the period 2015-2025. In addition, this study also seeks to identify the main concepts that dominate research related to environmental awareness in education through bibliometric analysis. Thus, the results of this study can provide strategic recommendations for the development of environmental education in Indonesia that is more based on identified global research trends. The significance of this study lies in its ability to provide a comprehensive overview of the development of environmental awareness in the context of education, which can be used as a basis for formulating more effective and relevant educational policies in response to global environmental challenges. Through the identification of research patterns and the relationships between key concepts in environmental education, this study also plays a role in filling existing gaps in the literature, particularly those related to the integration of environmental issues into educational curricula in various countries.

The benefits of this research are significant for policymakers, educators, and researchers interested in designing educational programmes that focus not only on environmental knowledge but also on pro-environmental behaviour change among students. By providing deeper insights into global research trends, this research is expected to help develop curricula that are more oriented towards environmental awareness and sustainability, particularly in Indonesia. Another benefit is for educational institutions and non-governmental organisations working in the environmental field to strengthen a more holistic and adaptive sustainability-based educational framework that meets global needs.

2. METHOD

This study uses a bibliometric approach to analyse global trends in research on environmental awareness in the context of education. The bibliometric method was chosen because it is capable of mapping relationships between research topics, publication trends, and academic collaboration based on bibliographic data from scientific databases (Auliah and Cahyani 2024; Cahyani and Romadin 2024). Research data was collected from two main databases, namely Scopus, which is one of the largest and most credible scientific literature databases. The article search process was conducted using the keyword 'Environmental Awareness' in the title, abstract, and keywords during the period 2015 to 2025. To ensure the relevance and quality of the analysed articles, several inclusion and exclusion criteria were applied. Inclusion criteria included journal articles published between 2015 and 2025, written in English, discussing environmental awareness

in the context of education, and available in full text. Exclusion criteria include non-scientific journal articles such as proceedings, reports, and editorials; articles not written in English; articles irrelevant to education and environmental awareness; and duplicate articles or those without complete metadata. From the initial search, 200 articles containing the keywords were identified, and after screening based on the established criteria, the most relevant articles were selected for further analysis. The data analysis process was carried out in several stages, namely: first, extraction of bibliographic data in RIS format from Scopus, which included titles, year of publication, abstracts, keywords, and author names. Second, bibliometric analysis using VOSviewer software, with co-occurrence analysis techniques to map the relationships between keywords that frequently appeared together. Third, interpretation of results and data visualisation, focusing on the main themes that emerge and their implications for education in Indonesia. The results of this analysis will be visualised in the form of annual trend diagrams, keyword network visualisations, and density visualisations to identify the most dominant topics. With this method, it is hoped that this study will provide a comprehensive overview of global trends in environmental awareness research and offer data-driven recommendations for the development of environmental education in Indonesia.

3. RESULTS AND DISCUSSION

3.1. Trends in Environmental Awareness Research in Education

Analysis of publication trends shows a significant increase in research on environmental awareness in education over the past decade (2015-2025). The initial stage of the research began with the collection of Scopus indexed data with the keyword 'environmental awareness' in 2015-2025 with the help of the Publish or Perish software. The output results were then saved in a .ris file. Most of the publications are scientific articles (181 out of 200), which cover 90.5% of all documents. This shows that more of the research conducted is disseminated in the form of journal articles, which are the primary medium for researchers to publish their findings. Publications in the form of book chapters only number 3, while books only number 1. There are 11 conference papers, which shows that besides journals, conferences are also one of the channels for disseminating research results. This may reflect the field of study being active in scientific discussions through academic forums. This indicates that although there are attempts to write in a longer format such as books or book chapters, the contribution is still very limited compared to journal articles. A total of 4 documents are categorised as 'Other,' which may include research reports, white papers, or other forms of publication not included in the main categories. Based on the data in Table 1, it can be concluded that academic publications are more focused on scientific articles, while contributions in the form of books and book chapters are still limited. To increase the diversity of publications, it may be necessary to encourage researchers to publish their research results in the form of books or book chapters, which can have a long-term impact on the development of science. In addition, participation in conferences is also quite significant, indicating the existence of academic discussion activities that can help expand research networks and increase collaboration.

