GTLabs

Review Article

Tropical laboratory research to support sustainability issues: A systematic literature review

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ABSTRACT

Background: The study of tropical laboratory research to support sustainability issues is very urgent to ensure that efforts to conserve and utilize natural resources in tropical areas can be carried out effectively and sustainably.
Objectives: This SLR focuses on analyzing research trends in relation to "tropical laboratory research to support sustainability issues".
Methods: This SLR will provide a relatively complete analysis so that it can inspire research activities for researchers, especially in countries that do not yet have a high interest in this aspect. This investigation constitutes a SLR to systematically identify, assess, and analyze all specific research inquiries, topics, or areas. The sequence of inclusion and exclusion was using PRISMA. Data simulation uses "Analyze search results" which is available on the Scopus system. To enrich data and analysis, the data was exported to *CSV format (for visualizing data process with VOSviewer and RStudio) and *RIS (for synchronized with Mendeley). The final result of this process was 17 articles that met the criteria and were worthy of analysis.
Results: We discuss the findings related to Tropical Laboratory Research to Support Sustainability Issues based on the established research questions.
Conclusion: Publications related to tropical laboratory research for sustainability have shown significant fluctuations since 2004, with the majority of publications coming from the United States. While there is potential for future growth, it is important to increase funding support and collaboration between countries to make this research more effective in supporting sustainability.

Keywords: Environmental, laboratory, Scopus, sustainability, tropical

SDGs Relevance: This article has strong relevance to SDG 13 (Climate Action), SDG 15 (Life on Land), and SDG 2 (Zero Hunger). The tropical laboratory research reviewed focuses on developing sustainable practices in natural resource management, which contributes to climate change mitigation and adaptation efforts. Furthermore, increasing understanding of tropical laboratory research will support the preservation of healthy and functional ecosystems, in line with SDG 15. This study also plays a role in increasing agricultural productivity through scientific approaches, which supports food security and reduces hunger, in line with SDG 2.
Laboratory Affiliation: The search process in Scopus database was carried out using the official subscription account owned by the Universitas Muhammadiyah Malang, held in Biology Laboratory of Universitas Muhammadiyah Malang.

INTRODUCTION

Tropical countries with very rich biodiversity face major challenges in managing their natural resources sustainably. Tropical areas are home to various important ecosystems that not only support local life but also provide global benefits, such as carbon sinks and oxygen providers (Nugroho et al., 2022; Sukara, 2014; Weiskopf et al., 2020). However, pressures from human activities, such as deforestation, urbanization, and climate change, threaten the sustainability of the environment and natural resources (Huo & Peng, 2023; Ortiz et al., 2022; Wang & Azam, 2024). Therefore, laboratory research that focuses on sustainability issues in tropical areas is very important to understand ecosystem dynamics and find effective solutions in

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maintaining and utilizing resources sustainably (Durgan et al., 2023; Freese et al., 2024a; Fu et al., 2021; Leung et al., 2020; McCrory et al., 2020, 2022; Tang et al., 2023).

Laboratory research conducted in tropical areas or oriented towards tropical areas can provide deep insights into the interactions between environmental, social, and economic factors (Bas et al., 2024; Harrison et al., 2024; Sandifer et al., 2015). Through in-depth and systematic scientific studies, researchers can explore various aspects, such as the impact of climate change on biodiversity, the effectiveness of environmentally friendly technologies, and sustainable agricultural practices (Abbass et al., 2022; Dönmez et al., 2024; Muluneh, 2021; Taoumi & Lahrech, 2023). The results of these studies are not only useful for academic purposes (in universities or research institutions), but can also be the basis for decision-making for governments, industries, and communities to formulate policies and practices that support sustainability (Freese et al., 2024b; Greever et al., 2020; Kwan et al., 2022).

Furthermore, collaboration between scientists, stakeholders, and local communities in laboratory research in tropical areas can strengthen conservation and sustainability efforts (Beck et al., 2019; Niesenbaum, 2019; White et al., 2023). By involving local communities in the research process, traditional knowledge and sustainable practices can be integrated with modern scientific approaches. This not only increases the relevance of research, but also builds community awareness and involvement in maintaining environmental sustainability (Lauter, 2023; Makondo & Thomas, 2018; Muhamad Khair et al., 2020; Obiero et al., 2023). Therefore, the study of "tropical laboratory research to support sustainability issues" is very urgent to ensure that efforts to conserve and utilize natural resources in tropical areas can be carried out effectively and sustainably.

Since 1994-2024 (4 decades) there have been 25 review articles indexed in Scopus around the themes of "tropical laboratory" and "sustainability issues" (Abimiku et al., 2016; Al-Radadi, 2022; Alasnag et al., 2023; Bashkin et al., 1999; Cerda et al., 2023; Chiou, 2022; Cureau et al., 2022; Farlie et al., 2024; Harper et al., 2002; Kernaghan et al., 2024; Larkin & Hartberg, 2005; Lovern et al., 2004; Molero et al., 2020; Morandini et al., 2023; Pali-Schöll et al., 2023; Pelehach, 1995; Poo et al., 2023; Seniczak et al., 2016; Simón et al., 2018; Spiers et al., 2015; Thakur et al., 2024; Uliani et al., 2011; Xu & Luo, 2018; Xuan et al., 2010; Zen, 2017). However, none of them constitute a systematic literature review (SLR) or bibliometric analysis. In fact, SLR or bibliometric analysis is useful to help researchers identify trends, patterns, and developments in research, as well as evaluate the quality and impact of publications through citation analysis and bibliometric indicators (Azarian et al., 2023; de Carvalho et al., 2020; Kraus et al., 2020; Kushwaha & Talib, 2024; Linnenluecke et al., 2019; Passas, 2024; Paul & Barari, 2022). The results of SLR and this analysis can be used to formulate research policies, direct resources to under-explored areas, and support better decision-making by stakeholders. In addition, SLR allows researchers to find gaps in the literature, encourage further research, and improve the relevance and quality of research conducted, thereby contributing to the progress and development of science and technology as a whole (Alsadi et al., 2024; Shaheen et al., 2023; Xiao & Watson, 2017).

