

Transformation of Environmental Education (EE) into Education for Sustainable Development (ESD) in Indonesia: Recent Trends, Gaps Assessment, and Policy Recommendation

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ABSTRACT

This study aims to understand the current trends in environmental education (EE) and education for sustainable development (ESD) in Indonesia and identify potential gaps in the scientific literature. This study used a systematic literature review (SLR) and a questionnaire survey sent to eight experts in EE and ESD. The Adiwiyata program is considered to be the oldest topic studied by researchers. The Adiwiyata program is a massive EE program in K-12 (kindergarten to 12th grade) education that is popular in Indonesia. During the pandemic, the Adiwiyata program could not be held, and the research topic shifted to students' behavioral changes. Therefore, gaps in the implementation of EE and ESD in higher education institutions (HEI) have been spotted; thus, research on this aspect should be enhanced. The transformation of EE to ESD in Indonesia should begin with improvements in the quality and competency of human resources.

Keywords: Adiwiyata program; environmental education; environmental sustainable development; systematic literature review; Indonesia.

INTRODUCTION

In recent decades, environmental challenges and the pursuit of sustainable development have become paramount concerns on the global agenda (Zaccari, 2012). As countries strive to address these pressing issues, education has emerged as a critical tool for fostering awareness, understanding, and action (Cammarota & Fine, 2008). In Indonesia, a nation rich in biodiversity and cultural diversity, the evolution of Environmental Education (EE) into Education for Sustainable Development (ESD) reflects a significant shift in educational paradigms and policy priorities. Traditionally centered on cultivating ecological consciousness and conservation practices, EE has undergone a profound makeover on the global stage (Lee & Efird, 2014).

In Indonesia, this metamorphosis has gained notable traction driven by the nation's resolute commitment to address environmental predicaments as part of its pursuit of sustainable development. The evolution from EE to ESD encapsulates a broader perspective that underscores ecological insights and embraces sustainability's social, economic, and cultural dimensions (Quinn, *et al.*, 2016). Esteemed scholars such as Ferguson, *et al.* (2021) and Paual (2015) have underscored the significance of infusing comprehensive sustainability perspectives into education, thereby equipping individuals with the requisite knowledge, competencies, and attitudes and values needed to contribute to a more sustainable world.

The reorientation of EE to ESD was introduced from February to March 2006 at a 7-days conference in Tokyo and Kyoto, Japan. At the conference, the progress of EE application in the Asia-Pacific Region and the integration of EE to ESD was introduced (Paden, 2007). MCKeown and Hopkins (2007) differentiated between EE and ESD, while the progress of ESD has been highlighted because it is beyond the EE context. Despite the progression of EE to ESD, Koprina (2012) stated that the development of ESD is precisely a turning point in modern education to stay away from the environment. Almost 15 years later, Acosta Castellanos and Queiruga-Dios (2022) reviewed EE's transformation of EE to ESD from the scientific literature. They used systematic reviews and meta-analyses to analyze recent advancements in ESD and EE. They found that studies related to ESD are currently more popular than EE worldwide. Although the progression from EE to ESD has garnered recognition as a prevailing trend, there remains an unexplored terrain for comprehensively dissecting the intricacies of this transition in Indonesia. This article bridges this gap by analyzing the definition, execution, and experience of EE and ESD within Indonesia's distinct sociocultural and ecological milieu. By placing the evolution of educational paradigms within this multifaceted archipelago, this study enriches the expanding insight into the global evolution of sustainable education.

By scrutinizing official policy documents, curriculum materials, and educational practices, this study examines the transformative journey from EE to ESD in Indonesia, elucidates recent trends, identifies gaps, and proposes policy recommendations to enhance the integration of sustainability principles into the educational landscape. This article seeks to delineate the conceptual underpinnings and practical manifestations of these educational approaches. Through a systematic literature review (SLR) and questionnaire-based survey, this study aimed to identify emerging themes, research gaps, and promising trajectories that characterize the evolution of EE and ESD in the Indonesian educational landscape. Building on the insights gained from the analysis, this study proposes questionnaire-based policy recommendations that can enhance the integration of sustainability principles into educational policies, practices, and outcomes in Indonesia. In the following sections, this article delves into the methodological approach, findings, and implications of this research, providing a clear understanding of the dynamic transformation of EE into ESD in Indonesia and its implications for sustainable development education worldwide.

METHODS

Theoretical Framework

This study has the following research questions (RQ):

RQ1: What are the definitions and implementations of EE and ESD in Indonesia?

RQ2: What are ESD's current research trends, gaps, and potential future directions in Indonesia?

RQ3: What are the policy recommendations to support the implementation of EE and ESD in Indonesia?

Therefore, this study combined a systematic literature review and a questionnaire-based survey to answer all of these questions. The SLR was used to answer RQ1 and RQ2 and extract several policy recommendations from the literature. Subsequently, a questionnaire-based survey was conducted to prioritize the developed recommendations. The theoretical framework is illustrated in Figure 1.

Data Collection for Bibliometric Analysis

This study initially outlined the phases involved in the systematic literature review (SLR) protocols employed to select and assess the metadata of environmental education (EE) and education for sustainable development (ESD). As previously delineated, the data collection procedures adhered to the PRISMA 2020 protocols formulated by Page et al., which serves as the foundational underpinning for crafting a robust systematic review. The inception of this research endeavor involved identifying the research scope within the domain, substantiated by a comprehensive analysis of the pertinence and significance of the research theme through extensive scrutiny of numerous correlated scholarly articles. Following this, data collection was conducted by designating the research database and documents in which metadata selection was conducted. Our choice for this process was based on the Scopus® database owing to its accessibility to the authors.

Scopus®, a multidisciplinary abstract and citation database encompassing a wide array of global scientific literature, was deemed suitable for this purpose. Once the database was selected, a series of steps were undertaken for the systematic literature network analysis (SLNA), encompassing: (1) pinpointing metadata-associated topics via databases and registries, (2) automating record screening through pertinent tools and evaluating the documents' suitability, and (3) incorporating studies that met the eligibility criteria for subsequent thorough analysis. The search of the database was confined to manuscripts indexed before April 26, 2023.

During the process of identifying metadata, the initial and crucial task involves the selection of pertinent keywords. In this study, we employed two keyword combinations. The first combination comprised "Environmental Education," compiling 21,197 documents. The second combination was "Education for Sustainable Development," resulting in 2,149 documents. After keyword selection, an automated filter was applied to refine the paper selection, thereby narrowing the corpus to papers germane to the research objective. A set of inclusion criteria was then introduced, encompassing language, publication year, document types, and source types, to curate the metadata pool.