Table 1. Publication document types

Type Document	Number of Document
Article	181
Book Chapter	3
Book	1
Conference Paper	11
Other	4
Total	200

From Table 1, 200 keywords related to environmental awareness were found. The keywords were then categorized based on publication year and data type to determine publication trends related to environmental awareness. The results of the categorization of publication trends can be seen in Figure 2. Figure 2 shows a graph of publication trends from 2015 to 2024, with a significant upward trend that peaked in 2020, then decreased in subsequent years. In 2015, the number of publications was recorded at 10 publications, and this number continued to increase until it reached 34 publications in 2020, which was the highest number in that period. This increase may indicate academic encouragement, policies that support research, or an increase in the number of researchers active in scientific publications. However, after 2020, the number of publications began to decline gradually, from 32 publications in 2021 to only 4 publications in 2024 and 0 publications in 2025. This decline can be caused by various factors, such as changes in academic policies, reduced research funding, or a shift in focus to other fields. If this trend continues, it is important to evaluate the factors that influence publication productivity so that more effective strategies can be put in place to support the sustainability of scientific research.
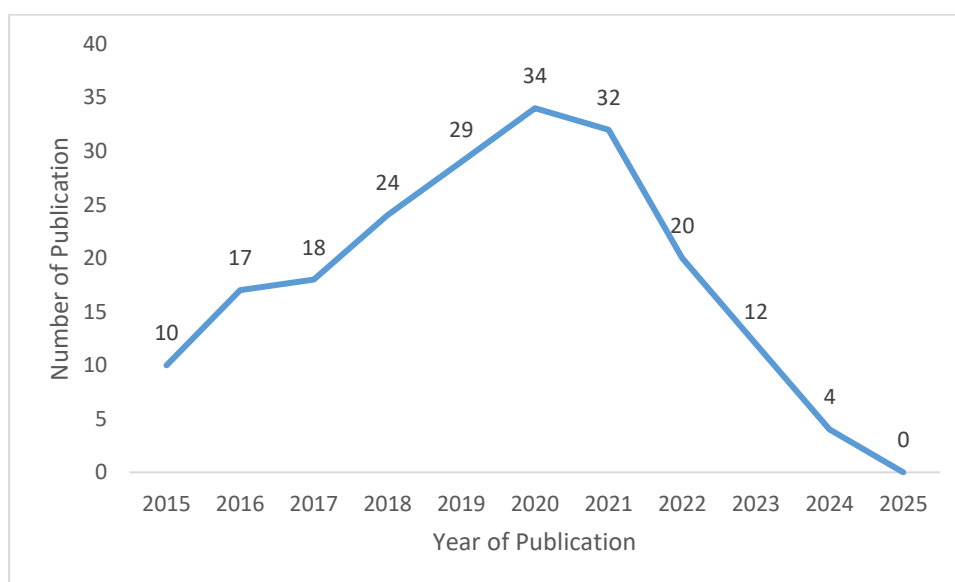
Figure 2. Publication trends related to environmental awareness

In the Figure 2 next stage is to analyse the keywords that frequently appear in relation to environmental awareness, which can be seen in Table 2. Based on Table 2, it can be interpreted that the keyword environmental awareness appears 90 times with a total link strength of 364, making it the most widely used term and the one with the strongest link to other keywords. This

shows that the concept of environmental awareness is the main topic in related research. Environmental education (15 times, 62 TLS) and sustainability (13 times, 55 TLS) also appear frequently, showing that environmental education and sustainability are important aspects of environmental awareness studies. Sustainable development and consumer environmental awareness each appear 7 times, showing the relevance of environmental awareness to sustainable development and consumer behaviour. Pro-environmental behaviour (6 times, 29 TLS) and environmental attitudes (6 times, 24 TLS) show that research also focuses on how environmental awareness affects people's attitudes and behaviour in protecting the environment. Environmental performance (5 times, 25 TLS) relates to how environmental awareness impacts real actions in better environmental management. This analysis indicates that research on environmental awareness is evolving with a focus on education, sustainability, and human behaviour. With strong links between keywords, future research can further explore how environmental education and policy can increase awareness and real action in supporting environmental sustainability.