This SLR focuses on analyzing research trends in relation to “tropical laboratory research to support sustainability issues”. This SLR will provide a relatively complete analysis so that it can inspire research activities for researchers, especially in countries that do not yet have a high interest in this aspect.

METHODS

Research Framework

This investigation constitutes a SLR to systematically identify, assess, and analyze all specific research inquiries, topics, or areas (Chigbu et al., 2023; Newman & Gough, 2020). A SLR is a form of review that employs a methodical approach to present a reliable synthesis of current literature focused on a distinct and well-defined inquiry (Moosapour et al., 2021). A SLR play a crucial role in enhancing our understanding of a particular subject matter by revealing both the known information and the gaps in knowledge, frequently surpassing the insights derived from individual research studies (Owens, 2021).

Research Question (RQ)

In order to achieve the stated objective, which is to find tropical laboratory research to support sustainability issues for four decades, we set the following research questions (RQ): RQ 1: What is the trend

of documents by year related to articles about tropical laboratory research to support sustainability issues? RQ 2: What is the trend of documents by country related to articles about tropical laboratory research to support sustainability issues? RQ 3: What is the trend of documents by affiliations related to articles about tropical laboratory research to support sustainability issues? RQ 4: What is the trend of documents by funding sponsors related to articles about tropical laboratory research to support sustainability issues? RQ 5: What is the trend of documents by subject area related to articles about tropical laboratory research to support sustainability issues? RQ 6: What is the trend of the number of citations related to articles about tropical laboratory research to support sustainability issues? RQ 7: What is the trend of the relationship between keywords in publications about tropical laboratory research to support sustainability issues?

Search article and inclusion criteria

The search was focused on the phrase "laboratory AND sustainability OR green" in the search within ""article title, abstracts, and keywords"", where the articles found were 27330. Because the search was too broad, the search was changed to search within "article title" so that fewer articles were found, namely 578 (article status is 1995-2024). The search was carried out using the official subscription account owned by the Universitas Muhammadiyah Malang. Data simulation uses "Analyze search results" which is available on the Scopus system. To enrich data and analysis, the data was exported to *CSV format (for visualizing data process with VOSviewer and RStudio) and *RIS (for synchronized with Mendeley). The search history in Scopus is as follows: (TITLE (laboratory AND sustainability OR green)) AND (tropical) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (OA, "all")) AND (LIMIT-TO (LANGUAGE, "English")). The search yielded 578 articles, so they needed to be filtered (inclusion and exclusion) to focus the analysis. We use Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA), consisting of four stages, namely identification, screening, eligibility, and inclusion (Selcuk, 2019). The sequence of inclusion and exclusion is shown in Figure 1. The final result of this process was 17 articles that met the criteria and were worthy of analysis.

