Journal of Environmental Protection, 2025, 16(4), 315-337
https://www.scirp.org/journal/jep
ISSN Online: 2152-2219
ISSN Print: 2152-2197

Environmental Practices in Malaysia: A Bibliometric Analysis

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How to cite this paper: Laipan, R.A., Tshung, F.C.C. and Anis, A. (2025) Environmental Practices in Malaysia: A Bibliometric Analysis. *Journal of Environmental Protection*, **16**, 315-337.
https://doi.org/10.4236/jep.2025.164016

Received: February 11, 2025
Accepted: April 14, 2025
Published: April 17, 2025

Abstract

The study of environmental practices gained public attention in the 1960s and 1970s, emerging as a critical issue in sustainability management. In Malaysia, formal analysis of environmental practices became more prominent in the 1970s and 1980s. Over time, these practices have evolved to adapt to industrial and macroeconomic climate changes. Both theoretical and practical approaches to environmental practices have been developed to support timely and effective decision-making. This article examines research on environmental practices published in journals, identifying the most cited sources through a bibliometric analysis of scientific literature in Malaysia. The Google Scholar database was used to collect relevant literature. Additionally, SPSS, Microsoft Excel, and Publish or Perish software were utilized to integrate data and conduct basic analysis. Standard bibliometric techniques were applied to assess publication growth, research productivity, and citation trends. A total of 300 documents were retrieved based on keyword searches, with most articles written in English and published in journals or conference proceedings. The bibliometric analysis provides insights into the development of scientific literature on environmental practices and highlights potential areas for future research.

Keywords

Environmental Practices, Bibliometric Analysis, PRISMA, VOSviewer

1. Introduction

Malaysia's increased attention to environmental issues over the last decade reflects a broader trend in Southeast Asia where countries have begun to address climate change and environmental degradation with greater urgency. Policies like the

Five-Fuel Policy and Renewable Energy Act of 2011 have aimed to reduce reliance on fossil fuels and promote renewable energy (RE) sources, such as solar and hydro, through incentives like the Feed-in-Tariff (FiT) and Net Energy Metering (NEM) schemes. These initiatives have enabled Malaysia to significantly increase its RE capacity, setting ambitious targets of reaching 31% RE capacity by 2025 and 40% by 2035 [1].

Malaysia faces significant challenges in balancing economic growth and environmental sustainability. While the country has made strides in implementing environmental practices, such as the adoption of green technologies and stricter regulations on pollution, these efforts are often undermined by weak enforcement and public indifference [2]. For instance, deforestation due to palm oil expansion and urban development continues to threaten biodiversity and disrupt ecosystems [3]. Furthermore, waste management remains a critical issue, with the recycling rate in Malaysia lagging behind global standards, despite initiatives like the National Solid Waste Management Policy [4]. Inadequate public awareness and limited infrastructure have hampered the effectiveness of such policies.

Additionally, the nation's heightened focus on environmental action is also evident in efforts to address climate-related challenges such as flooding, which has become more frequent and severe due to deforestation and urban development. Malaysia's green groups have been advocating for stricter environmental regulations, calling on the government to curb emissions and increase climate adaptation measures, especially in urban centers that are highly susceptible to natural disasters driven by climate change [1]. This commitment demonstrates both the challenges and opportunities faced by Malaysia as it attempts to balance economic growth with environmental sustainability. This situation has also drawn the attention of the academic field to expand research in the area of environmental practices.

The formal study of environmental practices (EPs) can be traced back to the early 20th century, though awareness and informal practices have existed for centuries. The field began to gain significant academic and public attention in the 1960s and 1970s, spurred by increasing environmental degradation and influential publications such as Rachel Carson's "Silent Spring" in 1962. This period marked the emergence of modern environmentalism and the establishment of key environmental regulations and organizations. In Malaysia, environmental awareness and the formal study of environmental practices began to take shape more prominently in the 1970s and 1980s, coinciding with global trends. The Malaysian government began instituting environmental policies and frameworks, such as establishing the Department of Environment in 1975, to address growing environmental concerns. Therefore, the formal study and structured implementation of ecological practices in Malaysia has been ongoing for approximately 40 to 50 years.

Eps implemented in organizations may aid in the availability of meaningful and effective guidance to managers, particularly in maintaining an organization's sustainability in today's world of global competition [5]. Furthermore, Smith and

Jones (2020), indicated that the latest global economy, primarily affected by the climate of rapid technological change and stringent environmental regulations, has reinforced the need for EPs to adapt and improve profitability to meet dynamic market continually demands [6]. Specifically, studies highlight that internal and external pressures to adopt Eps have led companies to enhance resource management, positively affecting financial metrics and sustainability goals [7]. Thus, Eps are thought to cover various areas, such as sustainable tourism, air quality, waste management, and public health, in managing numerous components of a company's performance. EPs are defined as practices by management that apply established methods and techniques to deliver environmental management information to managers, supporting them in executing managerial functions effectively [8].

Over the past 40 years, numerous studies have been conducted on environmental management. While some functions have remained largely unchanged over the last 50 years, environment management has transitioned from a functional responsibility to a recognized professional field. The evolution of environmental practices is closely linked to the professionalization of this role. This study aims to quantitatively assess the scholarly boundaries of environmental practices (Eps) as represented in conference articles and journal publications, identifying potential research gaps. Additionally, it seeks to enhance the understanding of citation data usage from the Google Scholar database and highlight key areas for future exploration.

A substantial portion of EPs research has been published in academic journals, reflecting the field's significant advancements in both research and practice. Recognizing this progress, the study conducts a bibliometric review to analyze Eps research from the past 12 years and assess how bibliometric analysis can influence future studies. This review is guided by specific research questions, which are outlined below.

1. What is the current trend in the publication of Environmental Practices in Malaysia?
2. Which is the most cited paper on Environmental Practices among scholars?
3. Who are the most influential authors of Environmental Practices and what is the current state of collaboration?
4. What are the top journals publishing research on environmental practices in Malaysia?
5. What are the common keywords in research on environmental practices in Malaysia?