Table 2. Frequently appearing keywords

Keyword	Occurrences	Total Link Strength
environmental awareness	90	364
environmental education	15	62
sustainability	13	55
sustainable development	7	33
consumer environmental awareness	7	29
pro-environmental behavior	6	29
attitudes	4	25
environmental performance	5	25
environmental attitudes	6	24
environmental sustainability	5	24

3.2. The Relationship of Keywords in Environmental Awareness Research

Figure 3. Network map to see the relationship between keywords.

In the Figure 3 relationship between keywords in environmental awareness research can be seen in the network visualisation output (Cahyani et al. 2024a; Cahyani et al. 2024b). This

image is a bibliometric visualisation generated using VOSviewer, which shows the relationship between various keywords in research related to environmental awareness. Based on figure 3, environmental awareness is the most dominant keyword, displayed in the largest font size. This shows that this topic is the centre of research and has strong links with many other concepts. This keyword is connected to various terms such as environmental education, pro-environmental behaviour, and environmental attitudes, showing that environmental awareness is closely related to education and human behaviour towards the environment. Environmental education has a close relationship with environmental awareness, which indicates that education plays an important role in increasing environmental awareness. Pro-environmental behaviour and environmental attitudes also often appear, indicating that research discusses how environmental awareness can influence individual attitudes and actions in protecting the environment. Keywords such as consumer environmental awareness, green consumption, green hotels, and consumer awareness indicate that the aspects of consumption and consumer behaviour in the context of sustainability are also a concern in this study. The terms internet of things (IoT), electric bicycle, and autonomous navigation show that technology is also part of the study in increasing green awareness and innovation. Different colours indicate research groups or themes that often appear together. The main clusters (blue and green) focus on environmental awareness and environmental education, while the other clusters (red, orange, and purple) focus more on pro-environmental behaviour, green innovation, and consumer awareness. It can be concluded from Figure 3 that research on environmental awareness is developing from various perspectives, ranging from education, individual behaviour, technological innovation, to consumer awareness.
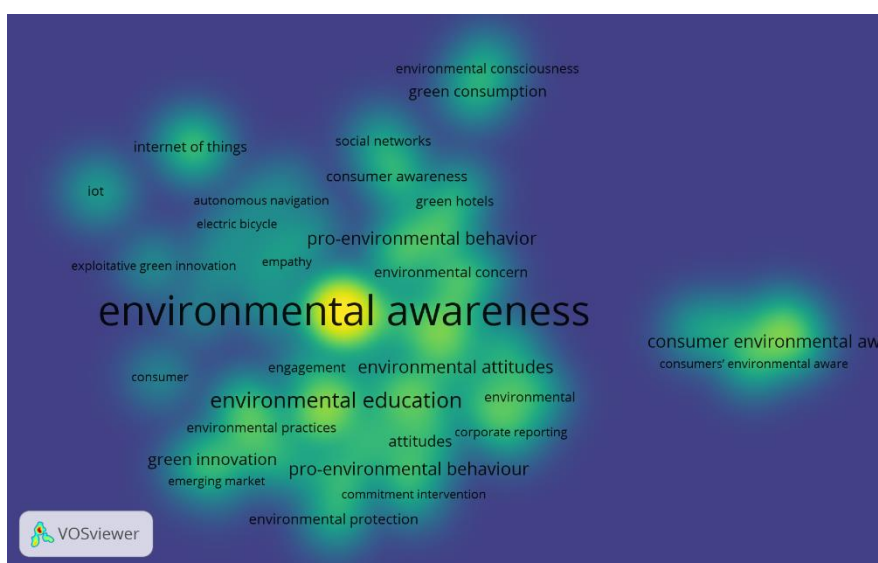