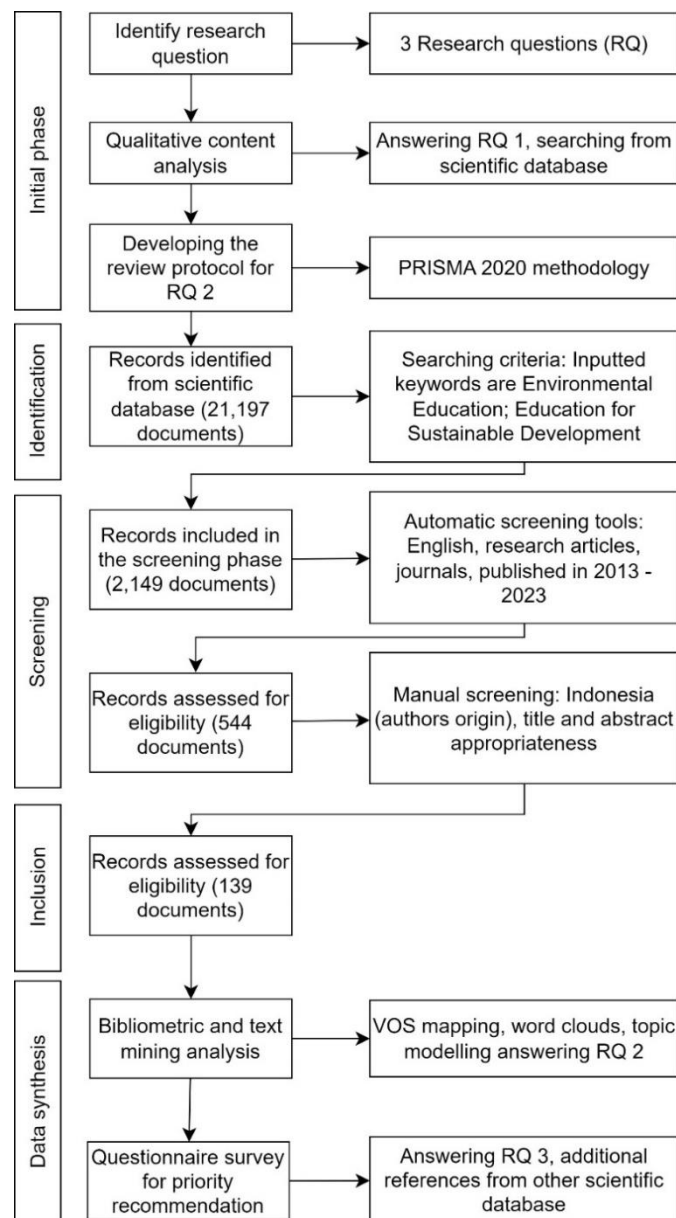


FIGURE 1: Theoretical framework.

Specifically, English was chosen as the language criterion, whereas document types were limited to original research articles and conference proceedings. Source types were confined to journals, aligning with the need for assured manuscript accessibility for subsequent qualitative content analyses. Furthermore, the scope of publication years was confined to 2013 to 2023 (10 years). The compilation was streamlined to 544 metadata entries, following these automated filtering steps. Manual sortation was done by examining the relevancy of the title and keyword to the topic of this study and the origin of the author's country was limited to Indonesia. Therefore, 139 documents were included in the next step. Ultimately, in the inclusion phase, metadata were extracted in comma-separated values (.csv) format, which serves as the foundation for bibliometric and content analysis, facilitating the exploration of ongoing research trends, identifying gaps, and conducting in-depth analyses.

Analysis of Literatures

Content analysis was used to define EE, ESD, and the story behind their implementation of EE and ESD in Indonesia. Several pre-processing criteria were applied, especially on how the keyword was used in the metadata search. The second RQ2 was answered by following Wibowo, *et al* (2023) methodology, which employs systematic literature network analysis (SLNA) as a combination of bibliometric analysis (BA) and content analysis (CA). In the process of bibliometric analysis, the study adhered to the approach introduced by Song, *et al.* for performing performance and science mapping analysis (Song, *et al.*, 2021). Performance analysis involves the assessment of various parameters, including journals, countries, and institutions. The essential indicators for this assessment encompass the count of articles or the volume of research, along with citations that indicate research quality. For this purpose, this study utilized VOSviewer and Excel to construct co-authorship, citation, and co-occurrence keyword maps.

VOSviewer is an open-source tool that facilitates the visualization of scientific landscapes (Semeraro, *et al.*, 2021; Harfadli, *et al.*, 2024). For co-authorship, co-authorship countries, and co-occurrence author keyword mapping, a minimum threshold of two documents for a country and occurrences of a keyword were set. For the co-citation network and co-occurrence term mapping, the minimum thresholds of 4 and 10 of a keyword were set, respectively. The software enables the generation of numerous scientific maps.

For specific title and abstract analyses, the study used Orange Data Mining, a potent platform for extensive data analysis and visualization (Han, *et al.*, 2019; Wibowo, *et al.*, 2023).

In this study, BA was performed using text mining within the Orange Data Mining. Text mining converts unstructured text into structured information, whereas bibliometric analysis examines research trends in metadata.

Both methods complement systematic literature reviews, summarize information, and reveal relationships (Feicheng and Yating, 2014). A word cloud was generated to show common words, with size indicating the frequency (Mohr & Bogdanov, 2013). This helps gauge the preprocessing impact. Topic modeling was used to identify significant subjects within the dataset. Latent Dirichlet Allocation (LDA) was employed for this purpose, known for its ease of interpretation (Putri & Kusumaningrum, 2017). Multidimensional Scaling (MDS) has been used to visualize topic similarities (Chen, *et al.*, 2015). Ultimately, qualitative content analysis (QCA) has delved deeper into the nanotechnology and materials topic within environmental and human protection. This method follows the framework of Mayring, (2015) by combining inductive and deductive category principles. This aids in defining and synthesizing new concepts from the literature. Content analysis is a robust method for bridging the gaps in bibliometric review approaches. A detailed analysis of each step and its preprocessing criteria is shown in Table 1.

TABLE 1: Inclusion and pre-processing criteria for analysis.

Type of Analysis	Detail of Analysis	Pre-processing criteria
Content analysis	Definition of EE, ESD, and historical view of EE and ESD implementation	Keyword search on reference manager: "Environmental Education," "Education for Sustainable Development," "Implementation."
Science mapping analysis	Co-authorship authors mapping	full counting, the minimum number of documents of an author is set to 2, the minimum number of citations of an author is set to 5, and the map shows all sets of networks
	Co-authorship countries mapping	full counting, the minimum number of documents of a country is set to 2, and the minimum number of citations of a country is set to 5
	Citation network mapping	In full counting, a document's minimum number of citations is set to 4, and the map shows all sets of networks.
	Co-occurrence author keywords mapping.	In full counting, the minimum number of occurrences of a keyword is set to 2, and the map shows only the most extensive set of networks.
Topic modeling	Co-occurrence terms mapping	The minimum number of term occurrences is set to 10 in full counting.
	Word clouds	Keywords, titles, and abstracts are included for topic modeling.
	Topic modeling	Transformation: lowercase, remove accents, parse HTML Tokenization: regexp, pattern \w+. Filtering: stopwords (English), numbers, document frequency. 0.10 - 0.90; regexp;
Content analysis	Multidimensional scaling (MDS)	LDA is set to 6 based on MDS results (no similarities between topics were found).
	Policy recommendations	Keywords search on reference manager: "Policy."
Prioritization analysis	Prioritizing the policy based on expert recommendation	-

Questionnaire Survey and Prioritizing the Policy Recommendations

The QCA in the previous subsection was used to extract several policy recommendations for transforming EE into ESD in Indonesia. This analytical process involves condensing and restructuring established keywords into complete sentences (Budihardjo, et al., 2021). From the metadata extracted from 139 documents during bibliometric analysis, specific terms identified using a VOS map and LDA modeling were chosen and subsequently defined through qualitative content analysis, as established in the preceding subsection. A total of eight experts comprising at least one penta-helix actor in Indonesian EE participated in responding to the prioritized policy recommendation questionnaire. The Penta-helix multi-stakeholder framework integrates five stakeholders in implementing ESD/EE, including public, private, academic, civil society, and entrepreneurs (Purnomo et al., 2021).