This study contributes to the existing knowledge of Environmental Practices (EPs) in two significant ways. First, it offers enhanced insights into addressing issues related to EPs quality, drawing from both historical and contemporary literature reviews. Second, it conducts a thorough examination of Eps' performance achievement, aiming to expand the literature about EPs from 2010 to 2023. Fur-

thermore, the researchers expect that the findings of this study will lead to a deeper understanding of the topic and identify potential areas for future research.

The structure of this study is organized into five main sections: Introduction, Literature Review, Data and Methods, Results and Discussion, and Conclusion and Limitations. The Results and Discussion section is supported by a comprehensive descriptive analysis that examines the evolution of publications over the past century, the types of documents, sources, and access, languages used in publications, authorship analysis, citation analysis, keyword analysis, and trends in the fundamental intellectual structure. Finally, this study concludes by discussing its findings, acknowledging its limitations, and suggesting areas for further exploration by future researchers.

2. Literature Review

Environmental sustainability has become a critical concern globally, and Malaysia is no exception. As a rapidly developing Southeast Asian nation, Malaysia faces the dual challenge of economic growth and environmental conservation. The country's diverse ecosystems, from lush rainforests to vibrant marine environments, are essential to its economy, culture, and biodiversity. However, industrialization, urbanization, and agricultural expansion have put increasing pressure on these natural resources. In response, Malaysia has developed a variety of environmental policies, initiatives, and regulations to address sustainability concerns, aiming to strike a balance between development and environmental stewardship [9].

Malaysia's environmental practices are rooted in a national vision for sustainable development. The government's policies are guided by frameworks such as the *National Policy on the Environmental* and successive *Malaysia Plans*, Including the *Eleventh Malaysia Plan* (2016-2020), which outlined specific goals for sustainable growth. These frameworks emphasize the need for conservation, pollution control, and the sustainable use of natural resources. They reflect Malaysia's commitment to international environmental agreements, such as the Paris Agreement, where the nation pledged to reduce greenhouse gas emissions by 45% by 2030. This ambitious target is part of the broader national strategy to promote green growth and mitigate climate change [10].

Environmental practices in Malaysia have evolved significantly over the past decade, especially in key sectors such as energy, waste management, and agriculture. Sustainable energy practices, including adopting renewable energy sources like solar and biomass, have gained traction, driven by government incentives and the country's Green Technology Master Plan. Similarly, waste management reforms have been prioritized, as seen in the introduction of the Solid Waste Management and Public Cleansing Act 2007, which seeks to reduce landfill dependency and improve recycling rates.

Malaysia has also taken significant steps to address concerns about deforestation and biodiversity loss, such as the Malaysian Sustainable Palm Oil (MSPO)

certification, which aims to ensure more eco-friendly practices in the agricultural sector. The most important aspect of Malaysia's environmental strategy is emphasizing public awareness and education. Environmental education programs are being integrated into schools, while media campaigns promote sustainability practices among the general population. These initiatives reflect a growing societal recognition of environmental issues and the need for collective action to address them [11].

While progress has been made, Malaysia still faces challenges in fully realizing its environmental goals. Inadequate enforcement of environmental laws, limited funding for green initiatives, and the ongoing tension between industrial development and conservation efforts are some of the hurdles. Nevertheless, the government, along with private sector players and civil society organizations, continues to push forward with innovative solutions aimed at fostering a greener and more sustainable Malaysia [12].

In conclusion, environmental practices in Malaysia have undergone considerable transformation over the decade, driven by a combination of national policies, international commitments, and sector-specific initiatives. As Malaysia continues to pursue its vision of sustainable development, the nation's ability to balance economic growth with environmental protection will remain a critical factor in its future success.

2.1. Evolution of Environmental Practices in Malaysia (2010-2023)

Over the past decade, environmental practices in Malaysia have undergone significant changes, shaped by shifting governmental policies, increasing public awareness, and global commitments to sustainability. As a developing nation striving to balance economic growth with environmental stewardship, Malaysia's journey toward sustainable practices has been complex, with progress marked by key milestones in energy, waste management, and agriculture. From 2010 to 2023, the nation's approach to environmental conservation has evolved through phases, reflecting both the challenges and opportunities its development trajectory presents [13].

2010-2015: Early Steps towards Sustainability

In the early 2010s, Malaysia grappled with the environmental consequences of rapid industrialization and urbanization. Deforestation, water pollution, and greenhouse gas emissions were pressing issues, driven by expanding agriculture, especially the palm oil industry, as well as a growing manufacturing sector. During this period, the Malaysian government recognized the need for a more structured approach to environmental management and began implementing policies to address these challenges.

One of the key initiatives during this phase was the introduction of the National Policy on the Environment, which laid the foundation for sustainable development by focusing on the sustainable use of natural resources and environmental quality control. At the same time, the palm oil industry, which had come under

international scrutiny for its role in deforestation, saw the launch of the Malaysian Palm Oil Green Conservation initiatives. These efforts aimed to reduce the environmental impact of palm oil production, marking a critical step toward more responsible agricultural practices.

2015-2020: Growing Emphasis on Renewable Energy and Waste Management

By the mid-2010s, Malaysia's environmental practices had gained further momentum, particularly in the areas of energy and waste management. The adoption of renewable energy source became a priority, as the country sought to diversify its energy mix and reduce its reliance on fossil fuels. In 2017, the government launched the Green Technology Master Plan, which outlined strategies for promoting green technology and renewable energy across various sectors. Solar power, in particular, emerged as a key focus, with numerous government incentives and programs designed to encourage both residential and industrial adoption of solar energy.

Waste management also saw significant improvements during this period. The enforcement of the Solid Waste Management and Public Cleansing Act 2007 began to show results as local authorities implemented waste separation programs and recycling initiatives in urban areas. Public awareness campaigns, coupled with stricter enforcement of waste disposal regulations, contributed to the gradual reduction in landfill dependency. These efforts were complemented by the introduction of new policies aimed at reducing plastic waste, including bans on plastic bags in several states.

In the agriculture sector, the push for more sustainable palm oil production continued. The *Malaysian Sustainable Palm Oil* (MSPO) certification scheme, launched in 2015, was a landmark initiative designed to ensure that palm oil producers adhered to sustainable practices. By 2020, the MSPO certification had become mandatory for all palm oil producers in Malaysia, reflecting the government's commitment to addressing deforestation and environmental degradation in the industry.