Figure 4. Density visualization

In the Figure 4 next stage is density visualization analysis, which is used to identify the most dominant topics with the output results that can be seen in Figure 4 (Auliah and Cahyani 2024). Bibliometric studies reveal that most environmental awareness research focuses on environmental education and how environmental awareness can be instilled at various levels of education, from primary to tertiary. Based on the bibliometric map visualisation generated by VOSviewer, the topic of environmental awareness emerged as the main focus and has been extensively researched in various literature. This is indicated by the bright yellow colour

surrounding the keyword, as well as its strong connection to a number of other terms such as environmental education, pro-environmental behaviour, environmental attitudes, green innovation, and consumer awareness. The yellow to light green colours indicate that these terms have a high frequency of occurrence and strong relationships with each other in the context of research related to environmental awareness. These findings suggest that research in the field of environmental awareness is largely focused on the role of education, environmentally friendly behaviour, and consumer involvement in sustainability issues. On the other hand, the blue area depicts keywords that have not been widely researched and have weaker connections in this keyword network map. Some of the themes in the blue zone include the Internet of Things (IoT), electric bicycles, autonomous navigation, social networks, green hotels, and corporate reporting. These themes are still rarely the main focus of environmental awareness studies, despite their great potential for development. For example, the use of IoT to support environmentally friendly behaviour, the use of social media as a means of raising environmental awareness, or the contribution of technological innovations such as electric bicycles and autonomous navigation to sustainable practices. Therefore, themes in the blue zone can be promising research opportunities and have the potential to contribute new insights to the development of studies related to environmental awareness. In addition, research also explores the relationship between environmental attitudes and pro-environmental behaviour that reflects the global urgency of the issue of sustainability and the role of education in shaping pro-environmental behaviour. There are 5 major topics related to environmental awareness, namely:

3.2.1. Environmental Awareness and Environmental Education

Environmental awareness is the main concept in environmental education. Many studies highlight that environmental education has an important role in increasing individual awareness of environmental issues. The integration of environmental values into the curriculum can shape environmentally conscious characters in students (Ludiya 2024). Good education will encourage students to build an understanding of the relationship between humans and the environment and provide them with the tools to analyse and participate in solving environmental problems (Salfita 2019). Analysed studies show that experience-based education, such as sustainability projects and nature-based learning, is more effective in building environmental awareness than traditional learning methods. With accessible information and innovative teaching methods, students are expected to develop positive attitudes and behaviours that support environmental conservation (Purwanti et al. 2022).

3.2.2. Sustainability and Sustainable Development

Sustainability and sustainable development are concepts closely related to environmental education. Much research emphasises that Education for Sustainable Development (ESD) plays a crucial role in teaching students about the impact of human activity on the environment and ways to achieve long-term sustainability. Education for sustainability must provide the competencies needed to achieve sustainability goals and convince students to put these principles into practice (Bertschy et al. 2013). This concept is also linked to the Sustainable Development Goals (SDGs), in particular SDG 4 (quality education) and SDG 13 (climate action). Education for Sustainable

Development helps build awareness and knowledge of the complex relationship between environmental, social, and economic issues, which is the basic principle of sustainability (Kioupi and Voulvoulis 2019; Donyavi and Yousefi Saeedabadi 2020; Krayneva et al. 2021).

3.2.3. Consumer Environmental Awareness and Pro-Environmental Behaviour

Environmental awareness not only affects education but is also related to consumer environmental awareness. Several studies show that individuals who have a better understanding of environmental issues tend to adopt pro-environmental behaviour, such as reducing the use of plastic, choosing environmentally friendly products, and supporting green policies. Quality education must include the knowledge and skills needed to understand and respond to global environmental challenges, which the UN recognises as an integral part of the sustainable development agenda (Kioupi and Voulvoulis 2019).

