

BIBLIOMETRIC ANALYSIS: GLOBAL TRENDS AND INDONESIA'S POSITION REGARDING ENVIRONMENTAL ECOLOGY IN LANGUAGE LEARNING

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Abstract. This study explores the dynamics of integrating environmental ecology into language learning through an empirical bibliometric analysis of 396 Scopus articles. Focusing on global trends, the findings show a significant increase in publications since the SDGs, with the United States (86 documents) and China (52 documents) dominating, while Indonesia (31 documents) emerges as a strategic link between Southeast Asia and Western perspectives through international collaboration. Key terms such as "environmental education" and "sustainable development" form interrelated thematic clusters, revealing an evolution from disciplinary separation toward holistic education based on local wisdom. Indonesia contributed 31 Scopus publications with a unique approach integrating local wisdom into ecological language learning. As a bridge for Southeast Asia, Indonesian research demonstrates innovations in ecopedagogy through leading institutions. Strategic recommendations include strengthening the Merdeka Curriculum, digital teacher training based on environmental literacy, and international research collaboration to empower students as agents of sustainable change. Keywords: bibliometric analysis, environmental ecology, language learning, global trends, Indonesia's position, ecological literacy, sustainable education

Keywords: bibliometrics, environmental ecology, language learning.

INTRODUCTION

Global warming, extreme climate change, and biodiversity loss have become issues of global concern. In response to this, a new educational approach is needed as a way of looking at improving sustainable literacy. This is because language not only functions as a tool for communication, but also shapes our understanding and perception of the outside world, integrating environmental ecology into language learning. Recent bibliometric analysis shows an increase in research publications combining both fields since 2014. This is in line with the United Nations' Sustainable Development Goals (SDGs), which prioritize quality education (SDG 4) and climate action (SDG 13). This phenomenon indicates a paradigm shift in which the whole world is beginning to recognize that language teaching can be a tool for environmental transformation, helping students talk about environmental issues through rich and contextual stories. However, education remains stuck in classification without deep integration, which hinders the development of collective awareness of issues such as the loss of natural habitats.

Indonesia's cultural diversity makes it a country with the most tropical ecosystems and more than 700 different regional languages, requiring integration to be clearly contextualized. Although programs such as Adiwiyata have encouraged schools to take environmentally friendly actions and national curricula such as the Merdeka Curriculum, they still tend to separate language education from environmental education, making it difficult for students to connect their language proficiency to support this theme. Previous studies, such as Husamah et al.'s (2022) systematic review of Scopus Indonesia journals, highlight the success of the Science, Environment, Technology, and Society (SETS) approach in improving ecological literacy, but they do not sufficiently examine the role of local languages in this context. This makes it difficult to understand how traditional terms such as the idea of "local wisdom" can be used to strengthen students' environmental identity. Therefore, the situation in Indonesia provides an extraordinary opportunity to adapt global trends to local circumstances, where linguistic diversity becomes a strategic asset for inclusive and relevant

education. This research is important because it provides an empirical mapping of global environmental ecology trends in language learning until 2025, especially how Indonesia functions as a bridge between Western and Southeast Asian perspectives. The advantage of bibliometric analysis lies in its ability to reveal hidden patterns through quantitative data.

On a global scale, environmental ecology in language learning has seen rapid progress in integration since 2014, but the lack of in-depth exploration of environmental ecology and language learning that relies on local wisdom as the core of learning is a crucial gap, especially in Indonesia. This study is based on bibliometric research to explore the following problem formulations: (1) Global publication trends related to environmental ecology in the context of language learning need to be identified and analyzed comprehensively to understand the overall research development. (2) The countries and institutions that are most productive in publishing research on the integration of environmental ecology and language learning must be identified to determine their main contributions at the international level. (3) The keywords or main topics that most frequently appear in publications on environmental ecology and language learning need to be extracted and categorized to reveal the dominant thematic patterns. (4) The relationship or connection between the concept of environmental ecology and language learning themes based on the results of bibliometric analysis must be described to show conceptual integration between disciplines. (5) The evolution of terms or research focus on environmental ecology in language learning from year to year needs to be traced to map the changing dynamics of research over time.

This study aims to analyze publication data published in the reputable Scopus database with a focus on environmental ecology and language learning. The analysis was conducted on reputable articles using a bibliometric analysis approach from a total of 396 Scopus article data, with a focus on publication patterns, keyword intensity, relationship patterns and thematic relevance, and the evolution of terms in global trends related to environmental ecology in language learning. The development of bibliometric studies has shown a significant global trend in integrating environmental ecology into language learning, reflecting the urgent need to align linguistic education with global sustainability goals. Bibliometric research by Darwis et al.(2025) identifies that the integration of information and communication technology in ecology education at the higher education level has increased substantially, with Spain, China, and Australia leading global publication contributions. Micalay-Hurtado & Poole(2022) emphasize the importance of eco-critical language awareness in language teaching as a platform for promoting the environment, well-being, and sustainability in the classroom, integrating ecolinguistic principles with transformative language pedagogy.

In research in Indonesia, Albaburrahim & Amin(2025) analyzed ecological approaches in Indonesian language learning in the digital age. The researchers identified that digital platforms offer transformative opportunities to integrate environmental awareness through language activities based on exploration and analysis of environmental issues. Saifulloh et al.(2025) explored environmental education in the context of learning English as a foreign language in a theoretical study, emphasizing that embedded environmental education not only develops communicative competence but also fosters critical awareness of environmental issues, empowering learners to become agents of sustainable change. Puspitaningsih et al.'s bibliometric analysis(2025) of teaching curriculum trends for the 2015-2025 period identifies research clusters covering eco-literacy, environmental education, sustainable language learning, and descriptive writing, reflecting that language teaching has expanded beyond linguistic competence to cultural awareness and environmental responsibility. Fatimah et al.(2025) , through a bibliometric analysis of sustainability literacy in higher education, revealed that the United States, the United Kingdom, Saudi Arabia, Spain, and Australia are the main contributors, with the journal Sustainability Switzerland as the most productive and cited publication, indicating that a variety of sustainability literacy evaluation instruments are used globally, with questionnaires and tests as the dominant methods. Lyesmaya et al.(2025) in a systematic review of ecological writing pedagogy found a positive correlation between the integration of ecological literacy and increased metacognitive awareness in writing and student engagement in deep learning, with contextual writing tasks on environmental themes facilitating critical thinking, problem solving, and self-regulation, emphasizing the urgency of fostering environmental awareness through writing education from an early age.