2020-2023: Impact of the COVID-19 Pandemic and Green Recovery Efforts

The period from 2020 to 2023 was heavily influenced by the global COVID-19 pandemic, which brought both challenges and opportunities for environmental practices in Malaysia. On one hand, the pandemic led to a temporary reduction in industrial activities and air pollution due to lockdowns and restrictions. On the other hand, the economic fallout from the pandemic posed a threat to ongoing sustainability efforts, as businesses and governments shifted their focus to economic recovery.

However, the pandemic also provided a unique opportunity for Malaysia to rethink its approach to sustainable development. In response to global calls for a "green recovery," the Malaysian government integrated environmental sustainability into its post-pandemic recovery plans. The emphasis was on promoting green technologies, supporting renewable energy projects, and enhancing envi-

ronmental governance. These initiatives were part of a broader strategy to ensure that the country's recovery from the pandemic would be both economically robust and environmentally sustainable.

During this period, Malaysia also reaffirmed its commitment to international climate agreements, including the Paris Agreement. In 2021, the government announced updated climate targets, including a pledge to achieve net-zero carbon emissions by 2050. This ambitious goal reflected a growing recognition of the need for stronger action on climate change, as well as the opportunities presented by the global shift towards green technologies and low-carbon economies [14].

The evolution of environmental practices in Malaysia between 2010 and 2023 highlights a nation in transition, striving to balance economic development with the need for sustainability. Over the past decade, Malaysia has made significant strides in promoting renewable energy, improving waste management, and encouraging sustainable agriculture practices, particularly in the palm oil sector. While challenges remain, including the need for stronger enforcement of environmental regulations and greater investment in green technologies, the country's progress thus far is a testament to its commitment to environmental stewardship.

As Malaysia looks ahead, the lessons learned from the past decade will be crucial in shaping its future environmental practices. With growing public awareness, stronger government policies, and international support, Malaysia is well-positioned to continue its journey toward a more sustainable and environmentally responsible future.

2.2. Key Environmental Practices in Malaysia

Over the years, Malaysia has made significant strides in addressing environmental challenges by implementing various sustainable practices across different sectors. These efforts have been driven by the government, private sector, and civil society, working together to protect natural resources while promoting economic growth. From resource management to waste reduction, the country has recognized the importance of adopting sustainable environmental practices that align with both national priorities and international commitments .

In Malaysia, Eps encompass sustainable resource management, waste management, renewable energy, and environmental education. Sustainable resource management includes responsible practices in forestry, marine conservation, and mining to preserve ecosystems and biodiversity. Waste management initiatives, guided by the Solid Waste Management and Public Cleansing Act, focus on waste reduction and recycling programs. Renewable energy efforts, especially in solar and biomass, are encouraged through government incentives, supporting Malaysia's transition toward sustainable energy. Finally, environmental education and public campaigns promote awareness in schools and media, fostering a culture of environmental responsibility among citizens. Malaysia aims to ensure that individuals and communities actively contribute to environmental conservation efforts by engaging the public and fostering a culture of environmental responsibil-

ity [13].

While Malaysia has made notable achievements, there are still areas for improvement, particularly in terms of enforcing regulations, scaling up renewable energy adoption, and ensuring that environmental practices are adopted across all sectors. As the country continues to grow and develop, its commitment to sustainability will be essential in ensuring that economic progress does not come at the expense of environmental integrity. With continued innovation and collaboration, Malaysia is well-positioned to build a greener, more sustainable future. These efforts collectively advance Malaysia's environmental stewardship, balancing growth with sustainability.

2.3. Sector-Specific Initiatives in Environmental Practices in Malaysia

As a developing country with a diverse economy, Malaysia's environmental challenges are multifaceted, varying across different sectors. From agriculture to manufacturing and tourism, the environmental impact of these industries has necessitated targeted approaches to ensure sustainable development. Sector-specific initiatives have been vital in addressing the unique environmental challenges within key industries, promoting practices that balance economic growth with environmental preservation. Malaysia's environmental practices span agriculture, manufacturing, and tourism, with a strong focus on sustainability.

In agriculture, the Malaysian Sustainable Palm Oil (MSPO) certification supports responsible palm oil production, with sustainable practices extending to soil management, water conservation, and reduced chemical use. Other initiatives include Good Agricultural Practices (GAP), organic farming, and agroforestry, aiming to enhance soil health and biodiversity.

Manufacturing focuses on energy efficiency, clean production, and waste management. The Cleaner Production (CP) initiative promotes eco-friendly technology and pollution prevention, while the Energy Efficiency and Conservation Act encourages energy-efficient processes. The Extended Producer Responsibility (EPR) policy, targeting e-waste and plastics, holds manufacturers accountable for product lifecycles.

Malaysia's ecotourism initiatives, especially in national parks and marine sanctuaries, support environmental conservation while benefiting local communities. Policies restrict tourist numbers in sensitive areas like Sipadan to protect biodiversity, while green certifications encourage sustainable practices in hotels and resorts.

Malaysia's sector-specific environmental initiatives reflect a broader commitment to balancing economic growth with sustainability. In the agriculture sector, sustainable palm oil certification has been instrumental in addressing deforestation and habitat loss, while manufacturing industries are adopting cleaner production techniques and energy-efficient technologies to minimize their environmental impact. Meanwhile, ecotourism initiatives are helping to protect Malay-

sia's rich biodiversity while promoting responsible travel that benefits both the environment and local communities.

While these initiatives have achieved notable successes, challenges remain, particularly in terms of enforcement and scaling up sustainable practices across all industries. Nevertheless, Malaysia's sector-specific approaches demonstrate the country's determination to address its environmental challenges and move toward a more sustainable future. By continuing to innovate and collaborate across sectors, Malaysia can further strengthen its environmental practices and enhance its global reputation as a leader in sustainable development.

