

Gold Open Access Publishing in ASEAN Countries: A Comparative Study

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ABSTRACT

Open Access publishing offers increased visibility, accessibility and quality assurance, promoting transparency in research. Governments worldwide are increasingly promoting open access to research findings, recognizing its importance in advancing knowledge and innovation. They are mandating open access publication of research findings, often funding Article Processing Charges (APCs) on behalf of authors. The study aims to examine the impact of Gold Open Access in ASEAN countries, analyzing research output and OA publishing culture across all fields of knowledge. It has investigated funding sources for APCs, average APCs in different fields and top journals for ASEAN researchers. This research will provide valuable insights for policymakers, funding agencies and institutions, supporting evidence-based strategies for a more equitable and sustainable open access landscape in ASEAN. Gold open access publishing, by providing unrestricted access to scientific research, fosters knowledge dissemination, accessibility, visibility, transparency and inclusivity and collaboration within the National Innovation System. This accessibility accelerates the exchange of ideas, promotes interdisciplinary research and facilitates innovation across academia, industry and government. The present study analyzed 1303 articles published under the Gold Open Access publishing model. The University of Putra, Malaysia, was the top contributor; the journal Sustainability, with an Impact Factor (IF) of 3.9, published 233 articles that accrued 3563 citations. The published research focused on various themes and subthemes pertaining to Sustainable Development Goals (SDG) 2023.

Keywords: Open access publishing, Gold open access, article processing charges, ASEAN, SDGs.

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Received: 28-02-2024;

Revised: 14-05-2024;

Accepted: 20-11-2024.

INTRODUCTION

The Association of Southeast Asian Nations is a regional organisation that unites diverse neighbours (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam) to resolve economic and security challenges. However, its influence is still relatively small.^[1] The organization has been a key player in fostering economic integration in Asia, leading discussions among Asia-Pacific nations to establish one of the globe's largest free trade blocs. Additionally, it has successfully concluded six free trade agreements with various regional economies.^[2]

ASEAN also seeks to promote peace and political stability based on United Nations (UN) principles and to nurture cooperation and strong ties among nations and other organizations.

Consequently, member states of ASEAN are expected to adhere to established rules and regulations while establishing regional connections and adhere to the principles outlined in the UN charter.^[3] Over the past few years, ASEAN has experienced a decline in its international credibility due to its inability to handle various significant regional events and situations effectively. To regain its standing, ASEAN has undertaken substantial institutional reforms. Notably, it has enacted and approved a new ASEAN Charter, marking the first instance where ASEAN is granted legal personality. Additionally, the organization has implemented measures to establish an 'ASEAN Community'.^[4]

The Development Gap in ASEAN is Assessed from three Perspectives

The income gap encompasses variations in income, as gauged by the average Gross Domestic Product (GDP) per person or per capita GDP, along with considering poverty levels. The disparity in the Human Development Index among ASEAN countries is significant, yet it has been diminishing over time. Unequal access to and utilization of information technology in the region is another worrisome issue.^[5]



DOI: 10.5530/jscires.20041199

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Significance of the study

The significance of this research lies in its comprehensive examination of research output and the culture of open-access publishing in ASEAN countries. It has assessed the impact of open access publishing by comparing citations in various fields. It has investigated how researchers who pay APC charges have financial burdens in STEM and non-STEM disciplines. The study's highlights of average APCs helped guide policy decisions and its identification of the best journals informed publishers and influenced author choices. It has contributed vital insights for policymakers, funding agencies and institutions, promoting evidence-based strategies for ASEAN's more equitable and sustainable open access landscape.

Objectives

The study has addressed the advantages and disadvantages of Gold Open Access in ASEAN countries and identified how authors, institutions and countries interacted in all fields of knowledge (science, technology, engineering, management, arts and humanities). The objectives of the study were as follows:

Investigate if researchers covered their article APC charge through research funding or personal funds and assess potential disparities compared to the STEM field.

Highlight the average APC levied by publishers in different fields of knowledge.

Identify the top journals APC-wise in which ASEAN researchers published.

Focus on the National Innovation System (NIS) of ASEAN countries.

The study has examined published research on scientific innovation systems and evaluated trends in this area. It utilized a mixed quantitative and qualitative approach, encompassing data collection, scientometrics analysis and systematic review analysis.

Scientometrics research methods significantly impact research and its citation processes, providing comprehensive insights through knowledge maps and their growth in specific research domains. The study of the National Innovation System within the field of science encompasses a wide array of research topics, making systematic analysis challenging. The increasing utilization of modern scientometrics analysis allows for the evaluation of scientific advancements and the identification of recent developments within specific knowledge domains.

While traditional manual evaluation offers in-depth insights into the study field, it has several limitations, including being time-consuming, susceptible to biases and interpretations and restricted in providing detailed information.^[6] The study recommends a thorough examination of the national innovation system associated with ASEAN countries.

ASEAN Countries and Open Access Journals (OAJ)

ASEAN has a great chance of becoming one of the global OAJ publishing empires. While not in every member state, the OAJs are flourishing across the area. For this reason, by fostering stronger intra- and inter-ASEAN scientific interactions, the member nations of ASEAN should work to raise the calibre of OAJs.^[7] Open Access publishing offers increased visibility and accessibility, potentially leading to more citations. It also ensures quality assurance, as a broader audience can access and evaluate the research, promoting transparency. Worldwide, Governments are making concerted efforts to put research findings in open access so that everyone has equitable access to the findings, which may be used as a foundation for future research. The governments, through funding bodies have mandated that research findings should be made available in open access as governments are spending a colossal amount of money on promoting and sponsoring research. Accordingly, research follow available routes of publishing Green and Gold publishing models. In the Gold publishing model, the authors pay APC (Article Processing Charges) to make their research openly available upon publication. The universities or funding bodies pay APCs on behalf of authors.