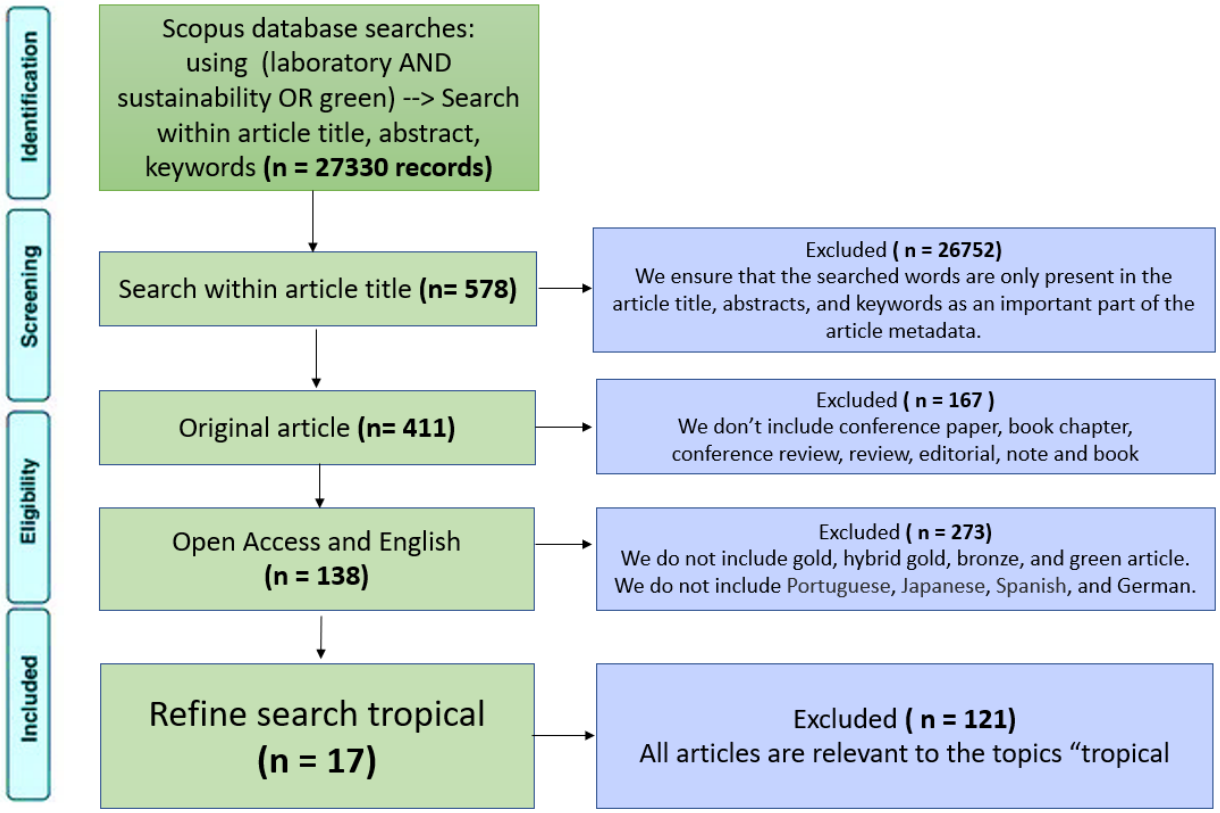

Figure 1. PRISMA flow diagram

RESULTS

Document by year

Figure 2 presents the results of the Scopus database simulation related to document trends by year. Based on the data in Figure 2, it can be seen that after the inclusion-exclusion process of selected articles began in 2004. The highest publication occurred in 2016, which was 3 articles. The number of publications on this theme tends to decrease, even reaching zero in 2019. In 2022 to 2024, the number of articles is only one each, although there is an opportunity to increase in 2024 because the year is still running.

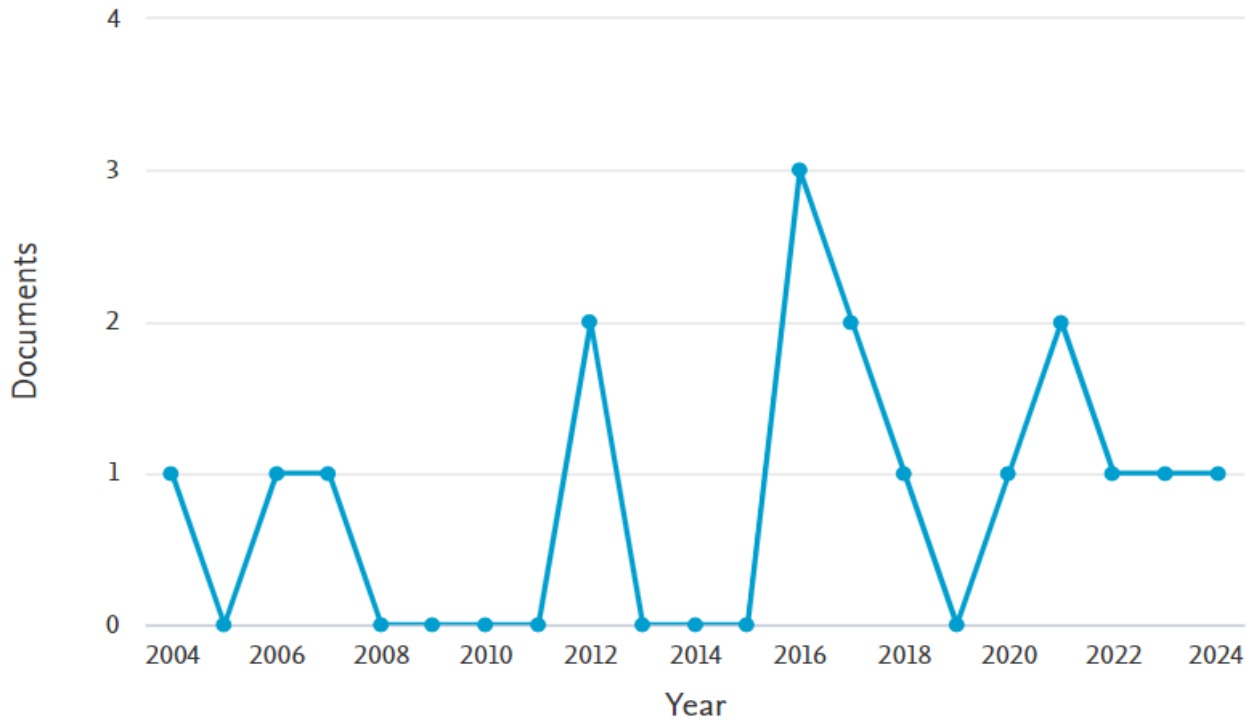

Figure 2. Trend of document by year

Document by country

Figure 3 presents data on document trends by country, while Figure 4 contains data on the most cited countries. Both figures show the dominant or leading country in the theme of tropical laboratory research to support sustainability issues, namely the USA. Based on continent, there are four continents of origin of countries that publish articles, namely America, Asia, and Africa. There are no articles published by countries in Australia-Oceania. Likewise, there are no articles published by countries in Southeast Asia. The interesting thing is that the US is not only dominant in terms of the number of publications, but also dominant in terms of the quality of publications as indicated by the high number of citations. Three other countries whose publications are highly cited are Italy (Europe), Brazil (America), and the United Kingdom (Europe). From the Asian side, the country with the most prominent publication quality is Japan, followed by China.