The experts were asked to assign a value from 1 to 10 to all recommendations extracted. The enormous number of priorities (10) represents the highest priority and vice versa. Finally, the sum of the priorities was given, considering that the most prominent value will have the most significant priority among the others.

RESULTS AND DISCUSSION

Definition

In this section, the definitions of EE and ESD are explained. The implementation of EE and ESD in Indonesia and its transformation are explained in the following subchapter.

Environmental Education (EE)

EE was first introduced in school curricula in the 1970s. Even at the time, EE was not acknowledged as a distinct concept; instead, it was scattered across diverse disciplines that employed the environment for instructional purposes. With growing environmental problems, in the 1980s, the public became more concerned with EE and its implementation in schools. This decade has become the starting point at which holistic philosophy is rooted. In the 1990s, EE was defined, promoted, and addressed in society because EE was connected to economic development and environmental conservation (Tilbury, 1995). Currently, EE is defined as methods, tools, and programs that foster attitudes, values, awareness, knowledge, and skills, equipping individuals to make informed environmental decisions (Ardoin, et al., 2020).

There is also a wide range of definitions that consider EE a subject. EE is not just one of many forms of education or a mere tool for addressing environmental challenges; instead, it is a vital aspect of fundamental education centered on the foundational sphere of interaction crucial for personal and social development—the relationship with our environment, our shared "home of life." Its goal is to initiate social dynamics, beginning at the local level and expanding to broader networks, thus promoting collaborative and critical perspectives on

socio-environmental realities. This encourages an independent and creative understanding of current issues and potential solutions (Stern, et al., 2014).

EE functions as a conservation tactic and establishes collaborative environments for scientists, decision-makers, communities, and stakeholders to converge. It emphasizes local knowledge in specific settings and encourages diverse groups, including marginalized ones, to engage constructively with research. It targets outcomes at different scales, from individual attitudes to societal capacity building and ecosystem considerations (Ardoin, et al., 2020). EE is not only an approach, philosophy, and tool, but also a profession. Its objective is to cultivate environmentally literate citizens who are capable of addressing sustainability issues related to the environment and resources. By instilling attitudes, values, knowledge, dispositions, and skills that promote pro-environmental actions, environmental education encourages active involvement in improving the sustainability of human-nature interactions over time (Ardoin & Bowers, 2020).

Education for Sustainable Development (ESD)

Sterling and Huckle (2014) introduced education for sustainability (Efs), stating that it plays an important role in tackling many global issues. It is therefore important to translate this awareness into suitable and impactful actions. When it comes to the local implementation of sustainable development goals (SDGs), the practical application of Efs has become a complex socio-technical phenomenon. While practitioners and researchers advocate for diverse perspectives on Efs, there is concern that encouraging such diversity may unintentionally reinforce dominant political ideologies and consolidate corporate power. This, in turn, could weaken the ecocentric perspective and overlook significant variations at the grassroots level of Efs practice, encompassing differences in goals, orientation, and educational program levels (Sonetti, et al., 2020).

In recent decades, global communities united by the UN have committed collectively to addressing Sustainable Development (SD). The "Transforming Our World: The 2030 Agenda for Sustainable Development" by the United Nations (UN) stands out as one of the most ambitious and globally impactful agreements in recent times. Encompassing the 17 Sustainable Development Goals (SDGs), this agenda serves as a comprehensive framework addressing urgent challenges such as inequalities, climate change, and new economic models worldwide by 2030. The 2030 Agenda, which offers a significant opportunity for societal transformation, specifically emphasizes ESD through Target 4.7. This target aims to ensure that all learners acquire the knowledge and skills essential for promoting sustainable development by 2030. This includes education on sustainable lifestyles, human rights, gender equality, the promotion of a culture of peace and non-violence, global citizenship, and an appreciation of cultural diversity and its role in sustainable development (Colglazier, 2015). ESD has emerged as a crucial approach to promoting sustainability.

ESD aims to equip students with sustainability skills by employing a comprehensive, interdisciplinary approach and diverse learner-centered teaching methods. The global adoption of ESD stems from the UN Decade for ESD, which has influenced curricula globally (Boeve-de Pauw, et al., 2015).

Implementation of EE to ESD in Indonesia

Indonesia holds the status of the world's largest Muslim-majority country, boasting a significantly large population. Indonesia is one of the most culturally diverse nations globally, with an extensive array of ethnic groups speaking more than 700 languages. The government's role in environmental issues began when President Soeharto sent an Indonesian delegation, led by Emil Salim. Indonesia participated in two significant UN environmental conferences during the Soeharto leadership: the 1972 UN Conference on the Human Environment in Stockholm and the 1992 UN Conference on Environment

and Development (UNCED) in Rio de Janeiro (Parker & Prabawa-Sear, 2019). According to Emil Salim's testimony, the Ministry of the Environment was established in 1974 as the Indonesian government's response to the urgency of environmental matters, driving the establishment of a new ministry. He was one of the twenty-three members of the Brundland Commission, which created concepts that eventually became the definition of sustainable development. Despite the criticism faced by the Ministry of Environment during that period, EE was initiated in Indonesia, starting with university-level education. Currently, both state-owned and private universities in Indonesia are actively involved in training and bolstering their research focus. This emphasis aims to discover appropriate environmental solutions for the growing socioeconomic challenges faced by this developing third-world country (Darmawan & Dagamac, 2021).

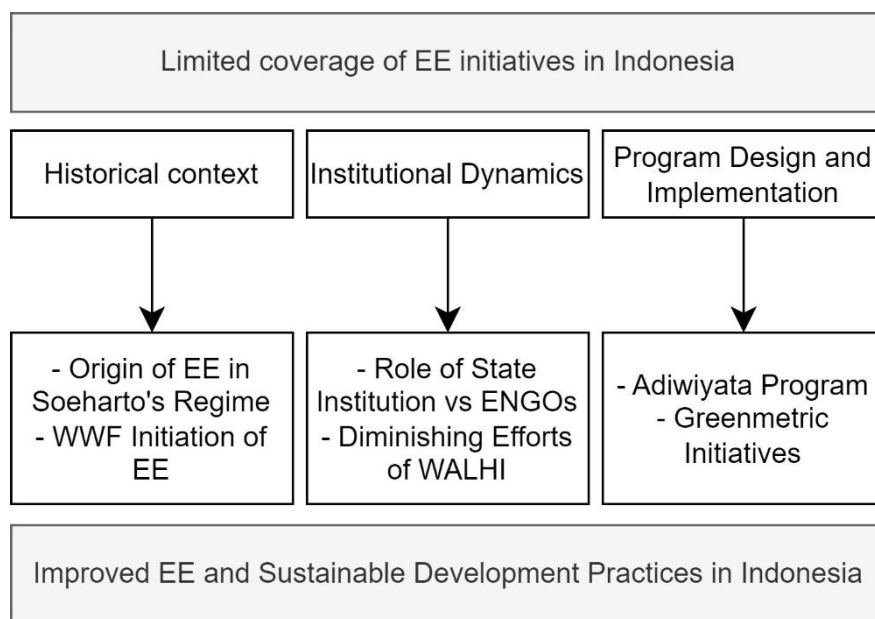


FIGURE 2: Coverage of EE Initiatives in Indonesia.