3.2.4. Environmental Attitude and Environmental Performance

Attitudes towards the environment (environmental attitudes) play an important role in determining individual actions in protecting the environment. Analysed studies have found that positive attitudes towards the environment are often associated with improved environmental performance, both at the individual and organisational levels. A number of studies have shown that positive attitudes towards the environment are significantly related to pro-environmental decision-making, both at the individual and organisational levels (Levine and Strube 2012; Dopelt et al. 2021). A study by Waliczek et al. emphasises that educational programmes that increase knowledge and positive attitudes towards waste management, such as composting programmes, can help students develop better environmental behaviour (Waliczek et al. 2016). These findings are in line with research by Dopelt et al., which states that a positive attitude towards the environment is a key prerequisite for real pro-environmental action (Dopelt et al. 2021). In the context of education, a good environmental attitude can be fostered through a sustainability-based curriculum and direct experiences such as recycling projects, energy conservation, and school greening. Effective environmental education not only conveys information but also fosters attitudes and values that support sustainability (Heberlein 2013).

3.2.5. Environmental Sustainability in Education

Environmental sustainability is the main goal of environmental education. Environmental sustainability is the main goal of environmental education, with a focus on building individual awareness and responsibility for ecological impacts. Effective environmental education not only improves students' knowledge of environmental issues but also builds the attitudes and skills necessary to play an active role in creating sustainable solutions. The analysed studies show that strengthening environment-based education can produce a generation that is more aware of ecological impacts and has the skills to face environmental challenges in the future. Emphasise that sustainability-based education prepares the younger generation to adapt to the threats posed by climate change and environmental damage. In the study, they found that education not only

serves to achieve sustainability goals but also acts as a continuous learning process for students in an ever-changing context.

3.3. Implications for Education in Indonesia

Based on this bibliometric analysis, there are several recommendations that can be applied in the context of education in Indonesia:

3.3.1. Integration of Environmental Education in the Curriculum

The education curriculum in Indonesia needs to place more emphasis on environmental education and sustainability at all levels of education. Learning materials should be designed so that students can understand the environmental impact of their actions and develop skills to manage resources wisely. Integrating environmental education across subjects can foster interdisciplinary understanding and encourage students to make informed, responsible decisions regarding ecological issues. This integration should not only be theoretical but also practical, incorporating project-based learning, outdoor activities, and community engagement. By involving students in real-life environmental problem-solving, schools can cultivate a sense of stewardship and proactive citizenship. Teacher training programs must also be aligned with this goal, ensuring that educators have the knowledge and pedagogical skills to deliver environmental content effectively. Moreover, collaboration between schools, local governments, and environmental organizations can enrich the curriculum with localized and contextualized environmental issues. Assessment methods should include not just cognitive outcomes but also attitudinal and behavioral indicators related to sustainability. Overall, embedding environmental education holistically within the curriculum can play a crucial role in shaping environmentally responsible generations in the future.

3.3.2. Experiential Learning Approach

Environmental education should be more experience-based (experiential learning), involving activities such as conservation projects, field trips to ecotourism areas, and school-based greening initiatives. These hands-on experiences allow students to directly observe and engage with environmental issues in real-world contexts, making learning more meaningful and memorable. Unlike passive learning in classrooms, experiential learning encourages active participation, reflection, and critical thinking. It fosters emotional connections with nature, which is a strong predictor of long-term pro-environmental behavior. Additionally, such approaches promote teamwork, problem-solving skills, and a sense of responsibility among students. Teachers can integrate these experiences into lesson plans to reinforce theoretical concepts with practical applications. Schools can also collaborate with local communities, environmental NGOs, and government institutions to design experiential learning programs that are contextually relevant. Research shows that students who participate in environmental activities outside the classroom tend to have higher environmental awareness and more sustainable lifestyle choices. Therefore, incorporating experiential learning into environmental education is a strategic step in fostering deeper ecological understanding and long-lasting behavioral change.

3.3.3. Encouraging Pro-Environmental Behaviour in Society

Environmental education should not only target students but also extend its reach to the broader school community and the general public. Building a culture of environmental responsibility requires collective effort and continuous engagement across all levels of society. Initiatives such as environmental awareness campaigns, green innovation competitions, and school-based recycling programs can serve as powerful tools to stimulate community involvement. These programs encourage individuals to take actionable steps in preserving the environment and serve as platforms to exchange ideas and best practices. Schools can act as community hubs that promote and model sustainable behavior, thereby inspiring families and local stakeholders to participate in eco-friendly activities. Collaborative events between schools and local government or environmental organizations can further amplify the impact and outreach. By creating shared goals and community ownership, such initiatives help normalize sustainable practices and encourage behavioral change. Moreover, sustained exposure to environmentally conscious practices in everyday settings reinforces the values of conservation and responsibility. Ultimately, engaging the wider community is crucial in cultivating a generation that not only learns about the environment but also lives in harmony with it.