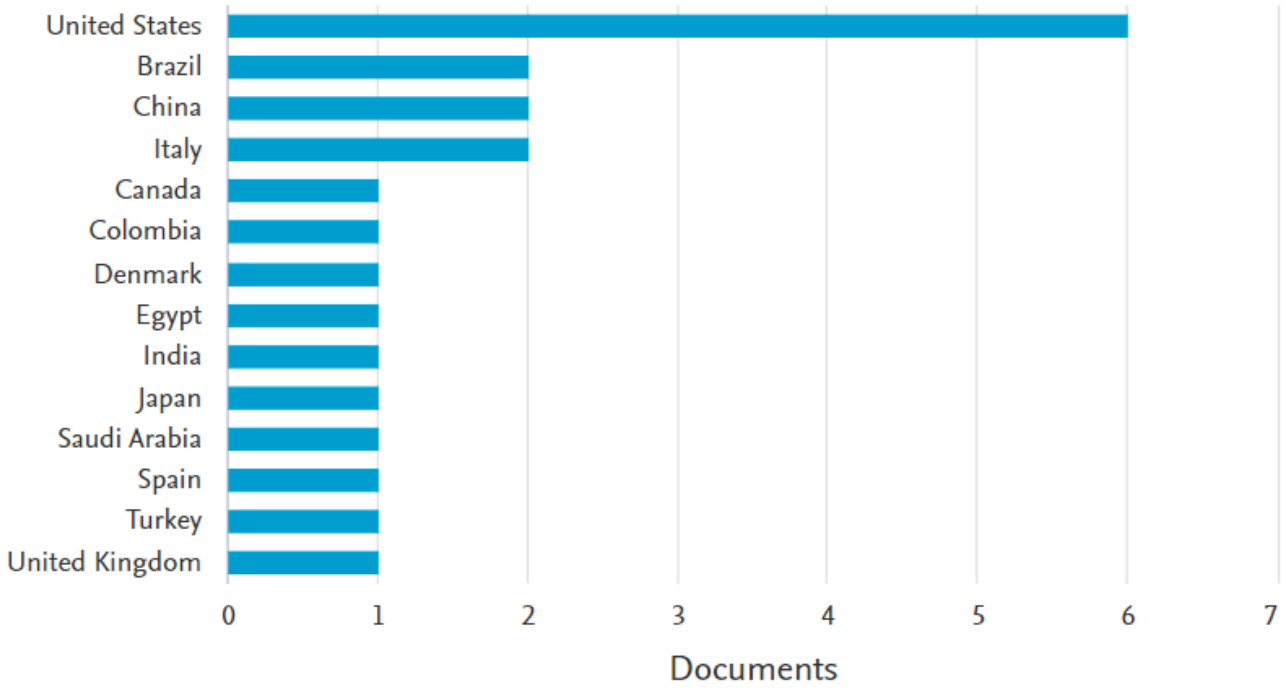

Figure 3. Trend of document by country

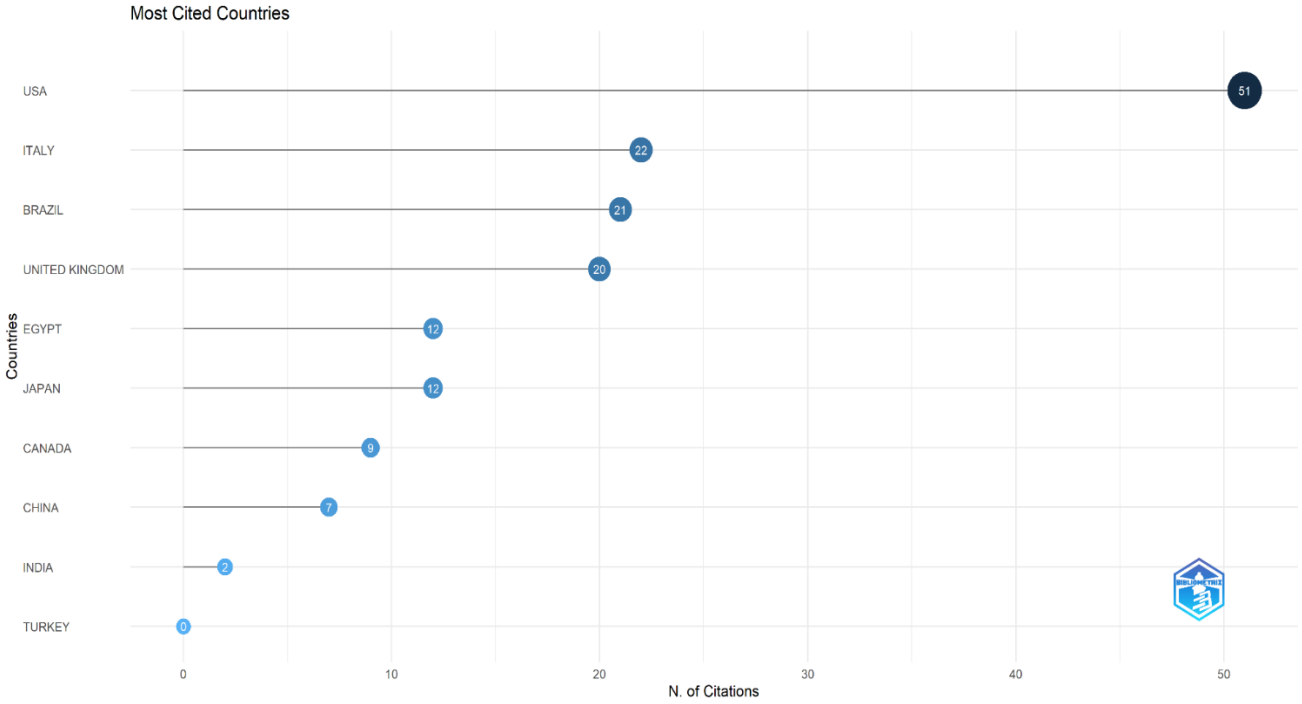

Figure 4. Data of most cited countries

Document by affiliations

We also focus the analysis on the affiliation aspect, as presented in Figure 5. Figure 5 shows two dominant affiliations, namely Coventry University (UK) and Amity University (India). Meanwhile, there are five universities that are quite good in the publication of the theme of tropical laboratory research to support sustainability issues (with the same number of publications), namely Beijing University of