The theoretical framework underlying bibliometric analysis in the context of environmental ecology and language learning is based on three main pillars that complement each other synergistically. From a methodological perspective, bibliometric analysis operates through a quantitative approach that combines techniques such as citation analysis, co-citation analysis, co-word analysis, and co-authorship analysis, utilizing visualization tools for science mapping that produce in-depth intellectual mapping of the knowledge architecture in a research domain (Donthu et al., 2021). Chen et al. (2023) also explain that bibliometric methodologies, when integrated with text mining, enable the extraction of key characteristics from bibliographic data through the operationalization of publication performance indicators, the identification of international collaboration patterns, and the mapping of epistemological trends that reveal conceptual evolution in a particular field of study. The systemic ecological theory provides a holistic framework for understanding how multi-level contexts interact in shaping individual linguistic behavior and learning (Chong et al., 2023). Bronfenbrenner's approach is particularly useful in second language acquisition research because it captures contextual complexities that go beyond individual factors, integrating social, institutional, and policy dimensions into a cohesive analytical framework. The integration of methodological and ecological systems theory approaches is reinforced through a comprehensive understanding of ecological literacy embedded in the context of contemporary language learning. The pedagogical perspective emphasizes learning as a transformative process in a pluralistic linguistic-cultural context, complementing this framework by recognizing learners' agency and critical engagement in constructing meaning related to environmental issues. This comprehensive framework supports a bibliometric approach to identify how global research has undergone a paradigm shift from disciplinary separation towards multidisciplinary convergence between linguistics, ecology, and pedagogy, reflecting a growing awareness that language is a central medium.

RESEARCH METHOD

This study adopts bibliometric analysis as a systematic quantitative approach to explore the global publication landscape related to environmental ecology in language learning. Bibliometric methodology was chosen for its unique ability to reveal hidden patterns, long-term publication trends, and the intellectual structure of a research domain through large-scale bibliographic data analysis. The procedure applied follows the internationally validated B-SLR (Bibliometric-Systematic Literature Review) protocol, integrating data consolidation, bibliometric indicators, science mapping, and cluster identification as the main stages of . This approach enables the identification of publication patterns, keyword intensity, thematic relationships between concepts, and the evolution of research dynamics over the period studied, resulting in comprehensive insights into Indonesia's position in the global research context on the integration of environmental ecology and language learning.

This bibliometric study focuses on three fundamental concepts that are dialectically interrelated, namely environmental ecology, language learning, and global publication trends. Environmental ecology is understood not merely as a domain that examines the relationship between organisms and their physical environment, but as a systems perspective that recognizes the interconnectedness and complex interdependencies between various elements of the socio-biological ecosystem and the learning process. Language learning, within the framework of this study, is positioned as a pedagogical praxis that goes beyond the mastery of communicative skills alone, encompassing learners' ability to analyze, interpret, and respond to environmental issues through texts and discourse in language. The concept of global publication trends refers to cumulative patterns of research output represented through structured bibliographic data, including quantitative metrics such as publication volume, geographical distribution of authors, patterns of institutional collaboration, and the evolution of terminology in reputable journals with databases sourced from Scopus. These three concepts are analyzed through a bibliometric lens to identify how knowledge about the integration of ecology and language learning has developed, where it is centralized, and what trends it is showing in the global academic community.

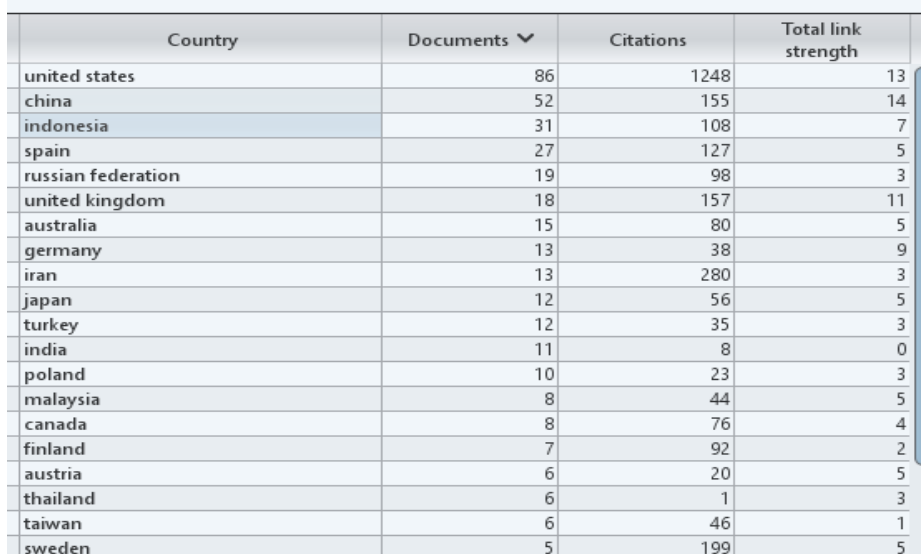
This bibliometric research procedure was carried out through six sequential, structured stages to ensure methodological rigor and the validity of the analysis results. The first stage involved defining

the research framework and formulating specific research questions that guided the entire investigation process, followed by establishing clear inclusion-exclusion criteria to limit the scope of the literature to be analyzed, namely peer-reviewed articles in English in Scopus journals focusing on environmental ecology in language learning. The second stage included the design and testing of a comprehensive and sensitive search string, combining Boolean operators with key terms such as ("environmental ecology" OR "ecological literacy" OR "eco-linguistics") AND ("language learning" OR "language teaching" OR "language education"), to ensure an optimal retrieval rate and high precision in identifying relevant documents. The third stage involved data extraction from Scopus by applying filters according to the inclusion criteria, producing an initial dataset which was then submitted for independent title-abstract screening by two researchers to ensure coding consistency and eliminate bias. The fourth stage focuses on data cleaning and preprocessing, including removing duplicates, standardizing metadata, and converting the Scopus export format to a format compatible with VOSviewer for visualization analysis. The fifth stage runs a battery of bibliometric analyses using VOSviewer and supporting software (R with the Bibliometrix or Biblioshiny package), executing co-word analysis, co-authorship networks, and bibliographic coupling to generate thematic clusters and identify research hotspots. The final stage (stage six) involves interpreting visual and quantitative results, integrating insights from bibliometric indicators with a deep conceptual understanding of environmental ecology and language learning to produce a cohesive academic narrative about global trends and Indonesia's unique position in the international research ecosystem.