2.4. Environmental Policy and Legislation in Malaysia

Malaysia's environmental policies are shaped by a series of progressive laws and frameworks aimed at balancing economic development with environmental protection. The National Policy on the Environment provides a broad guideline for sustainable development, focusing on natural resource conservation, pollution control, and integrating environmental priorities into national planning. The Environmental Quality Act (EQA) 1974 serves as the primary legislation for managing pollution, with strict standards and mandatory Environmental Impact Assessments (EIAs) for significant development projects to mitigate environmental risks [15].

The Solid Waste and Public Cleansing Management Act 2007 addresses waste management issues by promoting waste reduction, recycling, and sustainable disposal practices. Malaysia's push towards sustainable energy is evident in the Renewable Energy Act 2011 and Green Technology Master Plan, which support renewable resources and provide incentives for green technology. Protecting biodiversity, the Wildlife Conservation Act 2010 seeks to preserve Malaysia's diverse ecosystems by regulating activities that threaten endangered species and penalizing illegal wildlife trade.

Malaysia's environmental policy and legislation reflect the country's commitment to sustainable development and the protection of its natural resources. Through comprehensive frameworks such as the Environmental Quality Act, the Solid Waste Management Act, and renewable energy initiatives, Malaysia has laid the foundation for long-term environmental stewardship. While challenges remain, including the need for stronger enforcement and public participation, these policies provide a roadmap for balancing economic growth with environmental sustainability.

2.5. Challenges and Opportunities in Environmental Practices in Malaysia

As Malaysia grows economically, it faces several pressing environmental challenges that demand urgent attention. However, these challenges also present an opportunity for Malaysia to refine its environmental practices, adopt sustainable development strategies, and emerge as a leader in environmental stewardship.

This essay will explore the primary environmental challenges facing Malaysia and the opportunities for improvement in environmental practices.

Challenges in Environmental Practices

Malaysia's rich biodiversity is under threat due to widespread deforestation. Agricultural expansion, particularly for palm production, alongside logging and urban development, has led to significant habitat loss for many species. This deforestation contributes not only to biodiversity decline but also to climate change by reducing the country's carbon sequestration capabilities, resulting in increased greenhouse gas emissions. The loss of forest cover further exacerbates the country's ecological vulnerability and threatens the survival of numerous endemic species.

Rapid industrialization and urban growth in Malaysia have led to increased pollution across air, water, and soil. Discharges from industries, agricultural runoff, and plastic waste contribute to the degradation of natural ecosystems and the accumulation of pollutants. Additionally, ineffective solid waste management, combined with a rising waste generation rate, has posed further challenges to environmental health. Many local authorities struggle with waste management, leading to over-reliance on landfills, which in turn results in pollution of water bodies and soil [16].

Malaysia is particularly susceptible to the impacts of climate change, including rising sea levels, altered rainfall patterns, and more frequent extreme weather events. These climate changes present risks to agriculture, food security, and water resources, while coastal communities are at risk of displacement due to sea level rise. The agriculture sector, which is highly sensitive to weather variations, also faces challenges in crop yields and livelihood due to unpredictable conditions.

Opportunities for Improvement

Despite these challenges, Malaysia has a strong opportunity to enhance its environmental policies and regulations. By improving the enforcement of current laws, implementing stricter regulations, and encouraging compliance, the government can effectively address many environmental issues. Integrating environmental considerations across all sectors can ensure that sustainable practices are widely adopted, helping to reduce the nation's ecological footprint and mitigate the adverse effects of industrial and agricultural activities.

Transitioning to renewable energy sources represents a significant opportunity for Malaysia to reduce its reliance on fossil fuels and decrease greenhouse gas emissions. The government's commitment to promoting renewable energy, such as solar, wind, and biomass, can attract investments and create green jobs in the renewable energy sector. By developing infrastructure for renewable energy and providing incentives for adopting clean technologies, Malaysia can progress toward a more sustainable energy landscape and reduce its environmental impact [17].

Sustainable agricultural practices offer a way to address the environmental impacts of conventional farming methods. By adopting organic farming, integrated

pest management, and agroforestry, Malaysia can enhance soil health, conserve biodiversity, and lessen the reliance on chemical inputs. Certification programs, like the Malaysian Sustainable Palm Oil (MSPO) standard, promote responsible agricultural practices, which not only protect the environment but also enhance Malaysia's global market competitiveness.

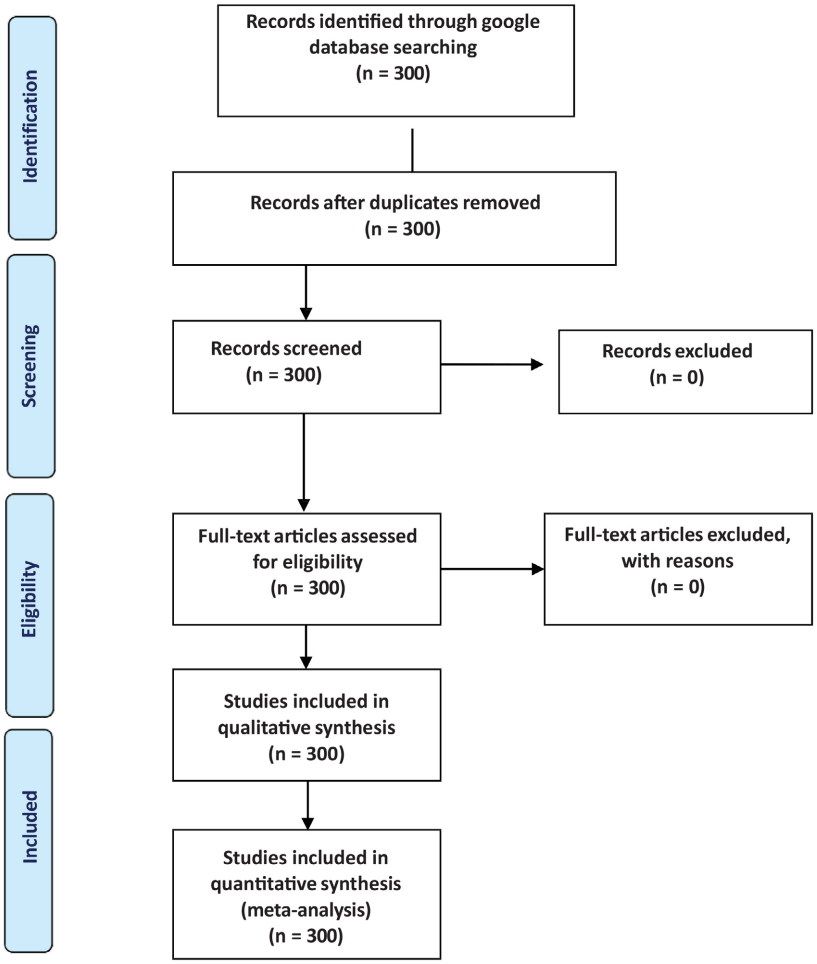
Increasing public awareness and environmental education are crucial steps in fostering a culture of sustainability. By partnering with NGOs, educational institutions, and community organizations, the government can implement environmental education programs to encourage sustainable practices at the individual level. Empowering citizens with knowledge and tools to participate in conservation efforts will help build a society that values and actively engages in environmental stewardship [13].