Figure 2 shows the coverage of EE initiatives and context in Indonesia. The historical context for initial EE endeavors in Indonesia began in 1974 with the World Fund for Nature (WWF) (Nomura & Abe, 2005). Recently, international NGOs such as WWF and The Nature Conservancy (TNC) have incorporated EE modules into their national park conservation initiatives. Environmental NGOs (ENGOS) have played a significant role in EE, often centered on single issues and primarily surpassing the involvement of state institutions. In EE, environmental non-governmental organizations (NGOs) have been essential, frequently emphasizing specific challenges and going above and beyond what official institutions can do, which is part of the dynamics of an institution.

Although the national NGO, WALHI, has made important efforts at the national level, its EE activities waned after certain publications. However, WALHI's provincial offices of WALHI operate independently and adopt diverse approaches based

on the local context. Established in 1996, the Jaringan Pendidikan Lingkungan (JPL) is considered a model of best practice in NGO networking, mobilizing resources, and facilitating information exchange among member organizations nationwide. Despite its success, JPL recognizes the need for expertise and program evaluation.

The Adiwiyata program design is part of EE and ESD implementation in Indonesia for K-12 (kindergarten to 12th grade). Adiwiyata is a collaborative program between the Ministry of Environment and Forestry and the Ministry of Education and Culture (Nurrochmat, et al. 2022). The Adiwiyata Programme, initiated in 2006 by the National Ministry of Environment, has expanded to include thousands of schools across Indonesia. However, its coverage is limited given the total number of schools (> 260,000) in the country. The program focuses on developing students responsible for environmental protection through school governance that supports sustainable development.

Contrary to fostering change capacity, the Adiwiyata Program concentrates on enhancing school capacity and management levels. It employs a prescriptive approach, assessing schools annually, based on specific criteria related to policy, curriculum, participation in activities, and environmental management. Despite emphasizing the production of environmentally responsible children, the program predominantly prioritizes school management of the environment, relying on numerical measures to demonstrate achievement of standards. The Adiwiyata program is a significant cornerstone in implementing Education for Sustainable Development (ESD) within the Indonesian K-12 education framework. By amalgamating the expertise and resources of these two entities, the Adiwiyata program has materialized as a robust platform for nurturing sustainable values, knowledge, and practices among students at all levels of the education spectrum (Parker & Prabawa-Sear, 2019).

The essence of the Adiwiyata programme lies in its holistic approach to education. It transcends the traditional confines of textbook learning by fostering a genuine connection between students and their environments. This is achieved through hands-on activities, experiential learning, and community engagement, all of which are centered on environmental conservation, social responsibility, and economic viability. By intertwining these critical dimensions, the program empowers students with the multifaceted understanding required to become active participants in a sustainable future (Megawati, et al., 2022; Yasin, 2019).

Collaboration between the Ministry of Environment and Education underscores a visionary alignment between environmental stewardship and educational advancement. This synergy is a testament to the recognition that sustainability education is not a standalone endeavor, but an integral component of a nation's development trajectory. The Ministry of Environment contributes its deep-rooted expertise in ecological preservation, while the Ministry of Education lends its pedagogical insights into seamlessly integrating sustainability concepts into curricula (Nurrochmat, et al., 2022).

Moreover, the Adiwiyata programme cultivates a sense of shared responsibility among educational institutions, local communities, and policymakers. Schools participating in the program adopted sustainable practices within their campuses and acted as catalysts for change within their surrounding neighborhoods. This ripple effect encourages the emergence of sustainable communities that are environmentally conscious, socially, and economically resilient (Parker & Prabawa-Sear, 2019; Roswita, 2020).

EE and ESD in Indonesia cannot be separated from the existing curriculum, especially from elementary to high school. Based on the curriculum 2013, the Indonesian Ministry of Education and Culture did not explicitly incorporate environmental education (EE)

into the new curriculum as part of the UN Decade of Education for Sustainable Development (UNDESD), and the 2013 Curriculum in Indonesia missed an opportunity to prioritize environmental education. While it includes mentions of pro-environmental behavior and values across various subjects, the portrayal of the environment mainly revolves around its creation by God with little emphasis on human responsibility for environmental degradation. As an optional subject, geography offers a more comprehensive exploration of the relationship between environmental sustainability and economic development. Despite the potential epistemological challenges for secular scholars, framing environmental education within religious terms aligns with Indonesia's religious context and may facilitate the development of religious environmental ethics.

The implementation of environmental education in Indonesia faces several challenges (Gani, 2023). One of the primary hurdles stems from the crowded curriculum, particularly in religious schools, which allocate substantial time to numerous subjects. Integrating environmental education into such an already packed schedule poses a significant challenge. Thus, a viable approach could involve initially incorporating environmental education within the citizenship education framework to ensure its inclusion.

Another obstacle lies in the imperative for in-service training for educators, which encompasses both teachers and Environmental Agency personnel. Adequate training is essential to equip students with the necessary skills to effectively impart environmental education. Moreover, pre-service training for university students is vital to instilling foundational knowledge. To support these efforts, engagement from non-governmental organizations (NGOs) at the international, national, and local levels is imperative for collaboration with governmental bodies, educational institutions, and NGOs.

Inter-departmental coordination presents another hurdle for the implementation of environmental education initiatives in Indonesia. Coordinating efforts across various departments poses a considerable challenge, necessitating commitment and collaboration from all levels of the government, NGOs, and private entities.

The convergence of EE and ESD within the realm of higher education has been propelled by the innovative Greenmetric initiative. Spearheaded by Universitas Indonesia, this groundbreaking initiative has become a beacon guiding universities worldwide toward a more sustainable and environmentally conscious path (Leal Filho, et al., 2022). At its core, Greenmetric serves as a pioneering benchmarking system designed to evaluate and enhance universities' ecological and sustainable practices on a global scale. Greenmetric bridges the gap between the theoretical concepts of environmental responsibility and tangible actions within the academic sphere (Fernández-Vázquez, 2021).

By providing a structured framework for assessment, the initiative prompts universities to integrate environmental and sustainability themes into their curricula and operationalize these principles in their institutional practices. This initiative recognizes that universities, as centers of knowledge and research, are uniquely positioned to drive meaningful changes in society through their collective influence and expertise (Kohl, et al., 2022).

Universitas Indonesia's pivotal role in spearheading the Greenmetric initiative underscores its commitment to elevating sustainability within higher education. By leveraging its academic prowess and expertise, the university has championed a worldwide movement that unites institutions with their shared responsibility to nurture environmentally conscious graduates and contribute to the broader goal of sustainable development (Ramakrishnan, et al., 2020). Through Greenmetric, universities are provided with a comprehensive assessment framework that evaluates various aspects of sustainability, ranging from campus infrastructure and energy consumption to waste management and community engagement. This comprehensive approach empowers institutions to showcase their existing sustainable practices and identify areas of improvement and innovation. As universities strive to climb the ranks in the Greenmetric assessment, they catalyze a competitive spirit that drives continuous improvement in sustainability endeavors (Galleli, et al., 2022; Suwartha & Sari, 2013).