RESULT AND ANALYSIS

1.1 Global Publication Trends Related to Environmental Ecology in the Context of Language Learning

The exploration of global publication trends aims to reveal several crucial phenomena in the global research landscape. This analysis identifies countries that hold central positions as centers of research collaboration, as reflected in their high publication volume and link strength (total link strength) with other countries. Second, this approach allows researchers to understand patterns of regionalism versus globalism in scientific cooperation, where certain countries may show a preference for collaboration with geographically close partners or develop cross-continental networks. The global publication data can be seen in the figure below.



Country	Documents ▼	Citations	Total link strength
united states	86	1248	13
china	52	155	14
indonesia	31	108	7
spain	27	127	5
russian federation	19	98	3
united kingdom	18	157	11
australia	15	80	5
germany	13	38	9
iran	13	280	3
japan	12	56	5
turkey	12	35	3
india	11	8	0
poland	10	23	3
malaysia	8	44	5
canada	8	76	4
finland	7	92	2
austria	6	20	5
thailand	6	1	3
taiwan	6	46	1
sweden	5	199	5

Fig. 1. Results of VOS viewer data analysis based on publications in a country

Based on the above data, the United States ranks first with 86 documents and the highest total link strength of 13, indicating America's position as a center for international research collaboration in

this field. This position demonstrates strong research capabilities, well-established academic infrastructure, and a strong tradition of international cooperation. China ranks second with 52 documents and a total link strength of 14. This indicates a growing trend in global research contributions. This phenomenon is in line with the Chinese government's large investments in research and development, particularly in the fields of education and sustainability. With 31 published documents and a total link strength of 7, Indonesia occupies a strategic position in the global collaboration network, behind the United States, China, and the United States. This achievement shows that Indonesian academics are deeply committed to integrating environmental ecology issues into language learning. Given its geographical context and wealth of local wisdom, Indonesia's position is increasingly important, especially in the development of ethnopedagogical and ecolinguistic methods in Indonesian language learning. For example, recent research highlights how the integration of ecolinguistic dimensions in Indonesian language textbooks in higher education can build environmental sensitivity among students, while preserving the diversity of local languages and cultures that are increasingly fading. For example, recent research highlights how integrating ecolinguistics dimensions into Indonesian language textbooks at universities can build environmental sensitivity among students, while preserving local linguistic and cultural diversity that is increasingly fading due to globalization (Permatasari & Rahardi, 2022). The network visualization shows an interesting clustering where European countries such as Spain (27 documents), the United Kingdom (18 documents), and Germany (13 documents) form a close-knit working group. This pattern indicates the existence of regional cooperation programs such as Horizon Europe (11), which encourages cross-border collaboration in education and environmental research. A growing network of cooperation is evident among Asia-Pacific countries, including Indonesia, Malaysia (8 documents), and Australia (15 documents).

From the data visualization results, Indonesia is in a strategic position connected to various regional and international clusters. This shows that Indonesia appears to form a bridge of collaboration between the Southeast Asian region and other global research hubs. This indicates that Indonesia not only conducts research but also helps disseminate knowledge between developed and developing countries. Indonesia's link strength of 7 indicates the intensity of cooperation with various partner countries. In addition to bilateral cooperation, there are multilateral consortiums that focus on education and sustainable environmental issues. There is a trend of increasing quality in research conducted by Indonesian academics who focus on contextual approaches that combine local wisdom. In line with this, a systematic literature review of environmental education research in Scopus Indonesia journals reveals that the implementation of approaches such as Science, Environment, Technology, and Society (SETS) has become a concrete example in building students' environmental literacy, with growing international collaboration, including with Malaysia and Japan, to address issues such as deforestation and pollution through education (Husamah et al., 2022). An overview of the trend in the distribution of collaboration between countries in publications can be seen in the following figure.

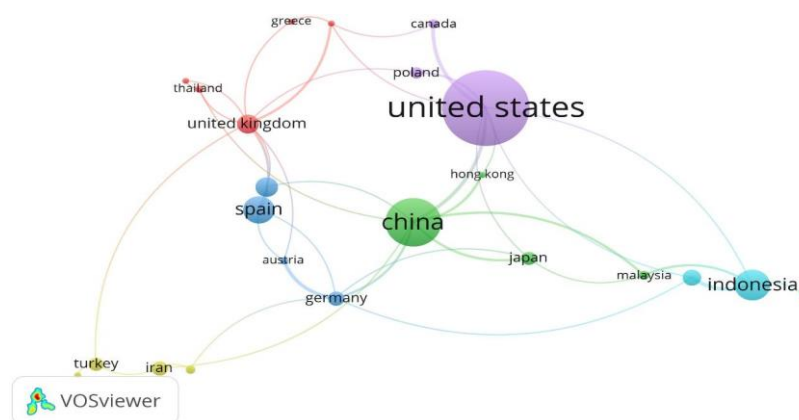


Fig. 2. Results of VOSviewer data analysis based on trends in the distribution of collaboration between countries in publications

These analysis results show the phenomenon of academic diplomacy, where collaborative research builds intellectual relationships between countries to address global challenges. To address environmental literacy issues, international cooperation in research and language learning about environmental ecology shows that a multicultural and multilingual approach is needed. By being part of this international cooperation network, Indonesia has a strategic opportunity to improve its research capabilities. In addition, this allows the country to promote its best practices in international forums. The overall number of strong relationships in certain countries indicates the existence of knowledge broker countries that help disseminate knowledge in an interregional context, utilizing the experience of implementing programs such as Green School, Green Campus, and the integration of environmental education into the national curriculum. With environmental learning in the national curriculum, Indonesia has great potential to develop this role, especially in the context of Southeast Asia and the Asia-Pacific. A global bibliometric analysis of higher education internationalization also reinforces this pattern, where countries such as the United Kingdom, the United States, Australia, and China dominate publications and collaborations, while developing countries such as Indonesia can leverage these networks to enrich cross-cultural perspectives in language teaching and sustainability (Ghani et al., 2022).