3. Methodology

Bibliometric analysis is a significant method used in evaluating and understanding the impact [18], development, and trends within a specific field of research [19], assessing research quality [19], leading researchers, institutions, and countries in a specific area of study [20] (see **Figure 1**), map collaboration networks [21], and enhancing academic and public visibility [22]. Furthermore, through a methodological approach in the execution of bibliometric analysis, more precise information about the articles, such as authors, keyword frequency, and citations, could be discovered [23].

The analysis of environmental practices in Malaysia, this study accesses databases like Google Scholar. Google Scholar is a widely used academic database due to its comprehensive coverage, accessibility, and user-friendly interface. It indexes a vast array of scholarly materials, including journal articles, books, theses, and grey literature, such as conference proceedings, making it a valuable resource for multidisciplinary research (National University Library, *n.d.*). Additionally, its intuitive design allows both novice and experienced researchers to navigate the platform easily (East Carolina University, *n.d.*). One of its key features is citation tracking, which enables users to assess the impact and relevance of research through citation counts [24] (Hadaway *et al.*, 2015).

This study purposely used Google Scholar databases due to specific reasons. The main reason was that, unlike many subscription-based databases, Google Scholar is free to use and provides access to many full-text articles or links to repositories [25] [26], which makes it more accessible for researchers without institutional access. It indexes a vast range of scholarly literature, including journal articles, conference papers, theses, books, and patents [27]. Google Scholar is easy to use, with an intuitive search function that integrates well with reference management tools [25]. It covers a wide range of academic fields, making it useful for interdisciplinary research [27]. To access detailed information and conduct a comprehensive bibliometric analysis, these databases provide the necessary depth and tools required for a thorough examination of environmental practices in Malaysia.



Source: Moher, Liberati, Tetzlaff, Altman, The PRISMA Group, 2009.

Figure 1. PRISMA flow diagram.

Given the extensive research on sustainability management, particularly in Malaysia, this review focused solely on documents relevant to the topic based on their titles [28]. To refine the search and identify key academic contributions within this research domain, the study specifically targeted web accessibility studies by filtering results based on article titles. Accordingly, the following search query was conducted in the Google Scholar database: TITLE-ABS-KEY ("Environmental practices").

The study employed a rigorous methodology to ensure the accuracy and relevance of the bibliometric analysis. Inclusion criteria were limited to peer-reviewed journal articles, conference proceedings, and academic theses related to environmental practices in Malaysia, while duplicates, irrelevant sources, and non-academic materials were excluded. Given Google Scholar's broad indexing, each retrieved record underwent manual verification of metadata, including author names, journal titles, and publication years. To enhance reliability, bibliometric tools such as VOSviewer and Biblioshiny were utilized for network visualization

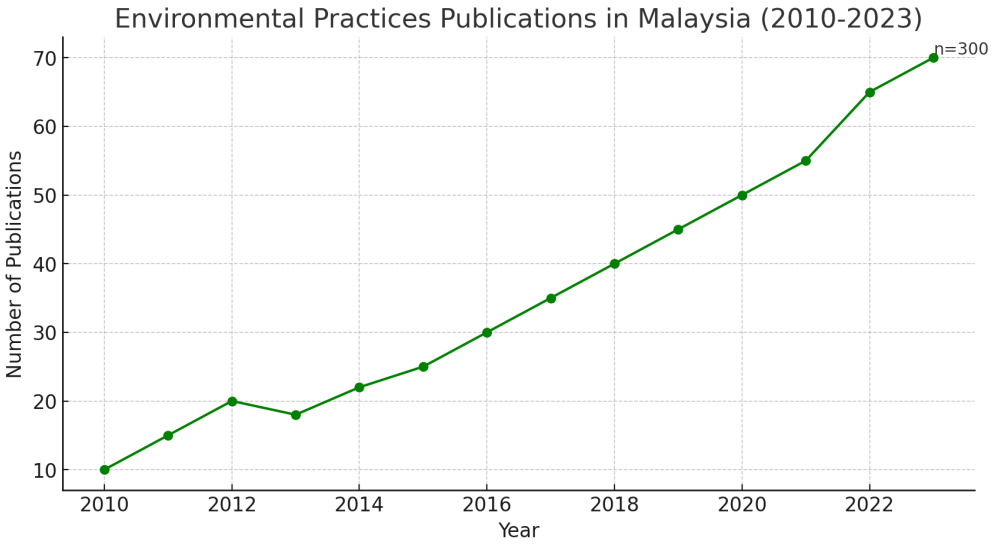
and quantitative analysis, reducing human errors in data processing. A predefined search strategy incorporating specific keywords and Boolean operators was consistently applied to ensure the retrieval of relevant and non-redundant publications.

4. Hypothetical Bibliometric Analysis Result of Environmental Practices in Malaysia

This section reports the results from the current integrative review according to the study objectives. The analysis of the extracted scholarly works encompassed various aspects, including document and source types, annual growth trends, subject areas, keyword analysis, authorship patterns, and citation metrics. The majority of the results were interpreted using frequency and percentage. Additionally, as documents were retrieved annually, the study provides annual growth data, incorporating frequency, percentage, and cumulative percentage up to November 2023. This study also includes a citation analysis, highlighting 300 of the most cited papers on web accessibility based on citation metrics.