3.3.4. Collaboration with Global Institutions

To strengthen the implementation of environmental education, governments and educational institutions in Indonesia can build strategic partnerships with global organizations that focus on sustainability, such as UNESCO, UNEP, and WWF. These collaborations can provide access to valuable resources, international training programs, and examples of best practices in environmental education. By leveraging global expertise, Indonesia can enhance the quality and relevance of its sustainability curriculum. In addition, collaborative projects can offer opportunities for knowledge exchange, joint research, and development of innovative teaching models. Participation in international forums and programs also increases the visibility of Indonesia's commitment to environmental issues on the global stage. Furthermore, global partnerships can support capacity building for educators through workshops, fellowships, and digital platforms. Through this network, Indonesian schools and universities can stay aligned with global sustainability goals, including the Sustainable Development Goals (SDGs). Engaging with international institutions fosters a sense of global citizenship among students and educators, encouraging them to view environmental stewardship as a shared global responsibility. Such partnerships ultimately enrich local initiatives with global perspectives and ensure that environmental education in Indonesia evolves with international standards.

3.3.5. Use of Digital Technology in Environmental Education

Along with rapid advancements in technology, the integration of digital tools into environmental education has become increasingly essential. Augmented Reality (AR) and Virtual Reality (VR) applications offer immersive learning experiences, enabling students to explore ecosystems, witness the effects of pollution, or simulate environmental disasters in a virtual space. Gamification elements, such as quizzes, challenges, and sustainability-themed games, can make

learning more engaging and motivate students to apply environmentally responsible behaviors in real life. Interactive online courses and e-learning platforms also provide flexible access to comprehensive content on climate change, biodiversity, and sustainable development. These technologies allow for personalized learning paths and can reach students in remote or under-resourced areas. Moreover, digital tools can support real-time data collection and analysis, enabling learners to engage in citizen science projects or monitor local environmental conditions. The use of social media and mobile apps also facilitates awareness campaigns and community involvement in environmental initiatives. Overall, digital technology enhances both the reach and depth of environmental education, helping to create a generation of tech-savvy, environmentally conscious individuals. This approach aligns well with the digital transformation in education and the broader goals of Education for Sustainable Development (ESD).

4. CONCLUSION

Based on the results of network visualisation, overlay, and density analysis, it can be concluded that global research on environmental awareness in education during the period 2015–2025 shows a downward trend in scientific publications, although this issue remains relevant and has a strong connection with the concepts of environmental education, sustainability, and pro-environmental behaviour. The emerging topic structure reflects five main focuses, namely: environmental awareness education, sustainable development, environmentally friendly consumer behaviour, environmental attitudes and performance, and educational sustainability. Network visualisation shows close interconnections between topics, while overlay visualisation illustrates a shift in research interest from general concepts to more applied issues. Density visualisation confirms the dominance of the keywords 'environmental awareness' and 'environmental education' as the focus of scientific attention. These findings have significant implications for the development of educational policies, particularly in Indonesia, by recommending the integration of environmental curricula, experience-based learning, global collaboration, and the use of digital technology in education. By responding to these global trends, Indonesia has the opportunity to design more adaptive educational strategies to shape an environmentally conscious generation ready to face future sustainability challenges.

REFERENCES

Ali, M.I., Abduh, A., Mahmud, R. and Dunakhir, S. 2023. Raising Students' Awareness on Environmental Education Issues. *Indonesian Journal Of Educational Research and Review* 6(1), pp. 1–8. Available at: https://doi.org/10.23887/ijerr.v6i1.59146.