As the data presented as findings shows, the paradigm has shifted in language education research. Now, ecological aspects are increasingly being incorporated into content-based learning approaches. Given its long-standing tradition of integrating local wisdom into education, Indonesia is in an ideal strategic position to lead this trend in the region. International collaboration in this field not only results in joint publications but also encourages the development of innovative methodologies such as ecopedagogy and green language learning. The potential for establishing an international research consortium focused on integrating environmental education into language teaching is evident from the collaboration patterns shown in the data analysis visualization in the figure above. In this study, the strength of Indonesia's cooperation network is an important indicator of the sustainability and impact of the research produced. With 31 documents and a link strength of 7, Indonesia shows a positive and consistent growth trend, reflecting the level of internationalization of research in this increasingly strategic field. By strengthening bilateral and multilateral cooperation, especially with countries that focus on sustainable education and environmental literacy, Indonesia has the opportunity to improve its position in the global network as a projection for the future. An in-depth study of ecoliteracy elements in Indonesian textbooks further reveals that environmental knowledge dominates, while cognitive skills are often underemphasized, indicating the need for curriculum revision to more effectively build environmental awareness and action among students (Suwandi et al., 2024).

1.2 Temporal Trends in Environmental Ecology Research in Language Learning

Temporal analysis in research combining environmental ecology with language learning provides a deep understanding of when this interdisciplinary relationship began to receive academic attention, when major advances occurred, and the latest trends indicating the direction of research. The data analyzed covers the period from 1998 to 2025. This provides a long-term overview spanning more than twenty years of research progress in a field that was relatively still developing at the beginning of the study period. The temporal data can be seen in the following figure.

Year	Documents	Year	Documents	Year	Documents
2025	74	2016	15	2006	1
2024	74	2015	5	2005	1
2023	57	2014	3	2004	2
2022	35	2013	9	2003	0
2021	27	2012	2	2002	0
2020	22	2011	4	2001	2
2019	15	2010	6	2000	2
2018	11	2009	4	1999	0
2017	13	2008	6	1998	0

Fig. 3. Data on the number of publications related to environmental ecology and language learning

From the figure above, it can be seen that the temporal data shows a very characteristic pattern, with a pre- growth phase marked by minimal productivity between 1998 and 2007. This period reflects that language learning and environmental ecology issues were not yet the main focus of global academic research. From 1998 to 2006, publications only reached 0-2 documents per year, indicating that the research paradigm was still separated by scientific disciplines. A shift began in 2008 with the emergence of 6 publications, after which there was a steady increase of around 2 publications per year between 2008 and 2013. Although the ecological approach to language learning has not yet gained significant momentum, this transitional phase shows an increase in academic awareness of the importance of this approach. When publications increased to 3 documents around 2014, there was an exponential increase. By 2016, publications had increased to 15 documents. The period between 2014 and 2016 was a crucial moment in the advancement of research, influenced by several interrelated factors. These included the growing urgency of global climate change, the adoption of the Sustainable Development Goals (SDGs) by the United Nations in 2015, and increased academic awareness of the importance of environmental skills in formal education. A bibliometric study of e-learning publications since 2015 also highlights how the integration of technology in education, including environmental aspects, began to surge after the adoption of the SDGs, with a significant increase in themes such as collaborative learning and digital literacy that support ecological awareness (Djeki et al., 2022).

The growth trend of 2017 continued with 13 publications, but from 2018 to 2025, the pattern actually shifted towards more aggressive acceleration. The data shows a consistent increase in 2018 with 11 documents, 2019 with 15 documents, 2020 with 22 documents, 2021 with 27 documents, 2022 with 35 documents, 2023 with 57 documents, and finally in 2024-2025, with 74 documents each year. This increase indicates a paradigmatic shift in educational research, in which the COVID-19 pandemic played a significant role. School closures and the shift to online learning prompted researchers to study the environmental and ecological aspects of language learning. This includes how the digital environment affects language acquisition and how nature-based methods can compensate for the limitations of virtual learning. An in-depth analysis of thousands of higher education publications during the pandemic reveals that this surge not only increased the focus on emergency e-learning, but also encouraged exploration of themes such as mental health, student experience, and more sustainable curriculum development of more sustainable curricula, including the integration of ecological elements to address global disruption (Aristovnik et al., 2023).

Indonesia's pattern of engagement in this temporal trajectory is different. Data shows that, in line with the global acceleration phase, Indonesia began to contribute significantly to the literature on this topic between 2014 and 2015. However, its relevance in the explosive growth phase of 2018–2025 became increasingly clear, particularly through publications that combined Indonesian local wisdom with an environment-based language learning approach. According to long-term research conducted on Indonesia's national repository, publications related to environmental literacy in language education have increased significantly since 2017. The number of articles collected peaked in 2021–2023. Universities such as Yogyakarta State University, Indonesia University of Education, and Surabaya State University contributed greatly to this acceleration phase by producing projects

that combined the ideas of eco-pedagogy with contextual Indonesian language learning approaches. A systematic literature review of environmental literacy trends in Indonesian education confirms an increase in publications since 2018, with an emphasis on secondary school students and the use of test instruments to measure awareness, although diversification of methods is still needed to enrich its impact (Rofiqi, 2024). Bibliometric data shows that Indonesia significantly increased its publication output from 2020–2025, particularly in subcategories linking environmental literacy with local and multilingual language learning. Although still below countries such as the United States and China, Indonesian researchers are also engaged in international collaboration. Recent studies on ecopedagogy in Indonesia show an increasing positive trend since 2016, peaking in 2023, where strategies such as problem-based learning have become dominant in building more contextual and sustainable environmental literacy (Amaliati et al., 2024).

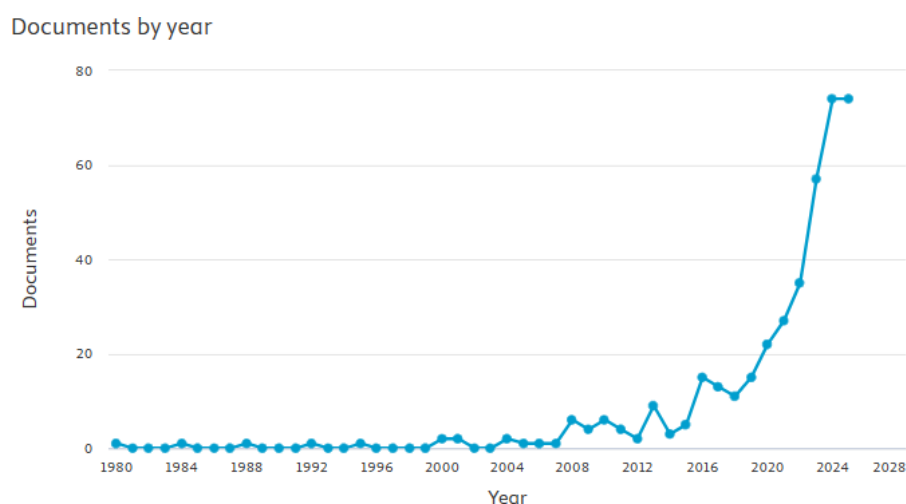


Fig 4. Graph of the number of publications related to environmental ecology and language learning