Article Processing Costs (APCs), paid by authors, their institutions, or sponsors, are their primary funding source. The proportion of open-access publications in these journals has grown significantly.^[8] Numerous funding organisations have also acknowledged the value of Open Access Publication and have stipulated that APCs may be paid for directly with their money.^[9] Reputation should be reflected in the APC as it is the real "good" that a researcher aspires to when selecting a journal for publishing. Researchers from IIM-A and IMU conducted an analysis of the quantity of articles published in well-regarded open-access journals in 2020, spanning various scientific disciplines. According to the study's findings, research teams with at least one Indian member spent around \$30 million on processing fees. The researchers in the fields of health and medical sciences paid \$7 million as APCs. In comparison, those in the life and earth sciences paid \$6.9 million; interdisciplinary researchers paid \$4.9 million and chemistry and materials scientists paid \$4.8 million. APCs for the social sciences, business, economics, literature and the arts, management and humanities were just \$53,000, \$311,000 and \$117,000, respectively.^[10]

National Innovation System (NIS)@ ASEAN Countries

The widespread recognition of innovation as a key driver of sustainable economic development and inclusive growth is evident. It goes beyond enhancing productivity in businesses, industries and macroeconomics, extending to its role in fueling the growth of consumption, investment and exports.^[11]

The concept of the National Innovation System (NIS) or National System of Innovation (NSI) has become increasingly prominent

as a conceptual framework for examining technological change, recognized as a foundational element for a nation's sustained economic development.^[12]

Each country in the Asia-Pacific region has adopted and implemented innovation-related policies in diverse ways. Policymakers must strike a harmonious equilibrium between market-oriented strategies and government intervention methods tailored to the unique circumstances of their respective countries.

Public policies are acknowledged as a crucial mechanism for enhancing the national capacity for innovation and economic performance,^[11] discussed about the innovative activities in ASEAN. R&D investment is a crucial indicator of innovation progress in nations. Most ASEAN Member States (AMS), except for Singapore, have maintained low R&D investments. Japan has sustained an R&D intensity of over 3% since 2000 and Korea since 2008. In terms of educated human resources driving innovation, Singapore leads with 6,658.5 researchers per 10,000

Table 1: Policy Framework Typology for ASEAN.

| Phase | Basic Infrastructure | High-tech Infrastructure | Network Cohesion | Global Integration |
|--|---|--|---|--|
| Initial conditions Cambodia, Lao PDR, Myanmar. | Stability in governance and an effective foundational framework. | Rise in the need for technology. | The spirit to compete and succeed fuels social bonds. | Linking with regional and global markets. |
| Learning Thailand, Philippines, Indonesia, Viet Nam. | Enhancement of fundamental infrastructure through improved customs and bureaucratic coordination. | Acquiring skills through hands-on experience and imitation. | Formal intermediary organizations are established to facilitate connections and coordination among economic agents, expanding on tacitly occurring social institutions. | Accessing knowledge from foreign sources, importing material and capital goods and receiving foreign direct investment are integral components of integrating into the global value chain. |
| Catch-up Malaysia | Seamless connections among economic entities. | Creative destruction activities commence with the importation of machinery and equipment, licensing agreements and innovative replication. | Intermediary and governmental organizations actively coordinate the influx of technology and initiate commercially feasible research and development. | Obtaining licenses and acquiring foreign capabilities, enhancing synergies through technology imports and developing robust technology-based exports are critical factors. |
| Advanced | Sophisticated infrastructure to meet the needs of economic entities. | Research and development aimed at expediting creative destruction activities. Commencement of frequent patent filings in the United States. | Active involvement of intermediary and government organizations in coordinating the influx of technology and initiating commercially viable Research and Development (R&D). | Access to international human capital, knowledge connections and competitiveness in high-tech products, along with collaboration with Research and Development (R&D) institutions. |
| Frontier Singapore | New infrastructure was created to reduce resource costs and expedite short lead times. | R&D laboratories for fundamental research to facilitate creative accumulation activities: Generating knowledge. Technology shapers extensively produce invention and design patents. | Involvement of intermediary organizations in bidirectional knowledge exchange between producers and users. | Establishing links with leading knowledge nodes and achieving competitive high-tech product exports. |

Lao PDR=Lao People's Democratic Republic, R&D=research and Development.
Source:- Intal *et al.* (2014) and Rasiah (2013) from Ambashi, M. (2017).

populations in 2014. While Malaysia tops the AMS list with 2,051.7 researchers, it lags behind Japan (5,386.2) and Korea (6,899.0) in absolute numbers, highlighting research workforce distribution variations.

With the upsurge in R&D investment in the late 1980s, Korea effectively transitioned out of its developmental phase. Since the late 1990s, the total R&D investment as a percentage of GDP has nearly matched that of advanced countries. Although there has been notable rapid growth in both the scale and intensity of R&D investment, a significant gap in accumulated know-how and quality remains when compared to advanced countries.^[13]

The ASEAN STI Watch project, a collaborative initiative between the National Science, Technology and Innovation Policy Office of the Ministry of Science and Technology and the College of Innovation at Thammasat University in Thailand, is structured to emphasize the importance of knowledge as a pivotal outcome of innovation. As the ASEAN member countries transitioned towards the ASEAN Economic Community (AEC) in 2015, this project has been established as a comprehensive web-based analytical tool. Its primary objective is to furnish Information and Communications Technology (ICT) infrastructure, aiding in policymaking and facilitating decisions pertaining to Research and Development (R&D) investment activities across ASEAN countries. In the context of establishing the ASEAN Economic Community (AEC) in 2015, the ASEAN STI Watch project aims to serve as a foundation for government policy dialogues, facilitating the enhancement and strengthening of the national innovation system.^[14]

In developing nations, innovation efficiency measures below 0.2, while the National Innovation System (NIS) efficiency of both the Republic of Korea and China has witnessed substantial improvement. In the case of India, the government's robust leadership has significantly enhanced national scientific and technological capabilities. Over the past decade, the Chinese innovation system has made notable strides, substantially reducing the overall disparity with developed countries. However, the discussion on economic efficiency remains unsatisfactory, posing a bottleneck to the Chinese innovation system.^[15]

Vietnam is currently in the process of establishing its National Innovation System (NIS). The government has demonstrated a long-term commitment to Science and Technology (S&T) activities, indicating the foundational elements of a comprehensive national innovation system. However, the development of the Vietnam National Innovation System (NIS) is still in its early phases and encounters various weaknesses, with one of the most prominent being the disconnect between research institutions, including universities and the productive sectors of the economy. The higher education sector is not operating efficiently as a source for knowledge creation and transfer. Additionally, there is inadequate coordination between policies, especially those aimed

at providing incentives for Research and Development (R&D) within the business community.^[16]

According to the framework mentioned above (Table 1), Cambodia, Laos and Myanmar are in the initial condition phase. These nations exhibit stability in governance and possess an effective foundational framework. There's a growing demand for technology, fostering a competitive spirit that strengthens social bonds. Their primary focus lies in establishing connections with regional and global markets.