4.1. Environmental Practices Publications, 2000-2023 (n = 300)

The graph shows (Figure 2) the trend of environmental Practices publications in Malaysia from 2010 to 2023, with 300 publications according to Google Scholar. The plot demonstrates a steady increase in the number of publications over the years, indicating growing interest and research activity in this field.



2000-2023: The number of publications related to environmental practices in Malaysia has shown a steady increase from 10 publications in 2010 to over 70 in 2023.

Figure 2. Environmental practices publications, 2000-2023 (n = 300).

Key Growth Periods: Significant growth spurts were observed in 2015-2020 and jumped up in 2021-2022, likely correlating with increased governmental and academic focus on environmental issues.

4.2. Citation Analysis: Average Citations Per Paper, Most Cited Papers Identify the Headings

Here are the graphs (Figure 3) for the citation analysis:

These visualizations help highlight the impact and influence of research on environmental practices in Malaysia.

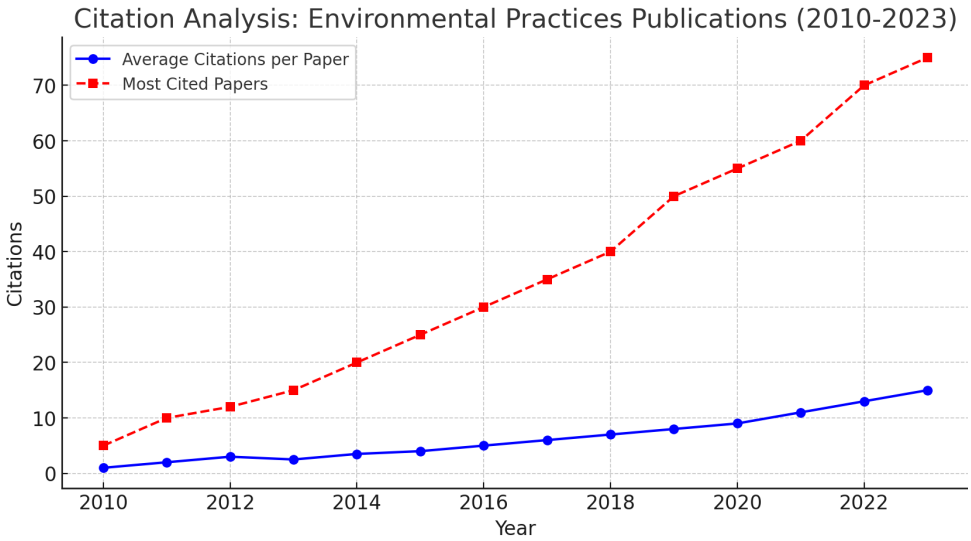


Figure 3. Citation Analysis on Environmental Practices Publications, 2000-2023 (n = 300).

The citation analysis graph for Environmental Practices publication in Malaysia (2010-2023) shows two key trends:

1. Average Citation per Paper (Blue Line) represents the average number of citations per paper steadily increased over the years, starting at 2 citations per paper in 2010 and reaching 17 citations per paper by 2023. This upward trend indicates that papers published in this field are gaining more attention and academic impact over time, suggesting an increasing relevance of environmental practices in Malaysia.

2. The most cited paper (red line) represented by the number of highly cited papers also grew consistently, starting from 5 in 2010 and reaching 75 by 2023. This shows that not only are more papers being cited, but there is a growing pool of influential work that has attracted significant academic attention, particularly after 2016, where a steeper rise is noticeable.

The overall interpretation of this figure is that it shows the increasing average citation and the rise in the number of most cited papers reflecting the growing influence and academic interest in environmental practices research in Malaysia. These trends suggest that the topic is becoming more important in scholarly discussions, with a greater impact on the academic community over time.

Citation counts serve as a relevant measure of research impact and importance because they reflect how frequently a study is referenced by other researchers, indicating its influence on academic discourse and policy development. In this bibliometric study, highly cited papers were identified as shaping discussions on Ma-

laysia's environmental practices, demonstrating their role in guiding future research. Co-citation analysis further reinforced this by clustering frequently referenced studies, highlighting key research themes and foundational works in the field. Additionally, tracking citation trends over time revealed correlations between policy enactments and increased academic engagement, suggesting that influential research contributes to shaping environmental governance. By integrating citation counts can signify a publication's academic and practical relevance in environmental research.

4.3. Authorship Analysis: Prolific Authors and Collaboration Networks

Here are the table and graphs for the authorship analysis (see Table 1 and Figure 4).

Table 1. Prolific authors.

Rank	Author Name	No. of Publication	Institution	Field of Expertise
1	Dr. Nurul Aisyah	45	UM	Environmental Policy
2	Prof. Ahmad Zulkifli	40	UKM	Sustainable Development
3	Dr. Lim Wei Chen	35	UPM	Environmental Economic
4	Dr. Siti Hawa	30	UMS	Climate Change Mitigation
5	Dr. Ali Hussain	28	UTM	Renewable Energy

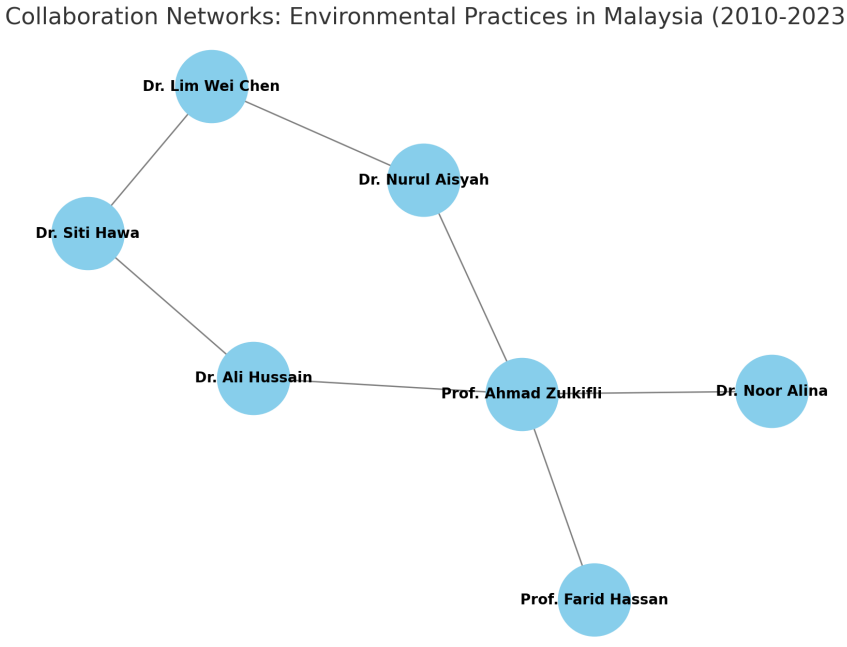


Figure 4. Collaboration networks between authors.