From the figure above, several important phenomena that should be highlighted can be examined through temporal analysis. First, in language education research, there is a slow effect between global awareness of environmental issues and the internalization of these ideas. A slow adoption process occurred from 1992 (Rio Conference on the Environment) to 2008, while the increase that occurred after 2014 shows a more concrete international policy push. Second, the increase in phenomena caused by COVID-19 is clearly visible in the surge in publications from 2020 to 2024. This shows that the global pandemic has encouraged the reimagining of language education practices and research. In particular, Indonesia has experienced this acceleration thanks to national programs such as Merdeka Belajar (Freedom of Learning) and the Green School Program, which encourage the integration of environmental awareness into education. Third, the publication pattern shows a consolidation phase from 2024 to 2025 with a stable number of 74 documents. This indicates that the industry has matured beyond the initial exploration phase and entered a phase where research has become more systematic and institutional. A review of environmental education research in Scopus Indonesia journals reinforces this idea, where approaches such as Science, Environment, Technology, and Society (SETS) have become the foundation for developing innovative models that integrate ecological literacy into the curriculum, although international collaboration still needs to be improved to achieve a broader impact (Husamah et al., 2022).

This temporal pattern reveals strategic opportunities and challenges in the Indonesian context. With a global increase since 2014, there is an opportunity for Indonesian researchers to help shape a new paradigm in this field. Indonesia's production has increased since 2017 and is expected to continue to increase until 2025. However, temporal analysis also shows that, compared to its cumulative contribution compared to Western countries during its early growth period (2014-2018), Indonesian research still lags behind. Improvements in research infrastructure, better international collaboration, and utilization of Indonesia's unique selling points in terms of local wisdom and rich pedagogical context are needed to overcome this lag. Furthermore, temporal data shows that, given the increasing global momentum and high contextual relevance to government programs such as educational

sustainability and green campuses, investment in environmental literacy research in Indonesian language learning should be prioritized

1.3 Conceptual Landscape of Environmental Ecology Research in Language Learning

In this bibliometric study, the analysis of the conceptual landscape of research used in studies combining environmental ecology with language learning reveals important phenomena about how this interdisciplinary paradigm is constructed, what terminology is most commonly used, and conceptual trends developing during the study. The data shows a keyword distribution that strongly reflects the development of academic thinking about the relationship between the environment, sustainability, and language education around the world. The following image shows the results of the analysis related to the conceptual landscape of research used in this study.

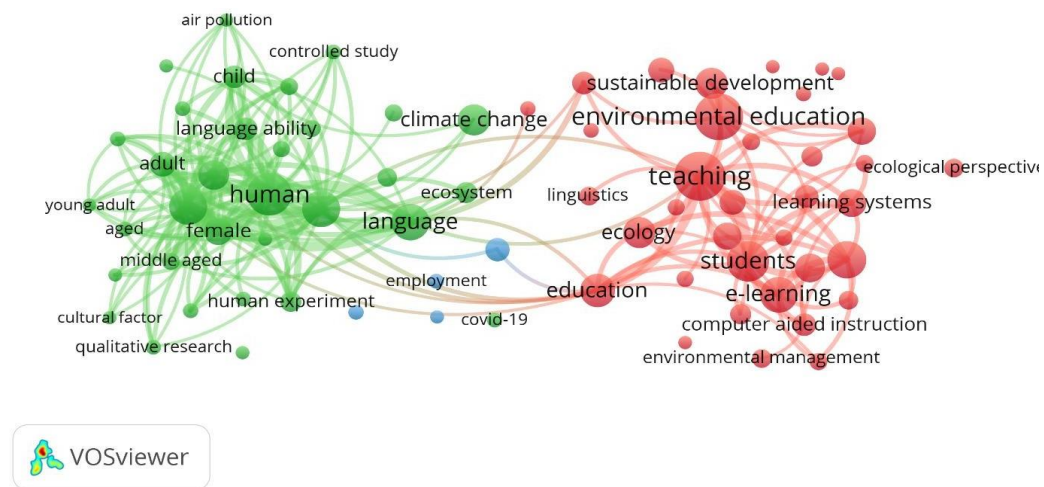


Fig. 5. Conceptual landscape of environmental ecology research in language learning

From the table above, it can be seen that several different but interrelated thematic clusters are identified through conceptual bridges via co-occurrence network visualization. The first cluster, shown in red-orange in the visualization, focuses on pedagogical and educational elements, with core keywords such as teaching (42 occurrences, total link strength 214), environmental education (39 occurrences, 76 link strength), students (31 occurrences, 150 link strength), education (23 occurrences, 137 link strength), and learning systems (17 occurrences, 82 link strength). This cluster reflects the research focus on how environmental learning can be applied in formal learning. Keywords such as English language teaching (16 occurrences, 55 link strength), language education (16 occurrences, 47 link strength), and language learning (18 occurrences, 52 link strength) indicate that most of the literature concentrates on how language learning is integrated with sustainable development and environmental awareness. A bibliometric review of the environmental education literature for sustainable development in primary education further reinforces this pattern, where themes such as attitudes, awareness, and knowledge emerge as the main cluster, emphasizing the need for interdisciplinary integration to build transdisciplinary skills and systematic thinking among young students (Zhiteng Yan et al., 2025).

The second prominent cluster, marked in green, groups keywords related to social and behavioral dimensions, including human (34 occurrences, 302 link strength), humans (26 occurrences, 254 link strength), male (19 occurrences, 212 link strength), female (16 occurrences, 188 link strength), and adult (14 occurrences, 170 link strength). This cluster shows the research's focus on how demographic differences (gender, age, and adult status) influence the understanding and adoption of environmental literacy. In addition, the study will investigate the role of human institutions in environmental behavior change. The third cluster, depicted in blue and purple in the visualization, discusses ecological and environmental terms. This cluster includes key words such as ecosystems (27 occurrences, 96 link strength), ecology (20 occurrences, 87 link strength), climate change (20 occurrences, 67 link strength), and sustainable development (20 occurrences, 67 link strength). This cluster emphasizes the importance of understanding ecological systems as the basis for

environmental learning. A bibliometric study of Scopus-indexed ecolinguistics publications from 2011 to 2022 further underscores this integration, where themes such as critical discourse analysis and ecolinguistic perspectives dominate, although there is still an imbalance in exploring broader ecological issues beyond discourse alone (Wirawan et al., 2024).