Thailand, the Philippines, Indonesia and Vietnam are situated in the learning stage. These countries concentrate on enhancing fundamental infrastructure by improving customs and bureaucratic coordination. Skills acquisition occurs through practical experience and imitation. The establishment of formal intermediary organizations aids in connecting and coordinating economic agents, facilitating integration into the global value chain.

Malaysia is positioned in the catch-up phase. Here, creative endeavours are pursued through the importation of machinery and equipment, licensing agreements and innovative replication. Both intermediary and governmental bodies actively coordinate the influx of technology and drive commercially viable Research and Development (R&D) initiatives.

Advanced countries boast sophisticated infrastructure tailored to meet the demands of economic entities. R&D efforts prioritize accelerating creative destruction activities, often resulting in frequent patent filings in the United States. Intermediary and government entities play pivotal roles in coordinating technology influxes and spearheading commercially viable R&D endeavors. These nations enjoy access to international human capital, knowledge networks and exhibit competitiveness in high-tech products. No ASEAN member country has been categorized as advanced.

Singapore is classified as a frontier country, characterized by its establishment of new infrastructure to minimize resource costs and streamline production lead times. R&D laboratories prioritize fundamental research to facilitate creative accumulation activities, thus fostering knowledge generation. Extensive production of invention and design patents by technology shapers is a notable feature. Intermediary organizations play crucial roles in facilitating bidirectional knowledge exchange between producers and users. Singapore has successfully established links with leading knowledge hubs and achieved competitive exports of high-tech products.

METHODOLOGY

The present study aims to answer how ASEAN countries have adopted the mechanism of APC. It is important to explore and understand how open access has affected scholarly communication across the different fields of knowledge during

the last 10 years, 2013-2022. The data has been collected from Web of Science, a bibliographic citation database of Clarivate Analytics, formerly Thomson Reuters.

Literature Search and Screening

For this study, literature data indexed from January 1st 2013, to December 31st 2022, were selected from the Web of Science (WOS) database. All documents related to NIS were retrieved from WOS on January 5th 2024. The initial search strategy was to use title-abstract-keywords (TITLE-ABS-KEY) to obtain all the selected keywords' publications. The initial search in Web of Science employed the following keywords: 'Scientific and Technological Innovation,' 'Artificial Intelligence / Machine Learning-based Innovations,' 'Innovation system policy,' 'Innovation development at the national level,' 'Regional Innovation Systems,' and 'Economic performances.' This initial search yielded a total of 131,567 records. Subsequently, the dataset was refined by the publication year, narrowing it down to the period between 2013 and 2022. This refinement reduced the dataset to 88,275 records, focusing on articles, review articles and proceedings papers, resulting in a final count of 87,731.

Further refinement was carried out based on the geographical scope, specifically targeting ASEAN countries of Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. The process of collecting data undergoes multiple tiers of quality control. Following a rigorous identification and screening process, we retrieved 4,164 articles from the Web of Science (WOS) database for scientometric analysis, removing 2 duplicates. The dataset was initially reduced to 4,162 records and further alteration led to identifying 1,816 open access articles. After another round of filtering to align with the objectives, 1303 articles specifically centered on Gold and other variants of open access were saved. The final dataset of 1303 articles were downloaded and utilized for the analysis.

It is important to highlight that in the dataset, the Green and Bronze articles with Gold OA articles are grouped under Gold OA for the study.

Data Analysis and Visualization

The study employed VOSviewer (version 1.6.20) and the R Bibliometrix package (version 4.1.4) to achieve its objectives. Bibliometrics study includes country/ origin, institute, author, keyword and journal, research areas, etc. Another visualization

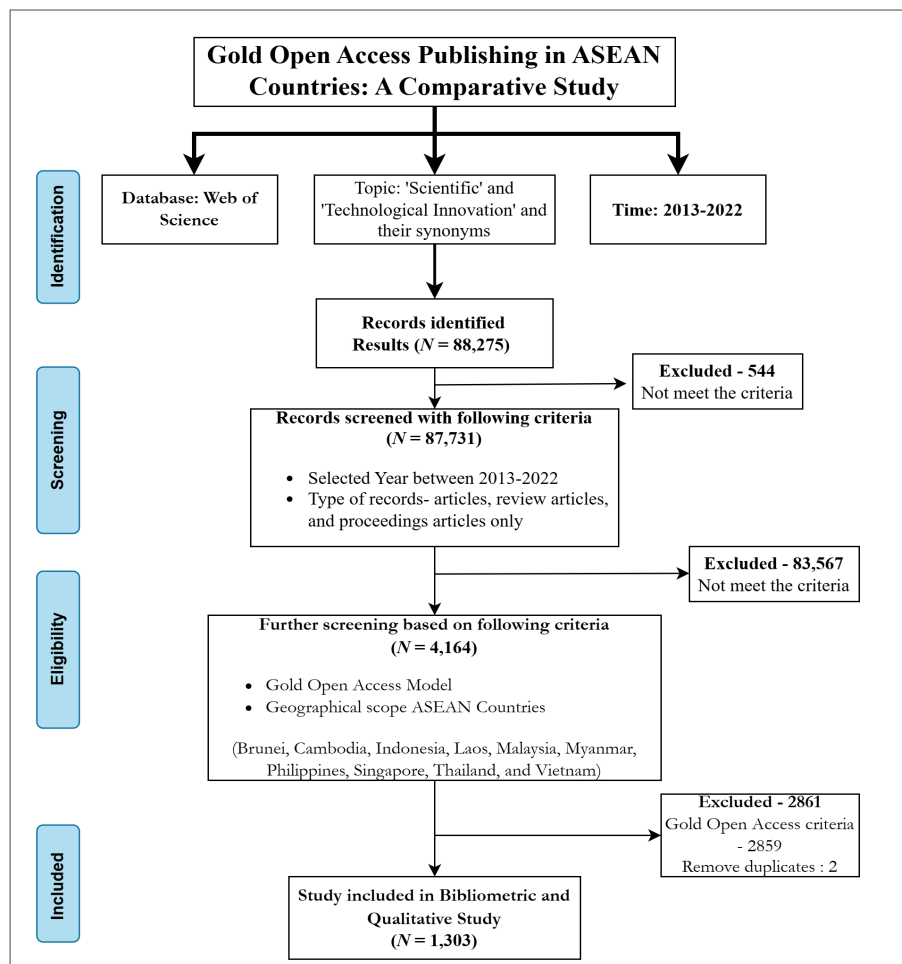


Figure 1: PRISMA flow diagram: identification, review and selection of articles included in the systematic bibliometric study.

software was used to extract insights from the dataset. To understand the impact of Open Access in the diverse landscape of ASEAN countries, researchers investigated key metrics like total citations and Journal Impact Factors, a traditionally systematic review of 100 articles used to gauge the quality of research.