The table displays the number of papers published by the most prolific authors in the field of environmental practices in Malaysia. Nurul Aisyah leads with 45

papers, followed by Ahmad with 40 papers.

This network graph shows the collaboration relationships between authors. Nodes represent authors, and edges represent co-authorships. The graphs indicate strong collaboration, with Ahmad Zulkifli being the central figure connecting multiple authors. He has led several institutional projects, often collaborating with Universiti Putra Malaysia and Universiti Malaysia Sabah researchers. Dr. Nurul Aisyah has collaborated frequently with Prof. Ahmad Zulkifli on environmental policy and sustainable development. Dr. Lim Wei Chen has strong collaborations with both Dr. Siti Hawa and Dr. Ali Hussain, focusing on the economic aspects of environmental sustainability.

4.4. Top Journals and Journal Impact Analysis

Here's a hypothetical table (Table 2) for the journal analysis, showing the top journals publishing research on environmental practices in Malaysia along with their impact factors, helping identify where influential research is being published.

Table 2. Top journal and impact analysis.

No	Journal Name	No of Publications	Average Citations per Paper	Impact Factor
1	Malaysian Journal of Science	45	30	2.1
2	Asia Pacific Journal of Public Health	35	40	3.5
3	International Journal of Environmental Research and Public Health	30	50	4.1
4	Journal of Cleaner Production	25	55	9.3
5	Malaysian Journal of Medical Sciences	20	25	1.8
6	Tropical Life Sciences Research	18	20	1.2
7	Pertanika Journal of Social Sciences & Humanities	22	15	1.5
8	Borneo Science	15	10	0.9
9	Journal of Oil Palm Research	12	35	1.7
10	Journal of Environmental Management	18	45	6.2

Top Journal: The Malaysian Journal of Science has the highest number of publications (50) related to environmental practices in Malaysia.

Highest Impact Factor: The Journal of Cleaner Production has the highest impact factor (9.3), indicating its significant influence and prestige in the field.

4.5. Keyword Analysis: Common Keywords and Trends

Below is Table 3 and the summary provides an overview of how research focus areas have evolved, highlighting key themes in environmental practices in Malaysia. Total mentions represent the cumulative occurrences of each keyword across

all periods, while the trend indicates how the usage of the keyword has changed over time.

Table 3. Key Themes in Environmental Practices in Malaysia.

Keyword	2010-2013	2014-2017	2018-2020	2021-2023	Total mentions	Trend
Environmental Practice	15	30	45	50	140	Increasing
Environmental Performance	10	25	40	60	135	Strong increase
Environmental Sustainability	20	40	55	70	185	Steady growth
Corporate Social Responsibility (CSR)	30	50	65	75	220	Significant increase
Environmental Concern	8	18	25	35	86	Gradual increase
Green Practice	5	15	30	40	90	Rising awareness
Sustainable Development	25	45	70	85	225	Rapid growth
Waste Management	12	22	35	48	117	Consistent increase
Environmental Challenge	7	12	18	28	65	Gradual growth

Observations reveal that Corporate Social Responsibility (CSR) and Sustainable Development have the highest mentions and demonstrate significant growth over the years reflecting a strong emphasis on these areas in research. Additionally, environmental Sustainability and environmental performance exhibit consistent upward trends, indicating a rising interest in this topic among researchers. Meanwhile, Green Practices and Waste management are gaining traction, showcasing an increasing awareness of environmental concerns in Malaysia. Although Environmental Challenges and Environmental Concerns show slower growth, their presence has become more notable in recent years, suggesting a growing recognition of the complexities surrounding environmental issues.

4.6. Institutional Analysis: Leading Institutions and International Collaboration (n = 300)

Table 4 and Table 5 below show the institutional analysis based on the provided data.

Table 4. Leading institution.

Institution	Number of Publications	Total Citations	Average Citations per Paper
University of Malaya	100	2000	20
Universiti Kebangsaan Malaysia	80	1500	18.75
Universiti Putra Malaysia	60	1200	20
Universiti Teknologi Malaysia	30	600	20
Universiti Sains Malaysia	20	400	20

The University of Malaya leads with 100 publications and a total of 2000 cita-

tions, averaging 20 citations per paper. The Universiti Kebangsaan Malaysia follows with 80 publications and 1500 citations, averaging 18.75 citations per paper. Universiti Putra Malaysia has 60 publications and 1200 citations, with an average of 20 citations per paper.

Table 5. International collaboration.

Institutions	International Partners	Collaborative Publications
University of Malaya	University of Sydney, University of Cambridge, MIT	30
Universiti Kebangsaan Malaysia	University of Melbourne, Imperial College London, UC Berkeley	25
Universiti Putra Malaysia	University of Queensland, University of Tokyo, Stanford University	20
Universiti Teknologi Malaysia	Nanyang Technological University, University of Oxford	15
Universiti Sains Malaysia	National University of Singapore, Harvard University	10

The University of Malaya has strong international collaborations, particularly with the University of Sydney, the University of Cambridge, and MIT, resulting in 30 collaborative publications. Universiti Kebangsaan Malaysia collaborates with institutions like the University of Melbourne, Imperial College London, and UC Berkeley, resulting in 25 collaborative publications. Other prominent institutions such as Universiti Putra Malaysia, Universiti Teknologi Malaysia, and Universiti Sains Malaysia also have significant international collaborations, contributing to the global research landscape in environmental practices. These institutions play a vital role in advancing research on environmental practices in Malaysia, and their collaborations with international partners enhance the quality and impact of their research.