Essentially, the Greenmetric initiative signifies a dynamic fusion of higher education, environmental consciousness, and sustainable action.

This initiative amplifies the impact of EE and ESD by establishing a global platform that recognizes and celebrates universities for their commitment to sustainability. 145 universities have joined UIgreenmetric, but this number is still small compared to the number of campuses in Indonesia, which has reached 3000 universities under the Ministry of Education and Culture.

However, UI GreenMetric World University Rankings are increasingly globalized and increasingly followed by universities in various countries. In 2020, the number of participants reached 956 universities from 80 countries worldwide and 912 universities from 84 countries. It inspires universities to become vanguards of positive change, shaping a future in which academia and sustainability converge to drive meaningful progress on a global scale.

Current Research Trends and Status on Publication

This subsection assesses current research trends in EE and ESD in Indonesia. The analysis comprises the publication count, citation count, and authorship occurrences. Based on the collected metadata, publications on EE and ESD surged notably in 2021. A slight decline in 2022 is likely linked to the global researchers' response to the COVID-19 outbreak. An incremental increase is anticipated this year (2023), potentially continuing until the closing of 2023. A similar trend was found in the number of citations, which increased in 2021, but narrowed down in 2022. Most come from conference proceedings, whereas the highest citation count comes from journal articles. Please see Figure 3 for details of the documents and citation production.

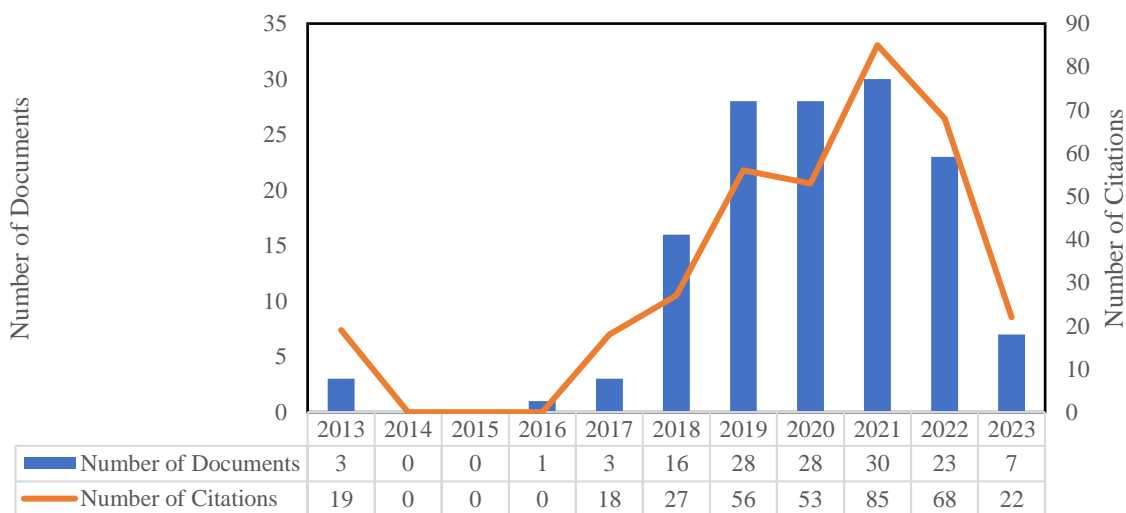


FIGURE 3: Scientific papers related to EE and ESD over the years.

The most productive authors for EE and ESD development in Indonesia are listed in Table 2. Ichsan, I. Z. produced the highest number of publications, with seven documents and a total of 60 citations. His publication average is also new to the average of 2020.

At the same time, the most productive authors' affiliation comes from Universitas Negeri Jakarta, with six authors nominated as the top 10 most productive authors on this topic. This finding is also noted as the most productive authors from the DKI Jakarta Province, the center of the economic, political, and culture of Indonesia.

TABLE 2: Topmost productive authors on EE and ESD development in Indonesia.

Name	Links	Documents	Citation	Avg. Publication Year	Affiliations
Ichsan I. Z.	10	7	60	2020.143	Universitas Mohammad Husni Thamrin
Rahmayanti H.	5	3	30	2020	Universitas Negeri Jakarta
Sigit D. V.	6	3	22	2020.333	Universitas Negeri Jakarta
Suryanda A.	6	3	22	2020.333	Universitas Negeri Jakarta
Safitri D.	2	3	21	2020	Universitas Negeri Jakarta
Karyanto P.	0	3	6	2019	Universitas Sebelas Maret
Wilujeng I.	0	2	26	2018.5	Universitas Negeri Yogyakarta
Fadrikal R.	5	2	22	2019.5	Universitas Sultan Ageng Tirtayasa
Komala R.	5	2	22	2019.5	Universitas Negeri Jakarta
Miarsyah M.	5	2	22	2019.5	Universitas Negeri Jakarta

As can be seen in Table 3, the highest-cited papers on EE and ESD were written by Sigit, *et al.* (2020). This study focuses on measuring knowledge and attitudes toward mangroves and coral reservations by applying the Environmental Education Community Network (EECN). As the largest archipelago in the world, Indonesia has the potential for mangroves and coral reefs.

This study implies the application of the EECN as a model to develop knowledge and attitudes to protect the environment. The other article, which has the highest citation, was written by Ekantini and Wilujeng (2018), who developed EE/ESD tools to enhance environmental literacy. The third most cited article mainly discussed students' existing attitudes and environmental awareness (Amran, *et al.*, 2019).

TABLE 3: Highest cited papers on EE and ESD-related topics.

References	Title	Journal Name	Citations
(Sigit, <i>et al.</i> , 2020)	EECN: Analysis, potency, benefit for students' knowledge and attitude to conserve mangroves and coral reefs	International Journal of Instruction	20
(Ekantini & Wilujeng, 2018)	The development of science student worksheets based on education for environmentally sustainable development to enhance scientific literacy.	Universal Journal of Educational Research	19
(Amran, <i>et al.</i> , 2019)	Assessing student's 21st-century attitude and environmental awareness: promoting education for sustainable development through Science Education.	Journal of Physics: Conference Series	18

References	Title	Journal Name	Citations
(Jannah, <i>et al.</i> , 2013)	Impact of environmental education kit on students' environmental literacy	Asian Social Science	15
(Rahmayanti, Ichsan, Azwar, <i>et al.</i> , 2020)	DIFMOL: Indonesian students' HOTS and environmental education model during COVID-19	Journal of Sustainability Science and Management	15
(Parker, <i>et al.</i> , 2018)	How young people in Indonesia see themselves as Environmentalists: Identity, behavior, perceptions and Responsibility	Indonesia and The Malay World	15
(Surata & Vipriyanti, 2018)	The subak cultural landscape as environmental education: Knowledge, attitudes, and experiences of Balinese teachers, student teachers, and Students	Journal of Environmental Education	14
(Arafah, <i>et al.</i> , 2021)	Saving the environment: environmental lessons in Colin Thiele's February Dragon	Journal of Language Teaching and Research	14
(Rahmayanti, Ichsan, Oktaviani, <i>et al.</i> , 2020)	Environmental attitude for smart city technology: Need assessment to develop smart trash in environmental education	International Journal of Advanced Science and Technology	12
(Safitri, <i>et al.</i> , 2021)	Web-based animation video for student environmental education at elementary schools	International Journal of Interactive Mobile Technologies	12

Among the 139 articles, 6 met the thresholds. Notably, Malaysia (seven documents) emerged as the foremost contributor and collaborator for Indonesian researchers, followed by Australia (six documents), Japan (four documents), Germany (two documents), Taiwan (two documents), and Brazil (two documents).