Civil Engineering and Architecture (China), Construction Technologies Institute of National Research Council of Italy (Italy), The Ohio State University (USA), Universidade Federal da Paraiba (Brazil), and University of Pisa (Italy).

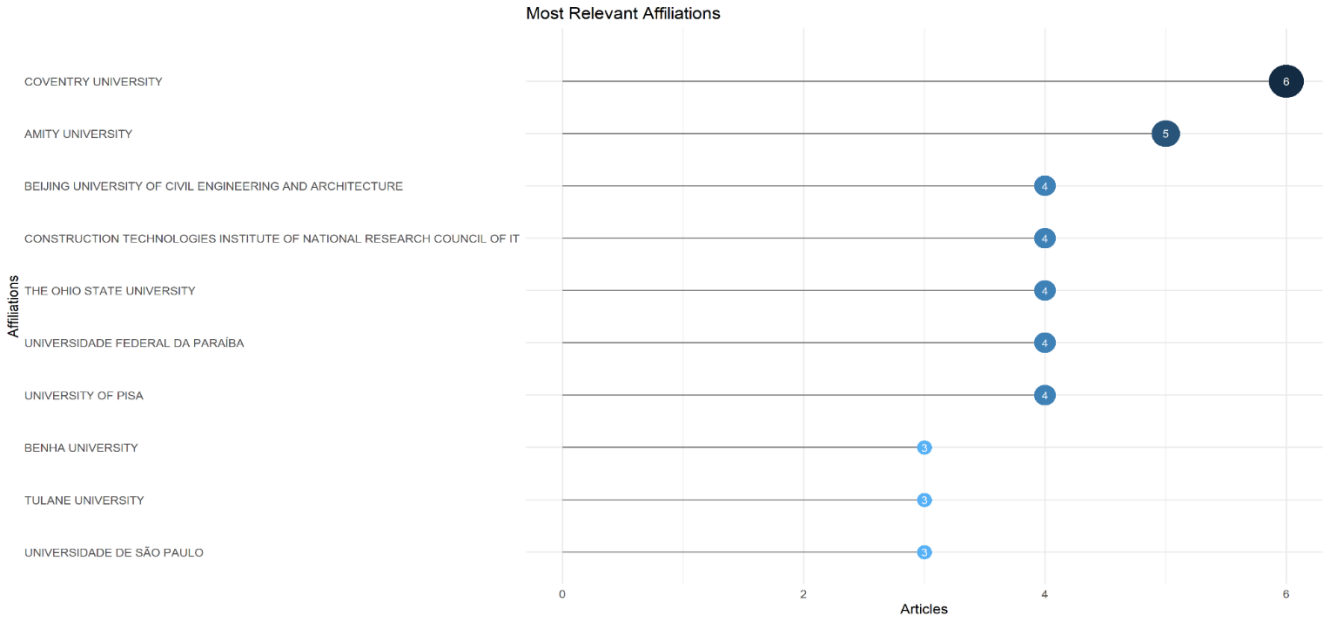

Figure 5. Document by affiliations

Document by Funding Sponsor

Figure 6 presents data document by funding sponsor. Based on Figure 6, it can be seen that there is no dominant sponsor. However, there are nine funding sponsors (from 17 articles/research), and the National Science Foundation (USA) funded 2 research/articles.