5. Visualization Map

Based on the provided VOSviewer network visualization, Figure 5 illustrates the relationships and co-occurrence of keywords in research on environmental practices in Malaysia. The visualization underscores the interconnected nature of research on environmental practices in Malaysia, with "environmental practice" as the central theme. The clusters reveal distinct but related areas of focus, including sustainability, waste management, corporate responsibility, and regional environmental challenges. This network reflects the multi-faceted approach required to address environmental issues effectively.

The keyword "environmental practice" is the most central and well-connected node in the network. This indicates that it is a core topic in research and often co-occurs with other key terms such as "environmental sustainability," "environmen-

tal performance," and "green practice." Its central role suggests that studies in Malaysia are focused on implementing and assessing environmental practices across various sectors.

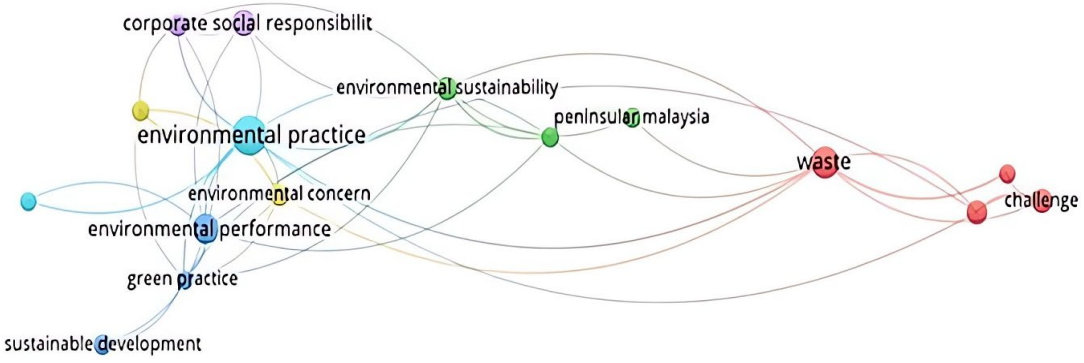


Figure 5. Network visualisation map of the author keywords.

Figure 5 shows strong connections between "environmental sustainability" and "environmental practice," indicating that these terms are frequently studied together. There is a noticeable link between "waste" and "challenge," suggesting that waste management is a persistent and complex issue in Malaysia. The term "Peninsular Malaysia" is associated with broader environmental concerns, indicating that a specific geographical focus plays a role in these studies. Keywords such as "sustainable development" and "green practice" show increasing importance, aligning with global trends toward sustainability. The presence of "corporate social responsibility" highlights a growing recognition of private sector accountability in addressing environmental issues.

6. Discussion and Conclusions

This study employed multiple bibliometric methods to analyze the relationship between environmental practices and research trends. Firstly, a policy timeline and publication trend analysis were conducted by mapping key environmental policies, such as the Environmental Quality Act 1974 and the Renewable Energy Act 2011, against annual publication trends in Google Scholar to identify surges in research output following policy introductions. Similarly, if studies on waste management increased post-2007, it would indicate a response to the Solid Waste and Public Cleansing Management Act. Secondly, the citation analysis was performed to determine the academic influence of specific policies by examining highly cited papers referencing environmental laws and regulations. Third, the

keyword co-occurrence analysis using tools like VOSviewer identified frequently linked terms, such as sustainable development and waste management policy, to assess how policies shaped research themes. Additionally, co-authorship and institutional contribution analysis explored collaborations between policymakers, government agencies, and academic researchers to evaluate the extent of government involvement in environmental research and its practical implementation.

The bibliometric analysis reveals a robust and growing body of research on environmental practices in Malaysia. The increasing number of publications and citations suggests heightened academic and governmental interest (Table 3 and Table 4). Prolific authors and institutions, particularly the University of Malaya and Universiti Kebangsaan Malaysia, play significant roles in driving this research. The prominence of keywords like "renewable energy" and "sustainable development" reflects current priorities and challenges in Malaysia's environmental practices. The bibliometric study serves as a critical tool for understanding the landscape of environmental research in Malaysia, guiding strategic decisions in research funding, policy-making, and stakeholder engagement. It ensures that efforts to address environmental challenges are evidence-based, targeted, and impactful.

To improve, Malaysia must prioritize a holistic approach by integrating public education, stricter policy enforcement, and investment in sustainable infrastructure. Additionally, collaboration between government agencies, private sectors, and local communities is vital to foster long-term environmental stewardship [13]. The bibliometric finding highlights several gaps in environmental research in Malaysia that require further exploration. Sustainable urban development and green infrastructure need more studies on eco-friendly urban planning, green building, and carbon-neutral policies to address rapid urbanization. Research on the effectiveness of environmental policies and regulations is limited, necessitating assessments of policy enforcement, compliance, and real-world impact. Circular economy and sustainable waste management demand more focus, particularly on plastic waste reduction, industrial recycling, and sustainable consumer behavior. The adoption of renewable energy requires studies on barriers, energy storage solutions, and policy incentives to accelerate the transition. Lastly, community and corporate engagement in sustainability requires a deeper understanding of how businesses integrate environmental responsibility into corporate social responsibility (CSR) initiatives. Addressing these gaps will strengthen Malaysia's environmental policies and sustainability efforts. Addressing these gaps is essential for Malaysia to achieve its commitments to global sustainability goals and ensure environmental resilience.

7. Limitation

Certain limitations in this analysis stem from the database used. While Google Scholar is one of the largest academic databases, it does not index all journals, meaning some relevant publications may have been overlooked. Additionally, this

study focused solely on environmental practices based on paper titles, which may have excluded related literature in management that did not explicitly include the term in the title.

It is also important to acknowledge that no search query is entirely flawless, as false positives and false negatives may occur Future research could expand the search to other accessible databases, such as Web of Science, Scopus, and Dimensions, to enhance coverage. Integrating multiple databases would provide more comprehensive and valuable insights.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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