The oldest average publications collaborate with Australia, Germany, and Taiwan, whereas newer publications hail from Japan, Brazil, and Malaysia. Figure 4 shows the VOS map of the collaborating countries to enhance the development of EE and ESD in Indonesia.

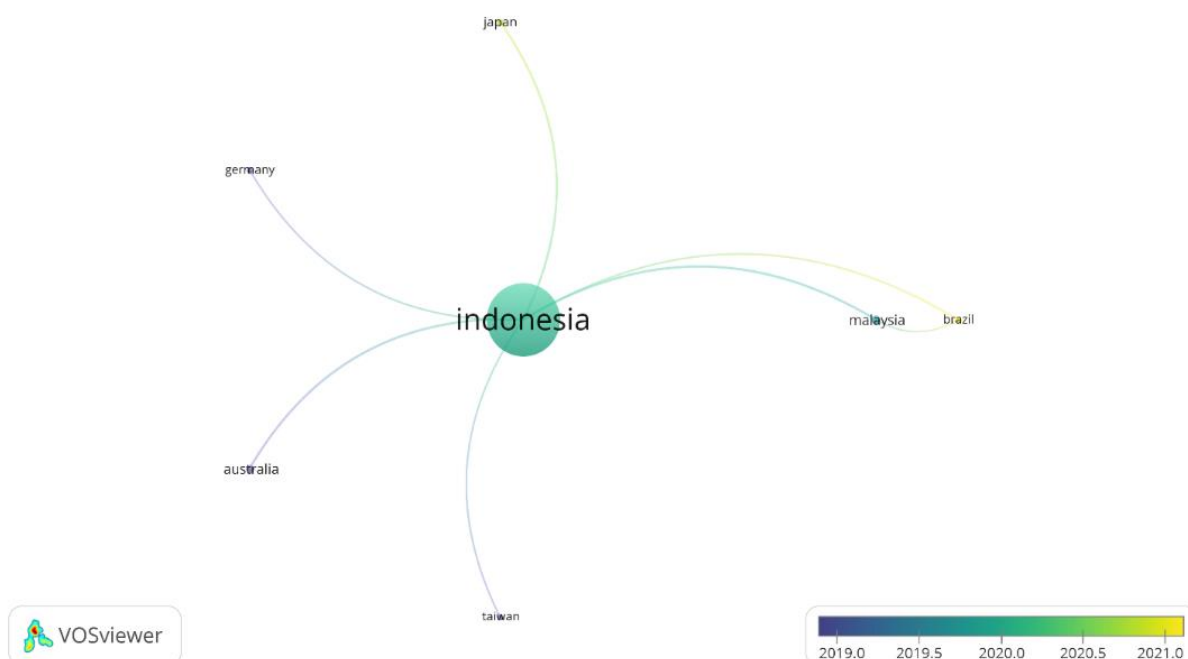


FIGURE 4: Collaborating countries on EE and ESD development in Indonesia.

Gap Assessment

Analysis using VOS Mapping

Analyzing Figure 5(a) and (b) yields valuable insights. Of 261 keywords, 30 met the threshold. Among the oldest keywords in the metadata are "place-based education," "adhiwiyata," "education for environmentally sustainable development," and "environmental literacy." These points point to an early focus on evaluating the Adhiwiyata school as part of the application of EE in Indonesia. Research related to environmental literacy needs to be updated, although this topic is still becoming a major problem in Indonesia. Post-pandemic, the newest publications pertain to sustainable development and environmental behavior, evident from keywords like "environmental attitude," "behavior," "knowledge," "sustainable development," and "systems thinking."

During the outbreak, researchers concentrated on the Adhiwiyata programme. However, after the pandemic came, the Adhiwiyata program could not be handled, and the topic of behavior change became popular. Six keyword clusters are identified. The giant red cluster highlights significant keywords indicating the Adhiwiyata school as the implementer of EE and ESD programs. The green cluster represents the Adhiwiyata programme. Therefore, other clusters such as yellow, dark blue, light blue, and purple indicate ecotourism, environmental behavior, higher education institutions' (HEI) sustainability, and the role of science teachers in environmental literacy.