Relying solely on scientometrics to analyze research in National Information Systems (NIS) proves insufficient for uncovering its intricacies and challenges. Therefore, a systematic review was undertaken to gain a deeper understanding of NIS and measure performance and future strategies. This combined approach investigated both the structure of classical research topics and performance metrics, providing valuable insights for future strategies.

It utilized a content analysis approach, selecting the top 30 highly cited articles from a dataset of 1303 articles for further analysis. Content analysis aims to methodically examine and construe textual, visual, or audio information to recognize patterns, themes and insights. The overarching objective is to attain a more profound understanding of the communication or phenomena being investigated.

RESULTS

A comprehensive count of 1303 publications, comprising 1116 original articles, 176 reviews, 10 Proceedings and 1 data paper, are associated with the national innovation system, accumulating

a Total of 24320 Citations (TC). The data was obtained from the WOS database and the publications displayed diverse frequencies, illustrating trends in both publications and citations from 2013 to 2022. The plotted data excludes 2023 due to articles being in press or in the process of publication. The model fitting curve (Figure 3A) indicates a noteworthy exponential growth trend in annual publications over the past decade. ($y=6.8218e^{0.4194x}$, $R^2=0.994$).

Figure 3B on the right side shows that the annual growth rate experienced an increase when the Gold Open Access model was employed from 2013 to 2022. Prior to opting for the Gold Open Access model, the annual growth rate exhibited a consistent upward trend. Meanwhile, trends in publication citations peaked in 2020, after which there was a significant reduction. Notably, the year 2020 stood out as the most productive and cited, with 5541 publications and 18163 citations, both before and after the adoption of the Gold Open Access model. The rise of Gold Open Access publishing is a global phenomenon and ASEAN countries are actively participating in this transformative trend.

Figure 4 provides an overview of research productivity and impact, specifically in terms of average article citations, for various countries. The data unveils diverse research landscapes across Asia and beyond. Within ASEAN countries, Malaysia led with 5,374 publications and an average of 18.3 citations per article, indicating substantial research output. Singapore followed closely with 1,986 publications but boasted a higher

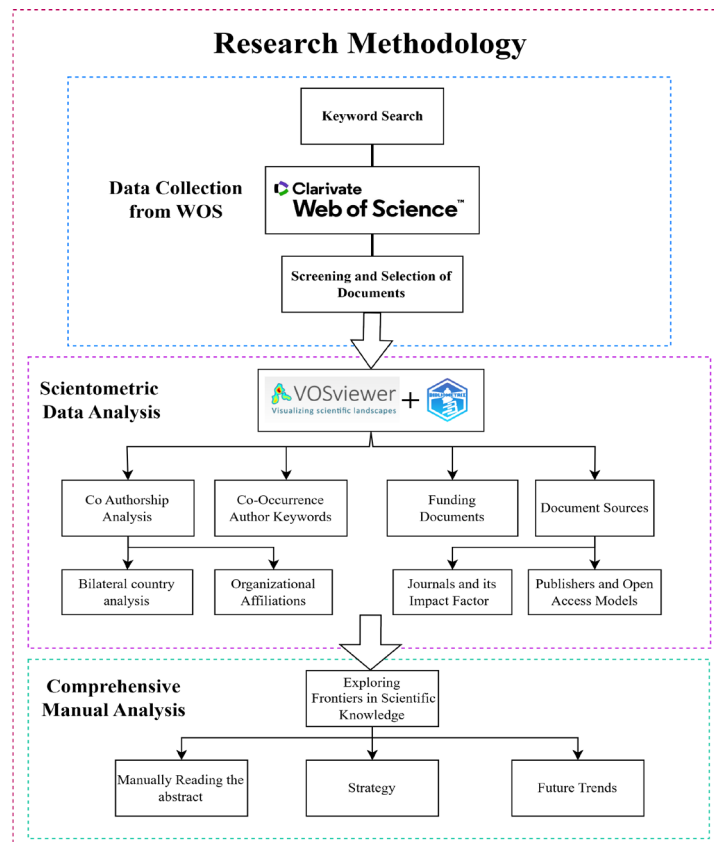


Figure 2: Research Methodology.

average of 28 citations per article, suggesting impactful research. Vietnam, Thailand and Indonesia also made significant research contributions, each with varying citation averages. Laos stood out with a surprisingly high average of 39 citations per article, despite a smaller total publication count. Meanwhile, the United States and European countries such as the United Kingdom, Netherlands and France exhibited high average citations, underscoring the impact of their research. Canada led with an impressive average of 47.5 citations per article, highlighting its strong influence in the academic community. This comparative analysis showcases the global distribution of scientific contributions and the diverse citation patterns observed across regions.

In single-Country Publications (SCP), Malaysia stands out with the highest number of corresponding authors; contributing to 127 publications (9.75%), followed by Thailand (5.76%), Indonesia (4.45%), Vietnam (2.53%) and no SCP publications were recorded for Brunei, Laos and Myanmar. In the case of Multiple-Country Publications (MCP), Malaysia maintains its leading position with 17% of publications, trailed by Thailand (5%), Indonesia (4%), Vietnam (7%) and so forth. The data underscores a collaborative approach to research, showcasing the involvement of authors from multiple countries in these publications. Figure 5 depicts clusters, where Malaysia, Bangladesh, Iraq, Qatar and Australia take the lead in collaborative authorship, while the other four clusters exhibit less coordination.

Table 2 illustrates the collaboration levels of ASEAN countries with other nations concerning academic publications on

NIS research outcomes. Brunei, Laos and Myanmar have not produced any single-country publications but have collaborated with other countries to produce 14, 6 and 14 publications, respectively. Brunei has not even been categorized within the initial conditions group.