What is particularly interesting about the visualization is the strong relationship between these clusters. This shows that the literature does not simply distinguish between the concepts of pedagogy and ecology, but also actively combines the two. For example, the total strength of the relationship for the keyword teaching (214) shows a strong connection with various other topics. This shows how language learning is used as a means of communication and facilitates understanding of environmental concepts. According to the analysis, language (26 occurrences, 193 connection strength) and communication (mentioned in the network) are central point connecting pedagogy with ecology. This indicates a strong academic recognition that language and communication are not only tools for conveying information about the environment but also important media that shape human perceptions, awareness, and actions towards the environment. Keyword data reveals several emerging ideas gaining attention. Digital learning, particularly accelerated by the COVID-19 pandemic, is indicated by e-learning (25 occurrences, 106 link strengths) and computer-aided. The presence of these keywords suggests that new literature seeks to integrate technology-based environmental learning with environmental literacy objectives. A bibliometric analysis of the interaction between environmental education and sustainable entrepreneurship development globally further highlights this gap, where strategies for integrating environmental education into sustainable practices remain under-explored, especially in the context of diverse demographics and the achievement of the Sustainable Development Goals (Arya et al., 2024). The presence of higher education and artificial intelligence in the visualization network indicates that research is increasingly entering the domain of higher learning. Integrating artificial intelligence into environmental learning opens new doors for teaching environmental literacy at universities.

Indonesia has shown significant involvement in this conceptual environment, particularly through its contribution to the development of a specific contextual pedagogical framework. Analysis of Indonesian literature shows that Indonesian researchers actively use more specific terms and concepts such as ecopedagogy, ecolinguistics, learning based on ecoliteracy, and integration with local wisdom or local potential. In addition, research in Indonesia shows a particular focus on environmental awareness, environmental language skills, and sustainable language skills. All of this research is integrated with the teaching of Indonesian and mother tongues. Indonesia's contribution is unique in that it emphasizes the natural and cultural knowledge of indigenous peoples in language learning, creating a thematic subcluster that differs from the more abstract mainstream Western literature. Indonesian researchers often use keywords such as Adiwiyata (Indonesian green school program), local context, cultural values, indigenous knowledge, and contextual learning. This shows that Indonesia not only adopts global frameworks but also adapts them into something culturally grounded and relevant to the local context. A systematic literature review of eco-pedagogical literacy trends in Indonesia from 2016 to 2024 reinforces these findings, where strategies such as problem-based and contextual learning are dominant, although research and development approaches are still rarely applied to create more interactive innovative learning modules (Amaliati et al., 2024).

Bibliometric analysis found several significant research focuses. One of the main centers of attention in teaching and learning related to environmental themes is student engagement and critical thinking in the context of environmental teaching. As indicated by the combination of keywords such as problem-based learning, project-based learning, and contextual learning, active learning methods are an important frontier in the application of environmental learning. Environmental health and environmental stewardship emerge as outcome-oriented keywords, indicating that research is interested in cognitive skills related to environmental health as well as the behavioral manifestations and practical practices of environmental health stewardship.

The analysis of the data has several significant implications for education and research in Indonesia. First, this conceptual mapping shows that environmental teaching and language are two sides of the same coin. They are not separate entities that must be mechanically integrated, but rather manifestations of a broader educational philosophy. Second, the fact that there are behavioral and demographic clusters in the network indicates that research on environmental literacy should not

ignore aspects of student differences in the application of environmental literacy. The data shows that age, gender, and social status influence how a person responds to and adopts environmental awareness. Third, the strength of the complete relationship between learning and educational technology shows that Indonesian researchers can leverage the power of educational digitization to develop innovative solutions that integrate environmental topics into e-learning platforms. This is particularly important given the growing number of students in Indonesia and increased access to digital technology. Fourth, the analysis shows that sustainable literacy and environmental management have emerged as new themes that have not been fully explored in Indonesian language teaching. This provides broad research opportunities for Indonesian academics to contribute to this frontier of knowledge.

1.4 Interdisciplinary Relationships and Connections in Language Learning and Environmental Ecology

In traditional education, language and environmental ecology are often viewed as separate entities, even though they shape each other through complex and dynamic interactions. Data analysis from this study highlights that this relationship is not merely instrumental, but relational and dialectical, where word choice and language structure shape human perceptions of the environment, and conversely, ecological experiences influence the evolution of language itself. The paradigm of linguistic ecology introduced by Einar Haugen in the 1970s forms the foundation of this integration theory, which views language as a living entity that adapts to its natural and social context. Therefore, in learning, ecological elements must be an integral part, not merely an addition.

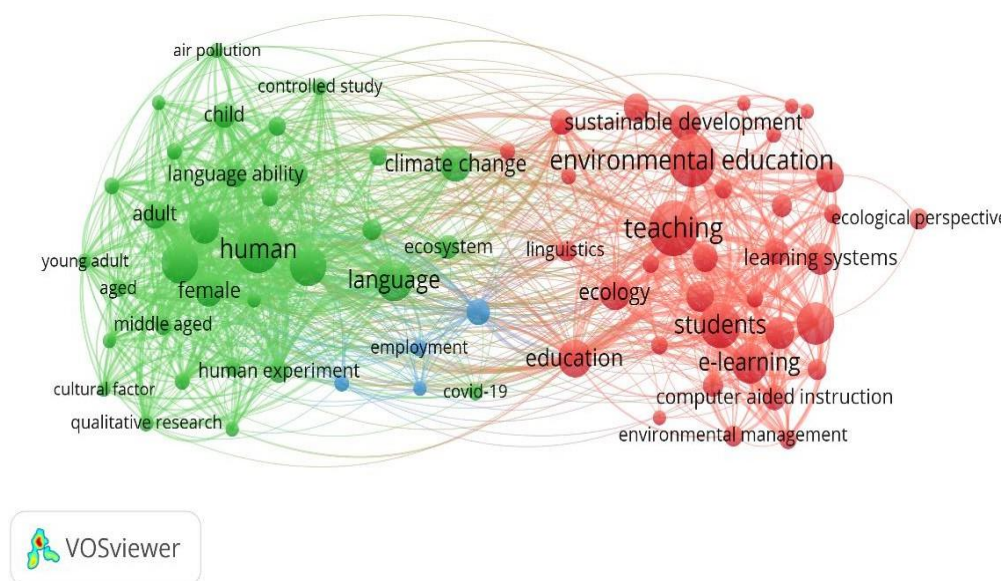


Fig. 6. Interdisciplinary relationships and connections in language learning with environmental ecology