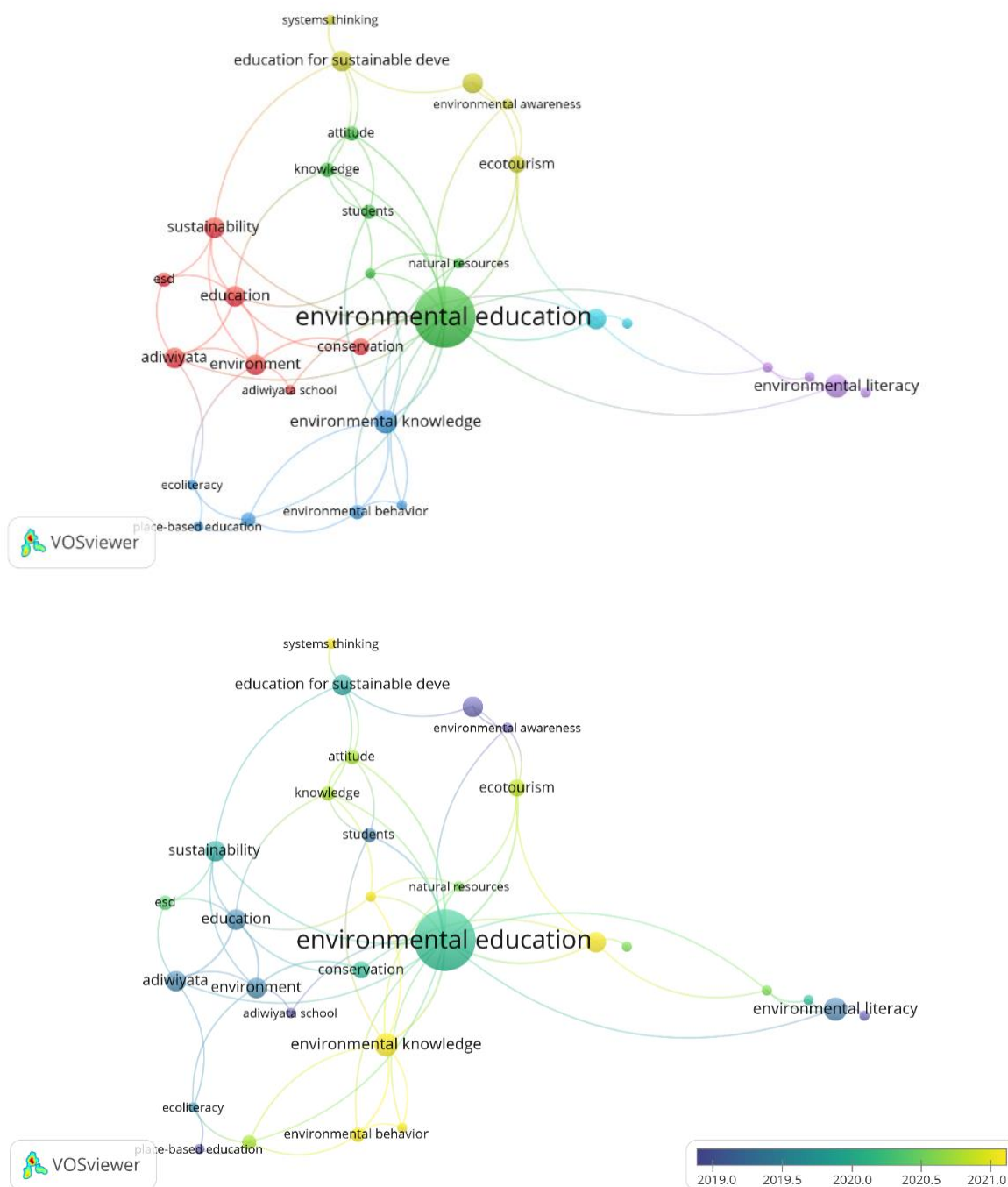


FIGURE 5: Author keywords (a) network and (b) overlay visualization.

Figure 6 also shows that EE is becoming the most prominent research topic for Indonesian researchers. Therefore, ESD has yet to become a more popular research topic than EE. This gap also signifies that EE's transformation of EE to ESD is far from the setting world target. Moreover, most of the research focuses on K-12, while the implementation of EE and ESD in HEI is also limited. Therefore, an analysis of Figure 6(a) and (b) is needed to confirm the findings of the co-author keywords. As shown in Figure 6(a), six clusters were found during co-occurrence term mapping. The first cluster, light

blue, focuses on environmental knowledge and attitudes. In the dark blue cluster, environmental literacy was the most prominent topic among metadata. The issue of education for sustainable development was also found in green clusters. The remaining purple, yellow, and red clusters focus on the teacher as the subject of EE/ESD, environmental behavior, and the Adiwiyata program. As found in the co-author keywords, environmental behavior is becoming the newest topic in this field. Indonesian researchers are leaving the topic of environmental literacy and are shifting to ESD.

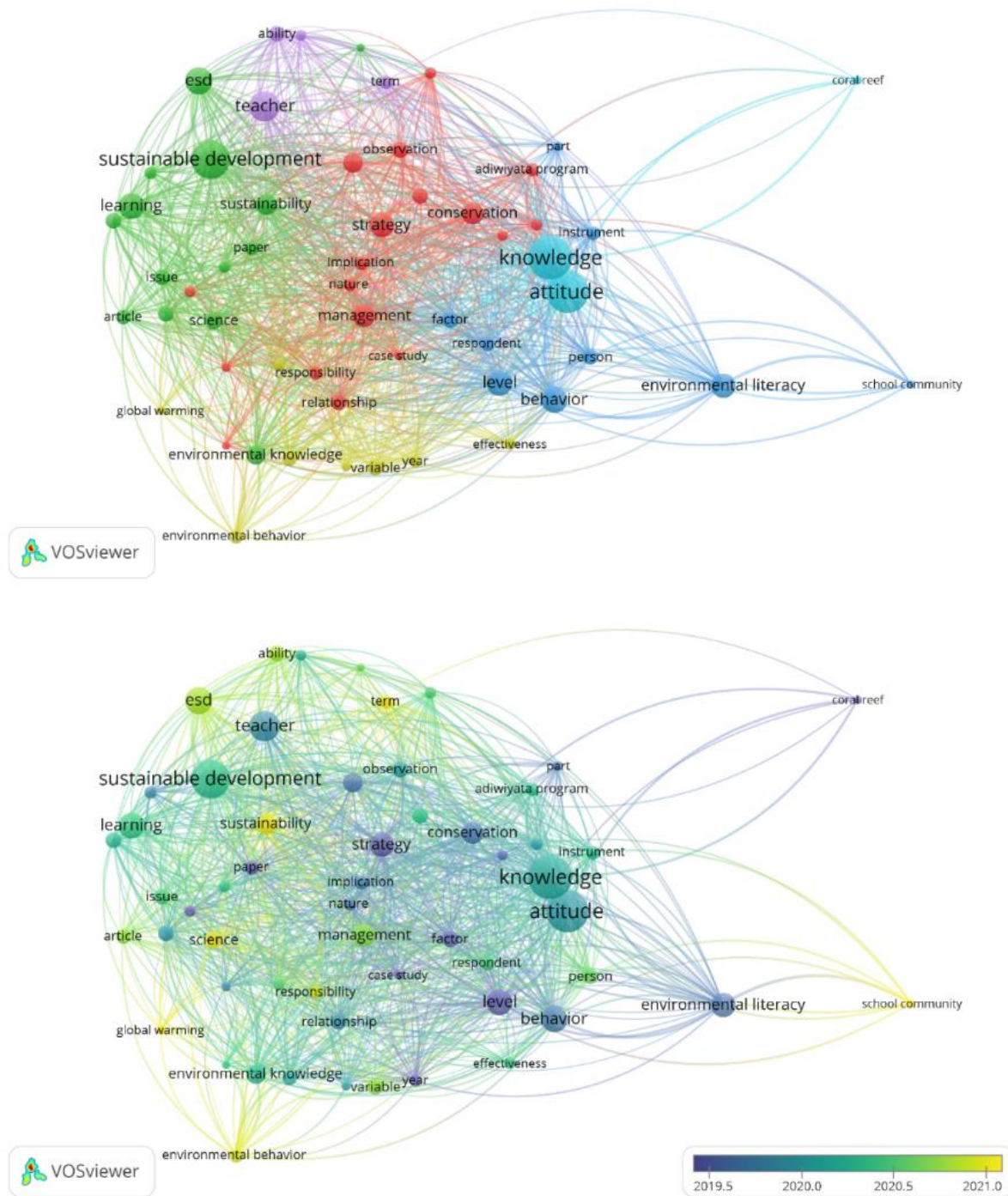


FIGURE 6: Terms (a) network and (b) overlay visualization.

Analysis using LDA Modelling

Before implementing LDA modeling, a word cloud was employed to verify the adequacy of the preprocessing steps, ensuring their suitability for subsequent LDA analysis. Figure 7 shows various words generated from the title and abstract data.

Alongside the keywords used for data collection, the top 5 significant words extracted include "students" (337 occurrences), "study" (243 occurrences), "learning" (197 occurrences), "development" (191 occurrences), and "research" (191 occurrences).



FIGURE 7: Word clouds.