Malaysia, put in the catch-up category, leads in both single-country publications and collaborations with other countries for academic publications. It surpasses Singapore, a frontier country, in both single-country publications and multi-country collaborations. Thailand, Indonesia and Vietnam, categorized in the learning phase, have progressed to surpass Singapore, a frontier country, in terms of both single-country and multi-country publications.

The results (see Figure 5) indicate a coordinated involvement of authors from various countries such as China, Australia, USA, UK, Japan, India, France, Pakistan, among others, in each other's research. The internal cross-country collaboration within ASEAN and the international collaboration highlights the significance of global cooperation in advancing knowledge and understanding in the field of the national innovation system. This emphasizes the role of collaboration in addressing complex challenges and issues.

Evaluating the significance of an author in a specific field necessitates a dual evaluation based on both productivity, indicated by the frequency of published works and impact, demonstrated through citations, awards and other recognitions. Figure 6 leverages both metrics to present the top 10 most active and influential authors from the past 10 years. Productivity is

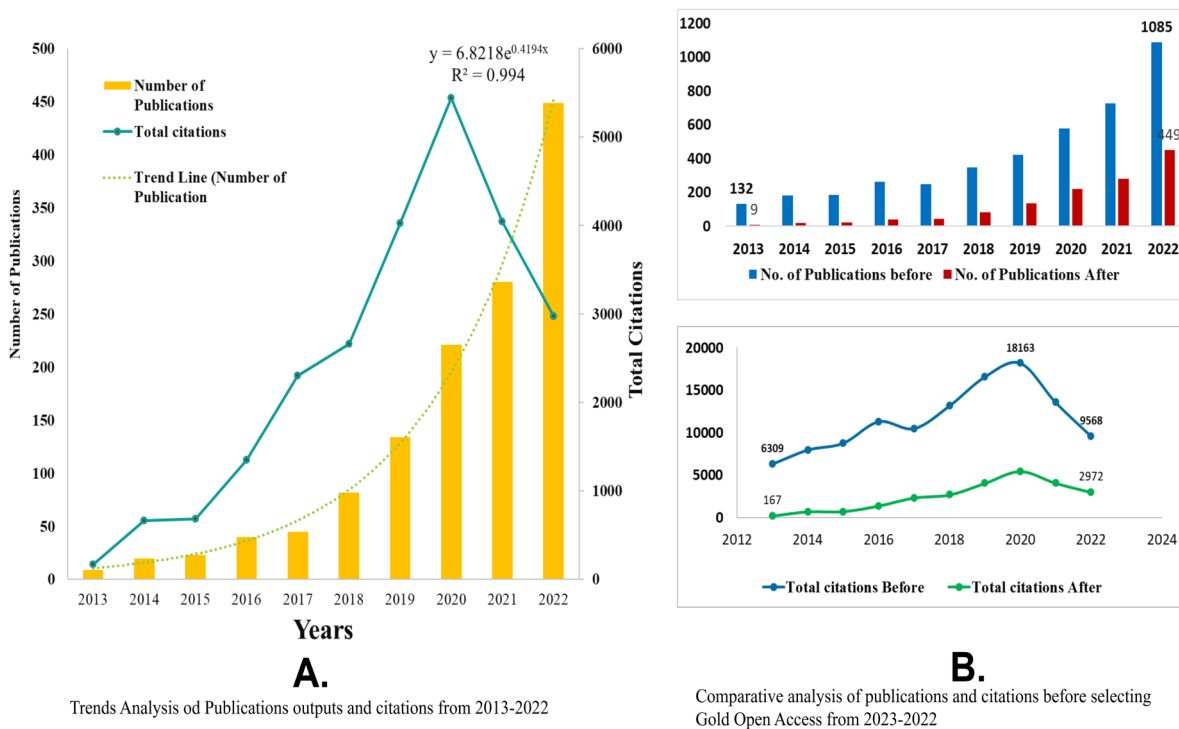


Figure 3: Presents a comparative analysis of Open Access (OA) model publications in ASEAN countries before and after adopting the Gold OA model. Part A focuses solely on Gold OA publications, while Part B includes all OA publications from the past decade.

gauged by tallying the number of published articles over a given period and impact is assessed through annual citations. Notably, Wang Cn, Wang X, Lili Li and Urbano emerge as the most prolific contributors, while Grimaldi and Fini command the highest citations per year. Additionally, it is evident that Li Yushan holds a pivotal position as an author on the topic, maintaining a continuous stream of publications from 2013 to 2022.

Although researchers' productivity, such as the number of publications, is a contributing factor, it should not be the sole criterion defining their contributions. A comprehensive evaluation requires consideration of other crucial factors. Hence, Table 3 presents three metrics related to the local dataset and the top 10 most productive authors: total citation number, the h-index and the m-index. The authors with the highest citations in the dataset are Li, Y. (519 citations) and Mosavi, A. (506 citations), closely followed by Li, L. (445 citations) and Mekhilef, S. (408 citations). These two authors are the only ones surpassing the 500-citation threshold in the results. However, Mahlia Tmi stands out with the most favorable combination of productivity and impact, contributing 8 local publications and possessing an h-index of 8, signifying that he has published 8 articles each receiving at least 8 citations. Wang Cn, Li L and Thang Trung Nguyen Ttn have also demonstrated commendable performance with 13, 9 publications and local h-index scores of 7 and 6, respectively.

Remarkably, the top four performing authors have delved into the economic performance topic with a primary focus on regional development and societal impact. Their analyses encompass technology transfer, energy transitions, environmental considerations and sustainable development. The m-index, as defined by Hirsch (2007), is applied as the h-index weighted for the activity period of an author. Therefore, in addition to well-established scholars like Mosavi A, Kumar A and Amran M, noteworthy mention is due to emerging influential authors such as Mahlia Tmi and Kumar V, who commenced their publications between 2016 and 2019.

Table 4 illustrates the annual research affiliation statistics, indicating publications or collaborations for various universities from 2013 to 2022. The University of Putra Malaysia leads with a total of 254 affiliations, demonstrating a consistent increase over the years. The University of Malaya closely follows with 233 affiliations, showcasing fluctuating trends. University Kebangsaan Malaysia and Ton Duc Thang University display noteworthy growth in affiliations, reaching 153 and 132, respectively. The data overall reveals a dynamic landscape of research collaborations, with some universities consistently excelling, while others show fluctuations or significant growth over the years.