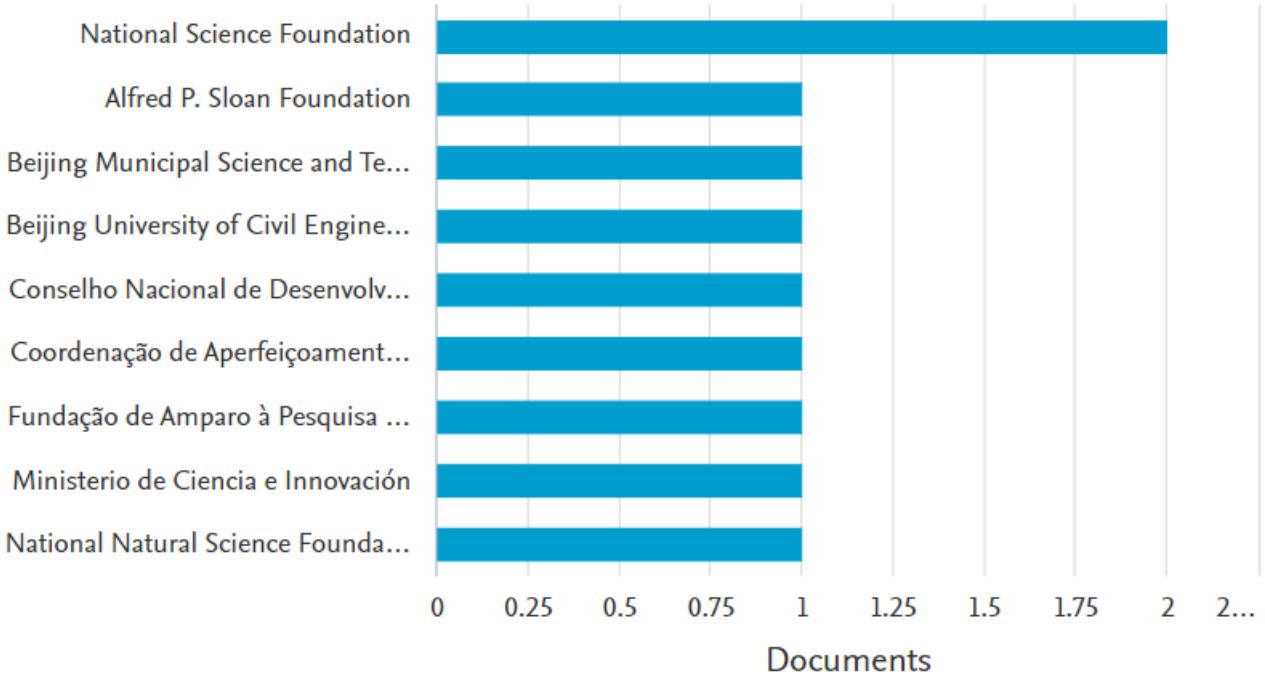

Figure 6. Document by funding sponsor

Document by Subject Area

Figure 7 shows the document by subject area. Based on Figure 7, it can be seen that the theme of tropical laboratory research to support sustainability issues is dominantly related to agricultural and biological

sciences (34.6%). In addition, there are documents related to the subjects of environmental sciences, Biochemistry, earth and planet, multidisciplinary, chemistry, energy, engineering, pharmacology, and veterinary. Interestingly, there are no articles related to the subject of social sciences.

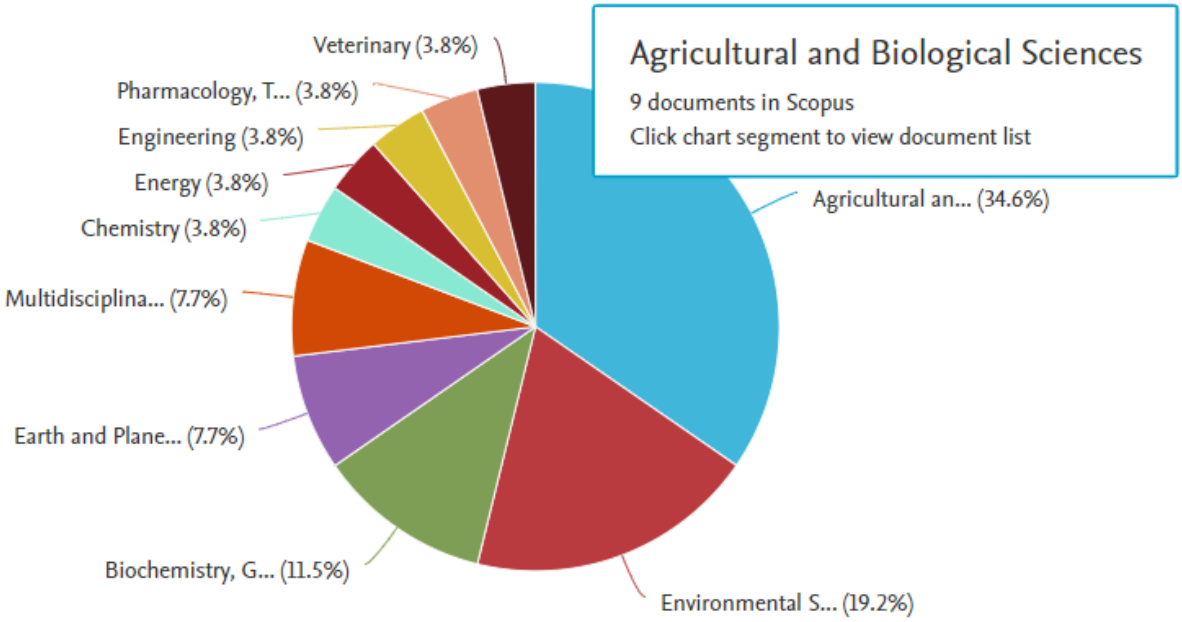

Figure 7. Document by subject area

Number of Citations

Table 1 presents the number of citations data from the 17 selected articles. The data shows that the highest citations were obtained by Huang et al (2023) with 28 citations. Interestingly, this article was only published in 2023, far outperforming the article that was published in 2004 (Togashi & Cox, 2004). The citation numbers that are nearly close are Moreno-Marín et al (2016) with 27 citations. The data in Table 1 also shows that there are two articles that have not been cited by other articles in the Scopus database.

Table 1. Number of Citations

No	Author(s)	Citations
1	(Huang et al., 2023)	28
2	(Moreno-Marín et al., 2016)	27
3	(Brannelly et al., 2012)	23
4	(Charlesworth et al., 2012)	20
5	(Ferreira et al., 2006)	19
6	(Radwan et al., 2022)	12
7	(Togashi & Cox, 2004)	12
8	(Barozzi et al., 2017)	11
9	(Cardelli et al., 2017)	11
10	(Le Gault & Hunt, 2016)	9
11	(Mosquera-Murillo & Pena-Salamanca, 2016)	9
12	(Zhang et al., 2018)	7
13	(Swanson et al., 2007)	3
14	(Chauhan et al., 2021)	2
15	(Macêdo et al., 2020)	2
16	(Cataldo & Elborolosy, 2024)	0
17	(Kiliç, 2021)	0

Trend of Keyword

Figure 8 shows the output data from Vos viewer which describes the dominant keywords and the relationship between each keyword. It can be seen that laboratory method and controlled study are the dominant keywords, both are interconnected. The keywords are also related to conservation of natural resources, and greenspace.