Six distinct topics were derived from the title and abstract metadata, and 6 distinct topics were derived, as shown in Table 4. Notably, previous text mining using VOSviewer has revealed several new topics. The Marginal Topic Probability (MTP) displayed in Figure 8 indicates that Topic 1 has the highest MTP value, focusing on the environmental literacy of a K-12 student. As shown in Figure 8, the highest topic found was topic 1, which was interpreted as environmental literacy. Karyanto (2019) stated that environmental literacy is part of the goals of EE and ESD. Meanwhile, good EE and ESD implementation is needed by improving the curriculum design, teaching, and learning processes. This finding was also highlighted by Wilujeng, et al. (2019), who stated that effective teaching materials for ESD could improve environmental literacy. Interactive student worksheets as teaching materials

can engage students in learning more about their environment. Environmental literacy is also strongly related to environmental education. Thus, excellent implementation of EE will increase literacy (Yusuf, et al., 2021). This topic has gained significant interest from researchers because it is a shortcut to properly implementing ESD and EE in Indonesia. The corpus data accentuate a strong trend towards ESD, as indicated in Section 2. Following this dominant topic are topics 2. These topics revolve around Adiwiyata schools and programs that focus on the development of students' environmental knowledge in order to conserve the environment. Conversely, Topics 3, 4, and 5 have the lowest MTP values, addressing EE and ESD in the context of higher education institutions, students' behavior, and efforts to conserve the environment. This presents potential research gaps for further intervention.

TABLE 4: LDA topic modeling results.

Topic number	Topic keywords	Interpretation
1	Students, learning, knowledge, based, research, study, school, literacy, student, model	Environmental literacy
2	Study, school, adiwiyata, students, Indonesia, conservation, environment, schools, data, knowledge	Adiwiyata schools
3	Students, research, awareness, data, results, analysis, used, behavior, study, community	Students' behavior
4	Management, waste study, knowledge, research data, behavior, Indonesia, higher students	Higher Education Institution
5	Environment, development, natural, sustainable, community, study, areas, also, resources, Indonesia	Environmental conservation
6	Development, sustainable, science, school, ESD, study, literacy, students, research, teachers	Education for Sustainable Development

All topics were detected by the MDS map, which has no similarities between them. All of these topics have similar results to VOS mapping. Notably, Topics 1 and 3 are remarkably similar, differing mainly in scope. Topic 4 revolves around waste management in the HEI and behavior change, indicating a gap in

the study. Both the Table and LDA outcomes consistently emphasize the discourse surrounding the importance of ESD while shifting from the old paradigm of EE. This perspective extends future research directions on the topic.

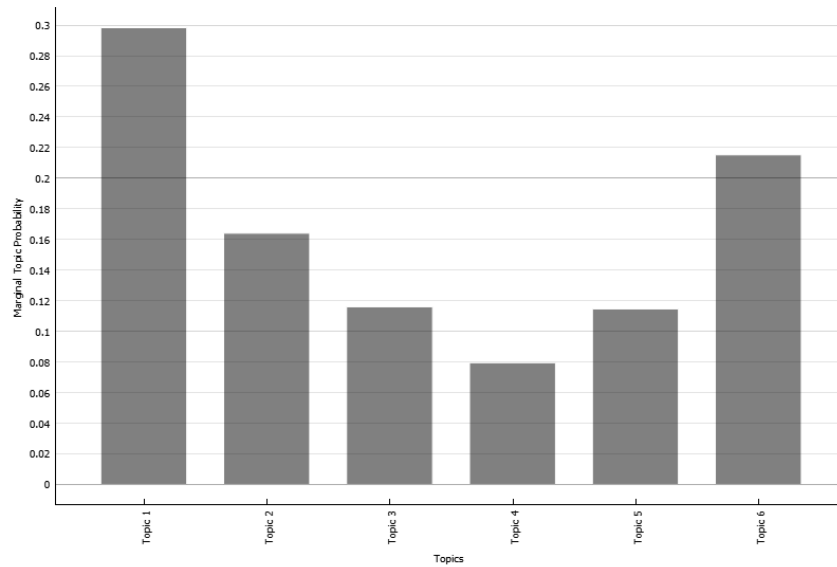


FIGURE 8: Marginal topic probability (MTP) results.

Policy Recommendations

The literature survey uncovered potential strategies and recommendations for transforming EE into ESD. First, there is a requirement to develop a national action plan for EE and ESD (ST 1). The second strategy entails establishing laws and policies to provide EE and ESD programs (ST 2). Third is the implementation of adequate funding for the development of EE and ESD programs (ST 3). It is also crucial to increase the institutional capacity of EE and ESD implementers (ST 4) (Babalola & Olawuyi, 2021), and the quality and ability of EE and ESD human resources (ST 5). Additionally, optimizing educational facilities and infrastructure for EE and ESD is necessary to foster EE's transformation of EE to ESD in Indonesia (ST 6) (Huang, et al., 2021). Another imperative strategy is to prepare and provide EE materials based on local, modern, and global issues (ST 7) (Parmawati, et al., 2023).

Improving the quality and accessibility of information by encouraging the use of advanced technology (ST 8) is equally important (Huang, et al., 2021). Encouraging the availability of community participation in the implementation and quality control of EE and ESD services and developing competency-based and participatory EE (ST 9) and ESD implementation methods are also necessary for implementing EE and ESD in Indonesia (ST 10) (Parmawati, et al., 2023). According to Table 5, the highest score is attributed to ST 5, followed by ST 7, and ST 2. This outcome indicates that improving human resource competency is the most efficient action for the effective implementation of EE and ESD in Indonesia. Experts also prioritize preparing EE and ESD materials and then focus on law and policy provisions for EE and ESD programs in Indonesia. This priority recommendation is necessary to develop exemplary implementations of EE and ESD in Indonesia.

TABLE 5: Priority of actions for effective implementation of EE – ESD in Indonesia.

Code	Actions	Scores
ST 5	Improving the quality and ability (competency) of EE and ESD human resources	53
ST 7	Prepare and provide EE materials based on local wisdom, modern, and global issues	51
ST 2	Establishing laws and policies to provision EE and ESD program	48
ST 3	Adequate funding for the development of EE and ESD program	47
ST 10	Develop competency-based and participatory EE and ESD implementation methods	43
ST 1	Evolving national action plan on EE and ESD	41
ST 6	Optimizing education facilities and infrastructure for EE and ESD	40
ST 9	Encouraging the availability of community participation in the implementation and quality control of EE and ESD services	36
ST 4	Increasing institutional capacity of EE and ESD implementer	31
ST 8	Improving quality and easily accessible information by encouraging the use of advanced technology	30

CONCLUSION

The transformation of EE into ESD in Indonesia is currently progressing. The Adiwiyata program and Greenmetric are part of the EE and ESD implementation in the form of benchmarking for the K-12 and HEI. The program supports and assesses the implementation of EE and ESD, and engages schools and HEI to achieve sustainable education. From the literature survey, it was also found that the number of publications on EE- and ESD-related topics has increased over the years, but is slightly reduced by the end of 2022. Environmental behavior is a current research topic that is currently attracting researchers. The influence of EE and ESD on environmental knowledge and attitudes is an interesting topic to be studied in depth. This study shifted from the focus of the Adiwiyata program as a tool to improve environmental knowledge in K-12 education.

From the gap assessment, implementation of EE and ESD in HEI is lacking, considering that more research should be conducted in this field. Some priority actions were defined based on a literature survey. The most strategic action to transform and implement EE into ESD is improving the quality and ability of human resources. Then, the government should prepare and provide EE materials to provide clear guidance for implementation. Establishing laws and policies is the third strategic action that should be undertaken to establish effective implementation of EE and ESD. However, the success of these actions should be measured in an ongoing research project to validate the findings.

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