Ardoin, N.M., Bowers, A.W., Roth, N.W. and Holthuis, N. 2018. Environmental education and K-12 student outcomes: A review and analysis of research. *Journal of Environmental Education* 49(1), pp. 1–17. doi: 10.1080/00958964.2017.1366155.

Auliah, A. and Cahyani, V.P. 2024. Exploring Trends in Chemical Education: A Bibliometric Analysis (2019-2024). *Jurnal Inovasi Pembelajaran Kimia* 6(2), pp. 297–304.

Bertschy, F., Künzli, C. and Lehmann, M. 2013. Teachers' competencies for the implementation of educational offers in the field of education for sustainable development. *Sustainability (Switzerland)* 5(12), pp. 5067–5080. Available at: https://api.elsevier.com/content/abstract/scopus_id/84894026649.

Cahyani, V.P., Ahmad, F., Zulfakar, M. and Nawi, M. 2024a. Authentic Assessment as a Solution

to Enhance Deep Learning and Maintain Academic Integrity in Higher Education. *Journal of Educational Analytics (JEDA)* 3(3), pp. 531–544.

Cahyani, V.P. and Fadly, D. 2024. The Development of Ethnoscience in Chemistry Learning in Indonesia: A Bibliometric Analysis of Literacy and Cultural Relevance. *Jurnal Studi Guru Dan Pembelajaran* 7(3), pp. 1201–1211. doi: 10.30605/jsgp.7.3.2024.4797.

Cahyani, V.P. and Romadin, A. 2024. A Comprehensive Bibliometric Analysis of Distance Learning Assessments: Key Themes and Future Directions. *International Journal of Integrative Sciences* 3(11), pp. 1265–1280. doi: 10.55927/ijis.v3i11.12348.

Cahyani, V.P., Romadin, A., Erniyani, Fahri Anwar and Nawi, M.Z. 2024b. Optimising Assessment in Project-Based Learning to Improve the Quality of STEM Learning. *International Journal of Scientific Multidisciplinary Research* 2(11), pp. 1645–1656. doi: 10.55927/ijsmr.v2i11.12392.

Debrah, J.K., Vidal, D.G. and Dinis, M.A.P. 2021. Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review. *Recycling* 6(1), pp. 1–21. Available at: https://doi.org/10.3390/recycling6010006.

Donyavi, Z. and Yousefi Saeedabadi, R. 2020. The Role of Scaffolding in Nature School to Promote Sustainable Development in Education. *Iranian Journal of Educational Sociology* 3(3), pp. 30–39. Available at: https://doi.org/10.52547/ijes.3.3.30.

Dopelt, K., Loren, O., Gapich, G. and Davidovitch, N. 2021. Moving From Indifference to Responsibility: Reframing Environmental Behavior Among College Students in Israel. *Frontiers in Climate* 3. Available at: https://doi.org/10.3389/fclim.2021.776930.

Flanagan, C., Gallay, E., Pykett, A. and Smallwood, M. 2019. The environmental commons in urban communities: The potential of place-based education. *Frontiers in Psychology* 10(FEB). Available at: https://doi.org/10.3389/fpsyg.2019.00226.

Gifford, R. and Nilsson, A. 2014. Personal and social factors that influence pro-environmental concern and behaviour: A review. *International Journal of Psychology* 49(3), pp. 141–157. doi: 10.1002/ijop.12034.

Heberlein, T.A. 2013. Navigating Environmental Attitudes. *Navigating Environmental Attitudes*, pp. 1–240. Available at: https://doi.org/10.1093/acprof:oso/9780199773329.001.0001.

Jabbar, H. 2015. Pendidikan Lingkungan dan Kesadaran Ekologis: Sebuah Tinjauan Teoritis. *Jurnal Konservasi* 7(2), pp. 45–56.

Jumini, S., Madnasri, S., Cahyono, E. and Parmin, P. 2022. Article Review: Integration of Science, Technology, Entrepreneurship in Learning Science through Bibliometric Analysis. *Journal of Turkish Science Education* 19(4), pp. 1237–1253. doi: 10.36681/tused.2022.172.