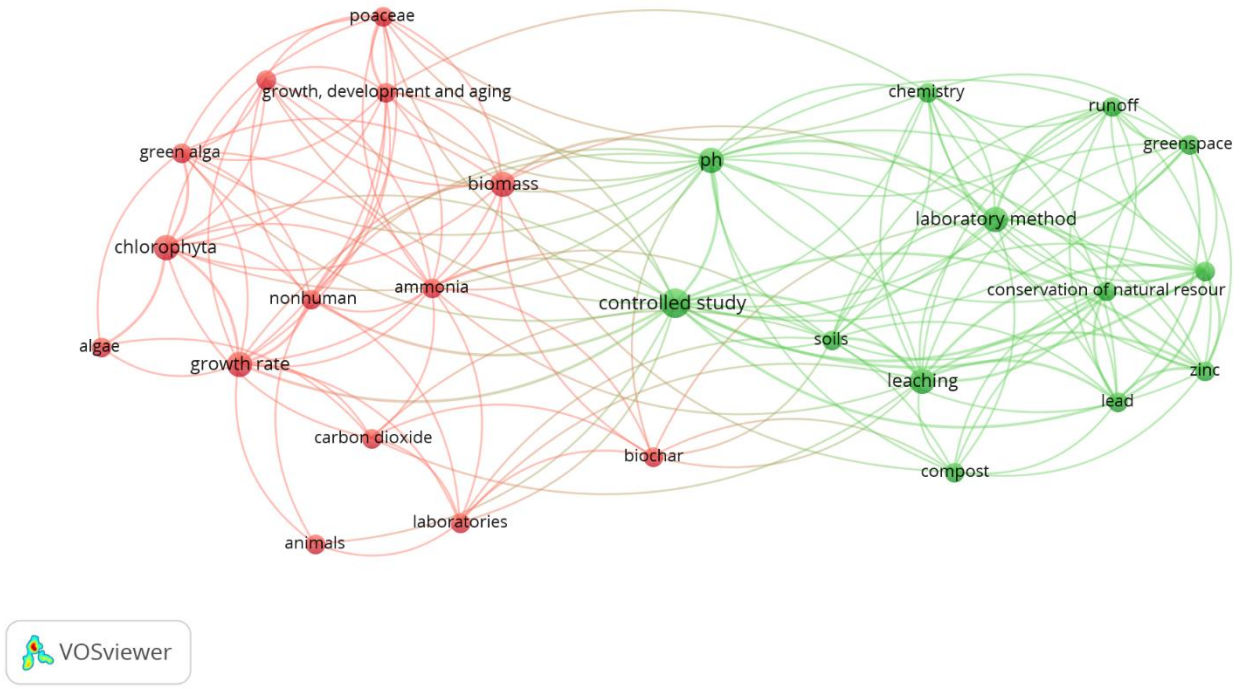

Figure 8. Trend of Keyword

DISCUSSION

Publications related to "Tropical Laboratory Research to Support Sustainability Issues" predominantly come from the US because the country has greater resources for research, access to advanced technology, and a strong academic infrastructure. Many research institutions in the US also have extensive international collaboration networks, allowing them to conduct research in various parts of the world, including the tropics. In addition, funding for sustainability research in the US is often more available, allowing researchers to undertake more ambitious and comprehensive projects (Anonymous, 2023; FAO, UNEP, WHO, 2022; Kruk et al., 2018; McGinley et al., 2017; Moran et al., 2019).

The urgency of increasing such publications in Asia and Southeast Asia is particularly high, given that the region has extraordinary biodiversity and faces significant environmental challenges, such as deforestation, climate change, and soil degradation. By increasing the number of publications, researchers in Asia can provide relevant local perspectives and tailored solutions to sustainability issues in their region. In addition, more publications can strengthen collaboration between countries and facilitate the exchange of knowledge needed to address environmental issues more effectively. This increase can also draw global attention to the unique challenges facing Asia and Southeast Asia, and help formulate better policies for sustainability at the regional level (Howes & Wyrwoll, 2012; Hughes, 2017; Y. Ma et al., 2023; Nguyen et al., 2023).

The theme of sustainability is more focused on agricultural and biological sciences because the main focus is generally the approach through "social sciences". This is based on the view that social sciences are considered to better understand human interactions, policies, and behaviors that affect sustainability. Social sciences explore aspects such as social, economic, and cultural justice that are very important in the context of sustainability, as well as how communities adapt and respond to environmental challenges. On the other hand, although agricultural and biological sciences provide important insights into sustainable agricultural practices and ecosystems, these approaches are often more technical and pay less attention to the crucial social dimension (Boix-Fayos & de Vente, 2023; Fisher et al., 2022; Hariram et al., 2023; Kamakaula, 2024; Ly & Cope, 2023). Of course, in the future, integration between social and natural sciences will be very important to create holistic and effective sustainability solutions, but research in the field of social sciences tends to dominate discussions and publications on sustainability issues.