The findings, as illustrated in the visualization above, reveal a strong connection between the keywords "teaching" (with a total link strength of 214) and "environmental education," reflecting the academic community's view that these two domains are manifestations of a holistic educational philosophy. In addition, the frequent encounters between "language" (link strength 193), "communication," and "ecology" emphasize the importance of not only understanding environmental issues, but also communicating them effectively. 's relationship between environmental ecology and language learning works through synergistic mechanisms that support each other. At the linguistic representation level, for example, students' conceptualization of natural phenomena is influenced by the metaphors, terminology, and grammar used in teaching, where critical discourse analysis shows that linguistic framing can change the view of environmental issues from individual issues to broader systemic ones (Prastio et al., 2023).

Furthermore, combining language learning with environmental themes not only improves linguistic proficiency but also builds deep ecological literacy, helping students understand the interconnection

between human and natural well-being to support sustainable decisions. This approach encourages critical understanding of language, enabling students to recognize how narratives influence their perceptions of global issues such as climate change. On the other hand, individual ecological identity, or what is known as environmental identity, is closely tied to language choices in a social context, where empirical studies show that students with strong ecological understanding through language learning tend to adopt more conservation-oriented expressions (Kholid & Maimun, 2023). Indonesia offers a unique context for this interconnection, given its linguistic diversity of more than 700 regional languages alongside its extraordinary ecosystem wealth. This creates a natural laboratory for exploring how local languages integrate traditional ecological knowledge, as seen in bibliometric research highlighting Indonesian scientists' efforts to combine tribal wisdom with formal language education. More than just content insertion, this integration involves an epistemological shift, where ecological perspectives embedded in regional languages are recognized as valid sources of knowledge for building environmental awareness in younger generations. Ecolinguistic principles are applied in teaching Indonesian and local languages through local case studies, where teachers combine nature stories, traditional wisdom, and indigenous terminology for example, the concept of "local wisdom" which encompasses not only oral literature, but also how language encodes the relationship between humans and their environment (Zein et al., 2020).

The Adiwiyata program in Indonesia is a concrete example of how language can function as an ecological medium, where students not only learn grammar but also use language for environmental advocacy, scientific communication about local ecosystems, and the preservation of indigenous discourse. From this analysis, various dimensions of the ecology-language connection are apparent: cognitively, environment-based language learning enriches understanding of both language structure and natural systems; affectively, nature-based experiences build emotional bonds with the target language, which increases student motivation and engagement; and socially, it facilitates critical discussion of sustainability and responsibility in the language being learned. The practical dimension is reflected in the application of language skills to real environmental projects, such as community advocacy. Linguistic pluralism and environmental variation in Indonesia add complexity, as students must master multiple systems of mother tongues, Indonesian, and English to convey contextual ecological knowledge. Co-occurrence analysis shows that the curricular separation between environmental and language learning causes inefficiency, as the two have significant epistemological overlap. The recommended integration is not the addition of environmental content to language lessons, but rather the transformation of language learning into an intrinsic ecological practice, where mastering language also means developing more harmonious ways of interacting with the non-human world (Husamah et al., 2022). While theoretically appealing, the implementation of this interconnection faces concrete challenges. First, there is a lack of teacher training to integrate environmental themes into language curricula, even though awareness in Indonesia is beginning to increase. Second, there is tension between standardized tests that focus on technical language skills and broader ecological learning outcomes, especially in the Merdeka Curriculum, which still prioritizes language structure. Third, there is a limitation of authentic teaching materials that integrate local environmental contexts, often relying on imported sources that are less relevant.

However, opportunities arise from these research findings. First, global awareness of the urgency of ecological literacy is growing, driving educational innovation. Second, a surge in research in Indonesia offers successful models of integration, such as the application of SETS (Science, Environment, Technology, Society), which has proven effective in building environmental literacy through an interdisciplinary approach (Husamah et al., 2022). Third, there is a growing alignment between the goals of environmental education, ecological sustainability, and language development in Indonesia's national policy. The relationship between language learning and environmental ecology is dynamic and reciprocal, involving mutually reinforcing theoretical and practical pedagogy. Indonesia has great potential as a pioneer of local wisdom-based language education and sustainable development models, utilizing linguistic and natural diversity to improve linguistic abilities and ecological awareness. To realize this, intensive collaboration is needed in curriculum development, teacher training, material production, and policy support, making language-ecology integration the core of education, not just an additional element.

1.5 The Transformation of Terms and the Focus of Environmental Ecology Research in Language Learning Changes Over Time

This study traces the evolution of terms and research focus on the relationship between language learning and environmental ecology from 2008 to 2025, based on a review of 396 articles in the Scopus database, while mapping the interactions between terms and their dynamic positions in the global research map. The main findings describe a fundamental shift in how researchers view the relationship between environmental education and language teaching. In the early period, namely 2008-2014, these two fields operated in isolation, with environmental researchers emphasizing terms such as "environmental awareness" and "environmental knowledge," while language experts focused on "language learning" and "English language teaching" without much reference to ecological aspects. Significant changes began to emerge around 2015-2017, with the emergence of transformative terms such as "sustainability education," "eco-literacy," and "ecological perspective," reflecting the scientific community's conscious effort to organically link the two domains. A similar bibliometric analysis confirms this trend, in which environmental literacy is increasingly integrated with sustainable development through interrelated keyword patterns in global publications (Ariyatun et al., 2024).