Figure 7, on the other hand, represents organization citation networks. The National University of Singapore, University of Malaya, Ton Duc Thang University and Nanyang Technological University have emerged as the most productive organizations in the past decade, playing a central role in the citation network.

Table 5 offers a summary of the top 15 publishers based on the frequency of articles in the dataset. MDPI stands out as the predominant publisher, contributing 40.5% of the total articles. Following MDPI, ELSEVIER, WILEY and Frontiers Media Sa hold substantial shares at 13.8%, 5.3% and 5.2%, respectively. The list includes renowned publishers like IEEE, BMC and Springer Nature. The data underscores the diverse publishing landscape, encompassing a mix of open-access publishers like MDPI and traditional publishers such as ELSEVIER and Wiley.

The present study analyzed a total of 1303 documents published in 392 distinct journals from various countries worldwide, all indexed in WOS, Table 6. Among these, 586 publications (44%) were distributed across fifteen core journals, while the remaining 735 (56%) were spread across 377 journals. The journal with the highest article count is Sustainability, totaling 233 articles, followed by Energies with 67, IEEE Access with 46 and PLOS One with 30 articles. Notably, authors predominantly choose journals that entail Article Processing Charges (APC). Frontiers In Psychology stands out with the highest APC, amounting to

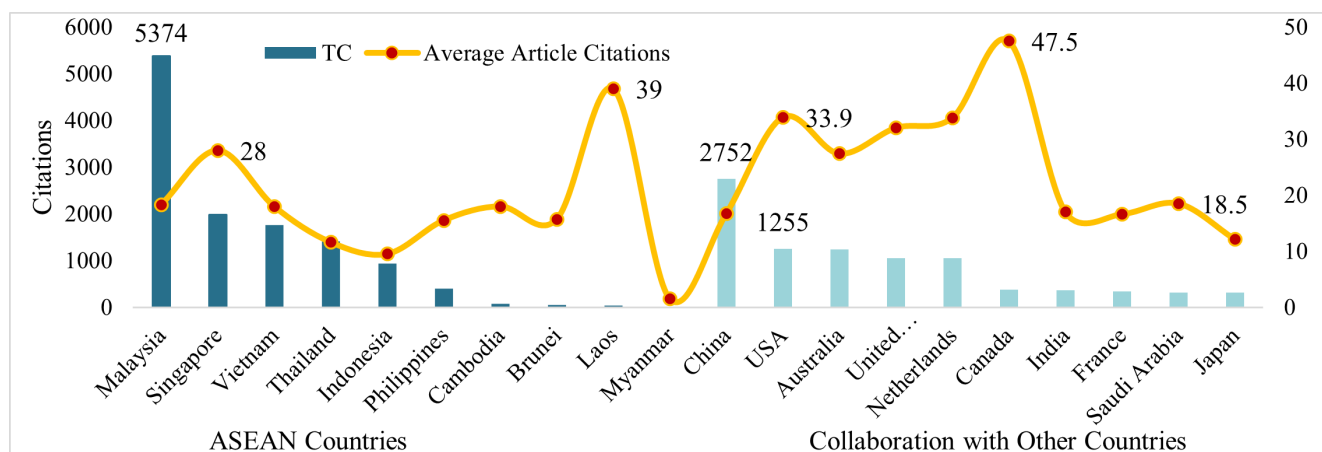


Figure 4: Most Cited countries. TC-Total Citations.

\$3,295. Conversely, Scientific Reports is noteworthy for not charging any publication fees, establishing itself as one of the high-Impact Factor (IF) journals within the group.

Comprehensive Manual Analysis and Result

The content analysis of the top cited 30 articles shows (Table 7) that research has been conducted on topics pertaining to sustainable development. The Sustainable Development Goals (SDGs) for 2030 and the ASEAN Vision 2025 are both strategic frameworks that aim at sustainable development, albeit with different scope and focus.

The Sustainable Development Goals (SDGs), unanimously adopted by all United Nations Member States in 2015, comprise 17 goals designed to tackle diverse social, economic and

environmental challenges. This strategic plan aims to benefit both people and the entire planet, addressing issues ranging from poverty and hunger eradication to ensuring access to clean water and sanitation, promoting gender equality and combating climate change. The SDGs serve as a universal framework, guiding countries in their efforts to achieve a more sustainable future by 2030.

Conversely, the ASEAN Vision 2025 is a strategic document endorsed by the member states of the Association of Southeast Asian Nations (ASEAN) in 2015. This document delineates the aspirations and commitments of the ten member countries for the period spanning from 2016 to 2025. The vision focuses on creating a rules-based, people oriented and people-centred ASEAN that promotes regional peace, prosperity and development through cooperation, collaboration and integration. The ASEAN Community Vision 2025 is centred on “One vision, one identity, one community”. It reiterates building an inclusive, sustainable, resilient and dynamic community.

While the SDGs are global and apply to all countries, the ASEAN Vision 2025 is specific to the ASEAN region and emphasizes regional cooperation and integration. However, both frameworks share common objectives related to sustainable development, poverty alleviation, environmental protection and inclusive growth. As such, ASEAN member states often align their national development plans with the SDGs and the ASEAN Vision 2025 to ensure coherence and synergy in their efforts to achieve sustainable development goals.