There is a university that is more concerned with the publication of tropical laboratory research to support sustainability issues, namely Coventry University (UK). Based on a search on the campus website

(https://www.coventry.ac.uk/the-university/key-information/green-campus/sustainability-involvement/) there is information presented as follows: "Sustainable Labs. A Green Lab Committee has been set up by technical and academic teams working in the Alison Gingell building to improve the sustainability of our laboratories. The group was formed in March 2021 and is working on identifying ways to make the laboratories within the building operate more sustainably. This work has also led to Alison Gingell's Lab+ winning awards in the International Freezer Challenge in both 2021 and 2022".

Increasing the amount of sponsorship funding for research and publications related to "Tropical Laboratory Research to Support Sustainability Issues" is very necessary because sufficient funds will allow researchers to carry out more comprehensive and innovative studies. With greater financial support, research can be conducted with adequate tools and technologies, and allow for broader and deeper data collection. It can also encourage collaboration between local and international researchers, expanding networks and sharing of knowledge that can improve the quality and relevance of research. In addition, more funding can help in effectively disseminating research results, making them accessible to stakeholders, including policy makers and the public, for better decision-making on sustainability issues in the tropics. Thus, increasing the amount of sponsorship funding will contribute significantly to the advancement of research and the implementation of more effective sustainability solutions (Arnott et al., 2020; Scheirer & Dearing, 2011; Schneider et al., 2023).

The publication related to "Tropical Laboratory Research to Support Sustainability Issues" falls under the subject area of "agricultural and biological sciences" because this research often focuses on understanding and managing natural resources, agriculture, and ecosystems in the tropics. The fields of agricultural and biological sciences provide the necessary framework for analyzing the interactions between plants, animals, and the environment, and the impacts of human activities on the sustainability of these ecosystems. By studying aspects such as sustainable agricultural productivity, biodiversity conservation, and water resource management, this research contributes to the development of practices and technologies that can improve sustainability in the tropics. Therefore, the integration between laboratory research and field applications in the context of sustainability is highly relevant to the fields of agricultural and biological sciences (Chaudhary & Kumar, 2022; Kalfas et al., 2024; Scherr & McNeely, 2007).

The data shows that the highest citations were obtained by (Huang et al., 2023) with 28 citations. This article is interesting by providing four highlights, namely (1) biochar is an effective strategy for climate-smart agriculture; (2) Biochar added to field (~20 Mg ha−1) can increase gross SOC stock by ~27%; (3) Biochar can decrease global warming potential and greenhouse gas intensity; and (4) Unrealistically high biochar rates in lab overestimated soil carbon sequestration. This study is expected to lead to the development of biochar management practices tailored to achieve climate-smart agriculture goals.

Climate-smart agriculture (CSA) is closely related to sustainability issues because this approach is designed to increase agricultural productivity while reducing negative impacts on the environment and increasing the resilience of agricultural systems to climate change. CSA integrates practices that support efficient resource use, such as water management, organic fertilizer use, and crop diversification, so that it can increase agricultural yields without damaging the ecosystem. In addition, CSA focuses on climate change adaptation and mitigation, which are key aspects in achieving sustainability goals in the agricultural sector. By implementing CSA principles, farmers can not only improve food security but also maintain biodiversity, reduce greenhouse gas emissions, and maintain soil health, all of which are important factors in building a sustainable and environmentally friendly agricultural system (Azadi et al., 2021; de Pinto et al., 2020; W. Ma & Rahut, 2024; Mpala & Simatele, 2023).

Based on the trend of Keywords, it can be seen that laboratory method and controlled study are the dominant keywords, both are interconnected. The keywords are also related to conservation of natural resources. Laboratory methods and controlled studies play an important role in natural resource conservation efforts by providing a systematic and measurable approach to testing hypotheses and understanding interactions within ecosystems. Through laboratory methods, researchers can conduct experiments under controlled conditions, allowing them to isolate certain variables and evaluate their impacts on natural resources, such as soil, water, and biodiversity. Controlled studies, on the other hand, provide stronger evidence about the effectiveness of certain interventions in conservation, such as sustainable agricultural techniques or habitat restoration strategies (Betts et al., 2021; Thorogood et al.,

2023; Turkington & Harrower, 2016; Weisser et al., 2017). By combining these two approaches, scientists can produce accurate and relevant data that supports the development of more effective conservation policies and practices, as well as encourage sustainable management of natural resources.

CONCLUSION

Analysis of data from various sources shows that publications related to tropical laboratory research to support sustainability issues have fluctuated significantly since 2004, with a peak in publications in 2016 and a drastic decline until 2019, and only one article was published in 2022 to 2024. The dominance of publications comes from the United States, which is not only superior in quantity but also in quality, as indicated by the large number of citations. In addition to the US, countries such as Italy, Brazil, and the United Kingdom also contribute significantly, while publications from Asia, especially Japan and China, show good quality despite their limited numbers. In terms of affiliation, Coventry University emerged as the leading institution in publications, followed by several other universities from various countries. Although there were nine funding sponsors for this research, there was no dominant sponsor, reflecting the need for greater support for research in this area. The research themes were mainly related to agricultural and biological sciences, while there were no publications related to social sciences, indicating a gap that needs to be filled in understanding the social aspects of sustainability. Overall, this study highlights the importance of laboratory methods and controlled studies in natural resource conservation efforts, with related keywords indicating a focus on scientific approaches in supporting sustainability. The data also show that while there is potential for future publication growth, funding support and cross-country collaboration are key factors that need to be improved to achieve better results in sustainability research.

Author Contributions: H. H. writing – original draft; methodology; data analysis; and review and editing; A. R. conceptualization, methodology, review and editing; A. A. M. S. review and editing.

Conflicts of Interest: The authors declare no conflicts of interest.

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