Khoiri, A., Sunarno, W., Sajidan, S. and Sukarmin, S. 2021. Analysing students' environmental awareness profile using strategic environmental assessment. *F1000Research* 10, p. 10. Available at: https://doi.org/10.12688/f1000research.51523.2.

Kioupi, V. and Voulvoulis, N. 2019. Education for sustainable development: A systemic framework for connecting the SDGs to educational outcomes. *Sustainability (Switzerland)* 11(21). Available at: https://api.elsevier.com/content/abstract/scopus_id/85074852652.

Kousar, S., Afzal, M., Ahmed, F. and Bojnec, Š. 2022. Environmental Awareness and Air Quality: The Mediating Role of Environmental Protective Behaviors. *Sustainability (Switzerland)* 14(6). Available at: https://api.elsevier.com/content/abstract/scopus_id/85126290790.

Krayneva, R., Rudenko, A. and Motylev, R. 2021. Role of education in implementing the sustainable development strategy. *E3S Web of Conferences* 250, p. 7008. doi: 10.1051/e3sconf/202125007008.

Law, M.M.S., Hills, P. and Hau, B.C.H. 2017. Engaging Employees in Sustainable Development – a Case Study of Environmental Education and Awareness Training in Hong Kong. *Business Strategy and the Environment* 26(1), pp. 84–97. doi: 10.1002/bse.1903.

Levine, D.S. and Strube, M.J. 2012. Environmental attitudes, knowledge, intentions and behaviors among college students. *Journal of Social Psychology* 152(3), pp. 308–326. doi:

10.1080/00224545.2011.604363.

Ludiya, L.F. 2024. Pentingnya Membangun Kesadaran Lingkungan Melalui Pembelajaran PKN di Sekolah Dasar Guna Membentuk Karakter Peduli Lingkungan pada Siswa. *Jurnal Pendidikan Guru Sekolah Dasar* 1(3), p. 11. Available at: https://doi.org/10.47134/pgsd.v1i3.529.

Monroe, M.C., Plate, R.R., Oxarart, A., Bowers, A. and Chaves, W.A. 2019. Identifying effective climate change education strategies: a systematic review of the research. *Environmental Education Research* 25(6), pp. 791–812. doi: 10.1080/13504622.2017.1360842.

Purwanti, E., Ibrahim, I., Maulana, A., Rahmadewi, R., Efelina, V. and Dampang, S. 2022. Pelatihan Pengolahan Limbah Dan Penanaman Hidroponik Untuk Meningkatkan Kesadaran Peduli Lingkungan Di Sman 6 Karawang. *SELAPARANG: Jurnal Pengabdian Masyarakat Berkemajuan* 6(1), p. 43. Available at: https://doi.org/10.31764/jpmb.v6i1.6701.

Salfita, M. 2019. Pentingnya Materi Lingkungan dalam Pembelajaran Bahasa di Sekolah Dasar (SD). Available at: http://dx.doi.org/10.31219/osf.io/mw4j2.

Sola, A. 2014. Environmental Education and Public Awareness. *Journal of Educational and Social Research* 4, pp. 333–333. doi: 10.5901/jesr.2014.v4n3p333.

UÇAR ÇABUK, F. and İŞAL, S. 2023. The Effect of Environmental Awareness Education Program on Children's Environmental Awareness. *İnsan ve Sosyal Bilimler Dergisi* 6(Education Special Issue), pp. 379–400. Available at: https://doi.org/10.53048/johass.1358178.

UNESCO. 2021. Education for sustainable development: A roadmap.

Waliczek, T., McFarland, A. and Holmes, M. 2016. The relationship between a campus composting program and environmental attitudes, environmental locus of control, compost knowledge, and compost attitudes of college students. *HortTechnology* 26(5), pp. 592–598. Available at: https://doi.org/10.21273/horttech03320-16.

Zhongbin, Z. 2024. Innovative Approaches to Art Education by Integrating Environmental Awareness in Art Curriculum in Beijing. *International Journal of Academic Research in Progressive Education and Development* 13(1). Available at: https://doi.org/10.6007/ijarped/v13-i1/20657.