Among the top thirty cited articles, 25 focus on Sustainable Development Goals (SDGs). The utilization of biogas production is on the rise as an alternative to using organic biomasses. Various

Table 2: Corresponding author country.

| Country | Single Country Publication | Multiple Country Publication |
|-----------------|----------------------------|------------------------------|
| Malaysia | 127 | 167 |
| Thailand | 75 | 47 |
| Indonesia | 58 | 41 |
| Vietnam | 33 | 65 |
| Singapore | 30 | 41 |
| Philippines | 12 | 14 |
| Cambodia | 2 | 23 |
| Brunei | 0 | 14 |
| Laos | 0 | 6 |
| Myanmar | 0 | 14 |
| Other Countries | 966 | 563 |

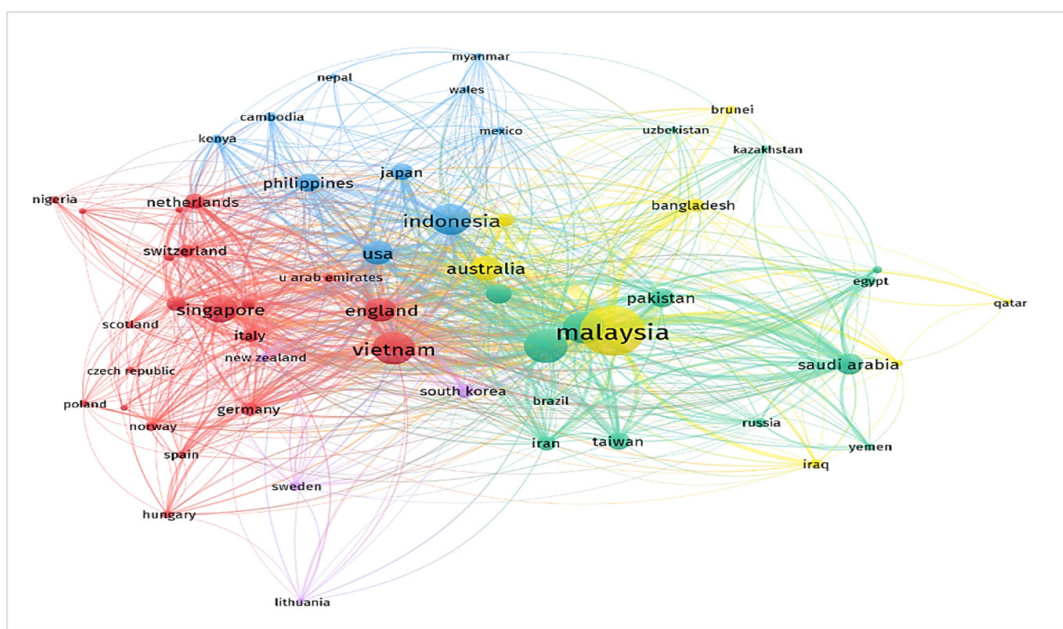


Figure 5: Network visualization map. Figure represents multi-country authorships (Cluster model-Louvain algorithm).

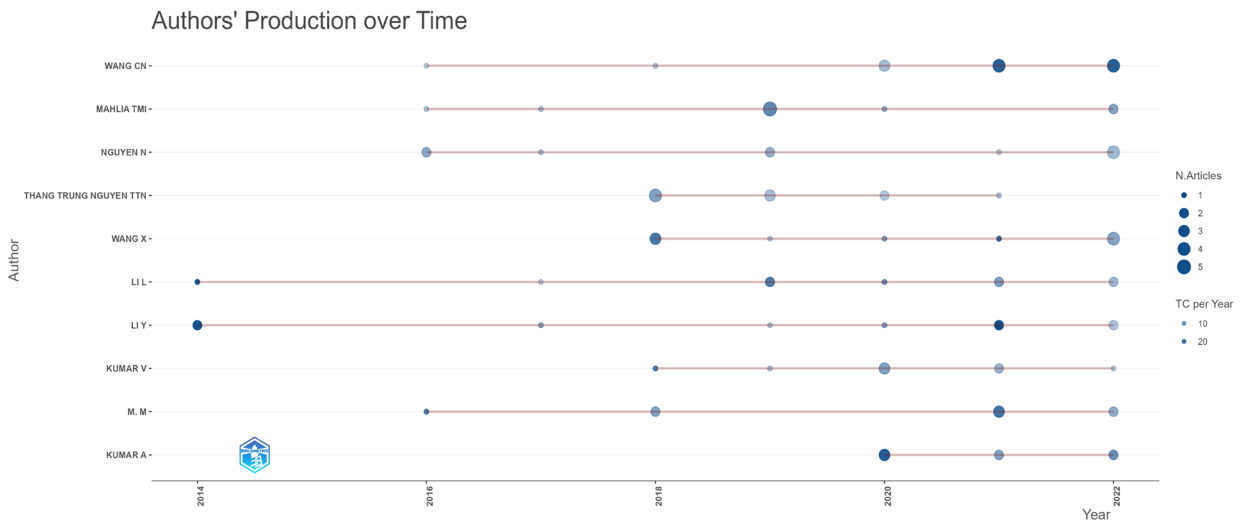


Figure 6: The chart presents a temporal analysis of authorial productivity, denoted by circle size and citational influence, denoted by circle shade. Larger circles correspond to a greater number of published articles within a given year, while darker shades signify a higher average number of citations received per year.

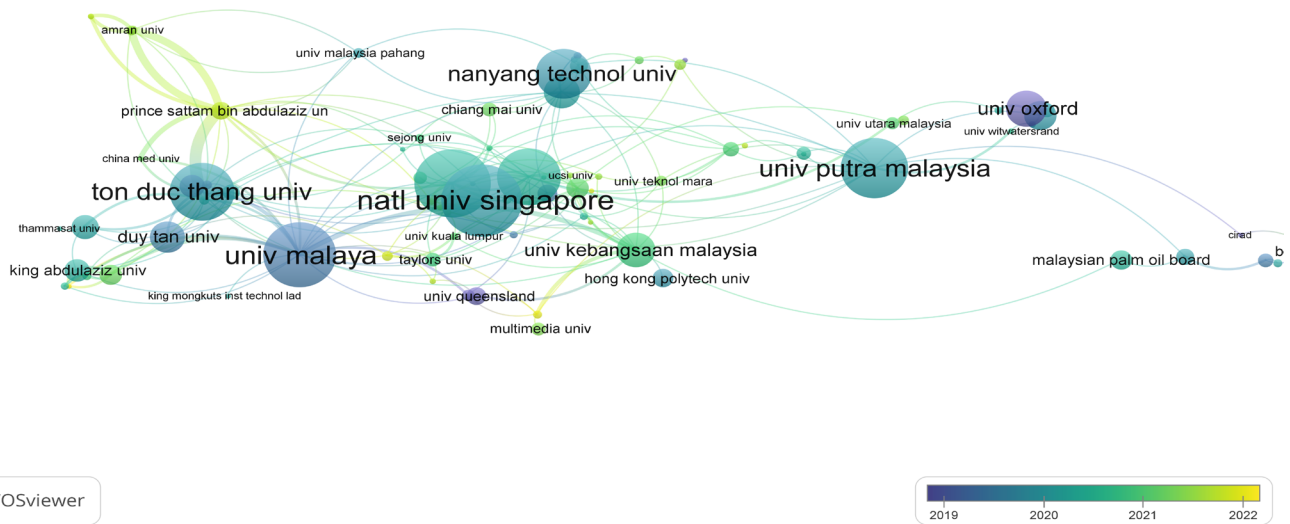


Figure 7: Organizations citation network.