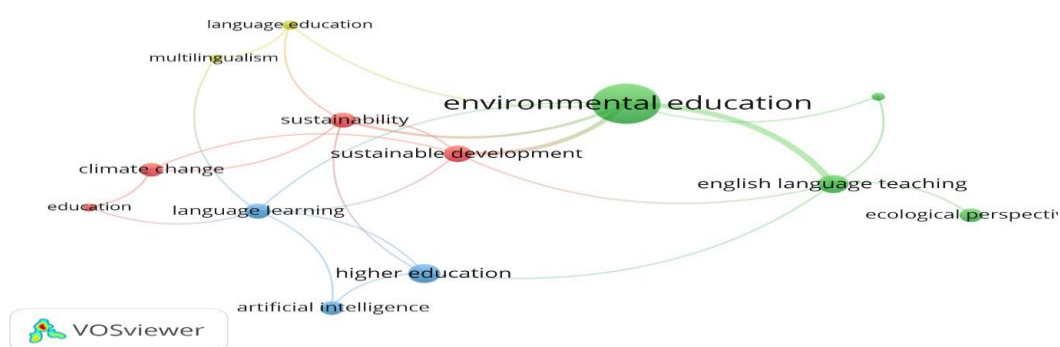


Fig. 6. Interdisciplinary relationships and connections in language learning with environmental ecology

The figure above shows that based on data from 396 publications, the dominant terms include "environmental education" (29 occurrences), which remained stable as the center of discussion throughout the period, signifying the enduring foundation of this research. "Higher education" (13 occurrences) has experienced a recent surge, signaling the role of universities as the main arena for combining environmental and language elements. "English language teaching" (12 occurrences) is now often paired with ecological concepts, making English language teaching a channel for communicating environmental issues. Meanwhile, "sustainable development" (11 occurrences) and "sustainability" (10 occurrences) are increasingly converging with learning terminology, indicating recognition that communication and education are key to the broader sustainability narrative. "Language- -learning" (10 occurrences) and "language education" (6 occurrences) have also undergone a transformation, from isolation to bridging with environmental themes, which was previously rare. Indonesia has made a unique contribution to this dynamic, where researchers initially adopted international terminology directly without significant local adaptation. However, since 2015-2017, contextual innovations have emerged, such as "local wisdom-based language learning," which combines language teaching with traditional knowledge; "integrated environmental literacy," which combines communication skills with an understanding of nature; and "Indonesian context-based ecopedagogy," which adapts ecological education to the realities of national education. Such developments demonstrate not only passive adaptation to global trends, but also the creation of new concepts relevant to cultural and geographical diversity, thereby enriching the international discourse on how language education can be colored by local values (Amaliati et al., 2024).

This evolution can be divided into distinct phases. The first phase (2008-2014) was marked by disciplinary separation, where the terms environment and language rarely intersected, including

among Indonesian researchers who had not yet integrated the two. The second phase (2015-2018) marked the beginning of convergence, with terms such as "ecological perspective" and "sustainability literacy" beginning to bridge the gap, driven by global awareness of the mutual reinforcement of the two fields. The third phase (2019-2023) reinforced integration, accelerated by the COVID-19 pandemic, which prompted new terms such as "climate education," "climate communication," and "ecological knowledge" to respond to the environmental crisis through language learning. Analysis of ecopedagogy trends in education shows a significant increase in publications since 2023, with strategies such as problem-based learning often linked to environmental awareness (Yuliani et al., 2024). The fourth phase (2024-2025) highlights differentiation, with advanced terms such as "digital sustainable education" and "bilingual environmental literacy," reflecting deep specialization. This transformation of terminology indicates a paradigm shift: language and the environment are now understood as interrelated entities, where communication influences human interactions with nature. Researchers no longer simply add environmental elements to language teaching, but rather redesign it to build deep ecological awareness and responsibility. Technologies, such as "artificial intelligence" and "digital learning," are increasingly integrated as solutions, not obstacles. Furthermore, an emphasis on local context and cultural diversity moves research away from universal models, valuing diverse perspectives on language, nature, and education. Indonesia is strategically positioned for the future, with data showing its active role in shaping trends, not just following them. The wealth of local wisdom, more than 700 regional languages, and initiatives such as the Adiwiyata Program enable the development of inclusive approaches that unite traditional values with formal learning. Indonesian researchers are creating terminology that captures unique nuances, benefiting global and national communities in advancing sustainable education (Husamah et al., 2022).

CONCLUSION

This study successfully reveals the dynamics of environmental ecology integration in language learning through a bibliometric lens, confirming that global trends have accelerated significantly since 2014, driven by the SDGs agenda and post-pandemic awareness of sustainability. The final results show that the United States and China dominate research production with contributions of 86 and 52 documents, respectively, while Indonesia ranks third with 31 documents, marking its strategic role as a bridge between Southeast Asian and Western perspectives through increasingly strong international collaboration. Dominant keywords such as "environmental education," "teaching," and "sustainable development" form interrelated thematic clusters, illustrating how language learning serves as a catalyst for building ecological literacy, where the interdisciplinary relationship between language and ecology is no longer separate but rather mutually shapes students' environmental identities. The evolution of terminology from an initial focus on basic environmental awareness to advanced concepts such as "eco-literacy" and "ecopedagogy" reflects a paradigm shift towards holistic education, peaking in 2024-2025.

Bibliometric analysis identifies several strategic research opportunities that attract the attention of the global academic community, opening substantial collaborative possibilities for Indonesian researchers with international partners. The emerging thematic clusters demonstrate that digital ecopedagogy, multilingual environmental literacy, and climate communication through language education emerge as frontier research areas with the highest publication momentum since 2024. Emerging keywords such as "sustainable development communication," "eco literacy in multilingual contexts," and "environmental justice through language education" indicate global demand for research that aligns linguistic aspects with concrete environmental action. Indonesia possesses a unique competitive advantage to explore how regional languages encode traditional ecological knowledge a topic that remains insufficiently explored in international literature. Research partnerships with universities in Australia, Malaysia, and Japan can produce high-impact publications that combine Southeast Asian perspectives with global rigorous methodology, while simultaneously creating ecopedagogy models relevant to multilingual and multicultural contexts in the region

In the Indonesian context, these findings highlight the country's unique potential to lead innovation through the integration of regional languages with ecological practices, bridging the gap between the national curriculum and sustainability needs. Based on Bronfenbrenner's ecological theory and tested co-word analysis, this integration is not merely an addition but a foundation for shaping linguistically competent agents of environmental change. As a recommendation, the Indonesian government is advised to strengthen its educational curriculum policy with a cultural approach, particularly in terms of environmental ecology. Meanwhile, academics are encouraged to increase cross-country collaboration to explore digital ecopedagogy. Further suggestions include intensive teacher training in multilingual ecological literacy and regular evaluation of research instruments to ensure relevance to current issues such as climate change, thereby enriching global contributions while maintaining local identity.

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