(Source-Visualization in VOSviewer from Web of Science. 84 organizations, minimum number of documents of a source 2, minimum number of citations of a source: 2 and 12 cluster.)

technologies for upgrading biogas, such as water scrubbing and pressure swing absorption, are employed to eliminate undesired elements from the biogas. The article also discusses potential future perspectives that could drive research in sustainable biogas upgrading technologies. The connection between entrepreneurial business networks and the sustainable performance of small firms is emphasized. Entrepreneurial business networks encompass business relationships and firm aggregations as their main categories. The attainment of sustainable performance requires a holistic and systematic model.

Natural fibres like bamboo fibre, oil palm, empty fruit bunch fibre, reinforced polymer composites, etc., are used for

lightweight structures in marine aerospace or construction industries for economic benefits and sustainable development. The impact of chemical treatments applied to cellulose natural fiber-reinforced thermoplastic and thermosetting polymers has been examined. A survey has been conducted on resource management in cloud networking using economic analysis and pricing models. The review specifically explores the application of economic and pricing models in resource management within cloud networking, with a focus on adaptive designs for resource allocation and workload allocation. It discusses how these models can improve social welfare, fairness and resource utilization, leading to sustainable profit advantage and cost

Table 3: 10 most relevant authors ordered by the local number of publications.

| Author | Country | TC | h-index | Number of Publication | m-index | Pub.Year Start |
|------------------------|--------------|-----|---------|-----------------------|---------|----------------|
| Li Y | China | 519 | 6 | 8 | 0.545 | 2014 |
| Mosavi A | Vietnam | 506 | 7 | 7 | 1.167 | 2019 |
| Li L | Singapore | 445 | 6 | 9 | 0.545 | 2014 |
| Mekhilef S | Australia | 408 | 6 | 7 | 0.6 | 2015 |
| Kumar V | Philippines | 200 | 6 | 6 | 0.857 | 2018 |
| Wang Cn | Taiwan | 195 | 7 | 13 | 0.778 | 2016 |
| Mahlia Tmi | Australia | 166 | 8 | 8 | 0.889 | 2016 |
| Kumar A | India | 128 | 6 | 6 | 1.2 | 2020 |
| Amran M | Saudi Arabia | 112 | 5 | 5 | 1.25 | 2021 |
| Thang Trung Nguyen Ttn | Vietnam | 87 | 6 | 9 | 0.857 | 2018 |

Table 4: Top 10 Universities Affiliations' production over time.

| Affiliation | Year | | | | | | | | | | Total |
|-----------------------------------|------|------|------|------|------|------|------|------|------|------|-------|
| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | |
| University of Putra Malaysia | 13 | 9 | 16 | 22 | 24 | 8 | 21 | 42 | 47 | 52 | 254 |
| University of Malaya | 11 | 11 | 26 | 17 | 9 | 13 | 27 | 17 | 27 | 75 | 233 |
| National University of Singapore | 5 | 5 | 20 | 9 | 13 | 28 | 33 | 20 | 43 | 49 | 225 |
| Nanyang Technological University | 2 | 5 | 6 | 8 | 12 | 17 | 43 | 33 | 19 | 21 | 166 |
| University Kebangsaan Malaysia | 1 | 3 | 2 | 5 | 6 | 4 | 7 | 22 | 51 | 52 | 153 |
| Ton Duc Thang University | 0 | 0 | 0 | 0 | 0 | 20 | 29 | 56 | 12 | 15 | 132 |
| University Sains Malaysia | 3 | 3 | 1 | 12 | 4 | 10 | 6 | 21 | 24 | 41 | 125 |
| University of Technology Malaysia | 1 | 5 | 2 | 7 | 7 | 13 | 8 | 17 | 23 | 41 | 124 |
| Chiang Mai University | 0 | 0 | 0 | 2 | 0 | 6 | 2 | 17 | 21 | 41 | 89 |
| PETRONAS University of Technology | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 25 | 21 | 35 | 88 |

reduction. The researchers have explored incentive mechanisms and pricing strategies for sharing resources in edge computing and cloud-based software-defined wireless networking while highlighting challenges and future research directions.

The researchers have identified predictors of poor functional outcomes and mortality in hip fracture patients, including low hand grip strength, frailty, medical factors (e.g., co-morbidities), surgical factors (e.g., delay in operation), socio-economic factors (e.g., age, gender) and system factors (e.g., lower case-volume centres). These predictors can inform healthcare providers about early intervention and improved patient care. Another study has highlighted the utilization of natural fibers in Poly(Vinyl Alcohol) (PVA) composites, showcasing their properties, processing methods, biodegradability and applications in various industries. It discusses the advantages of chemical and physical modifications and the importance of proper nanocellulose arrangement for improved dispersion. Despite their potential, challenges regarding technological feasibility, environmental impact and economic viability also need to be addressed.

Another study has reviewed 111 research papers on the Soil and Water Assessment Tool (SWAT), specifically examining its performance in addressing hydro-climatic extremes such as droughts and floods. The majority of the studies indicate satisfactory performance, particularly in comparisons related to peak flow. Future research requirements encompass the development of a unified performance assessment framework, enhancements in replicating both peak and low flows and the incorporation of artificial intelligence into SWAT modeling.

Gold open access publishing serves as a crucial driver of research innovation, fostering the widespread dissemination of research findings. In an environment where research findings are freely accessible, innovation thrives as ideas and technologies are readily shared and built upon. This accessibility promotes transparency, accountability and encourages collaboration across disciplinary boundaries, leading to the generation of new ideas and the advancement of knowledge. Authors who publish in open access journals ensure that their work is accessible to a global audience immediately upon publication. By building upon existing research and identifying gaps in knowledge, researchers can explore new

Table 5: Top 15 publishers.

| Name | Frequency | Percentages |
|---|-----------|-------------|
| MDPI | 528 | 40.5% |
| ELSEVIER | 180 | 13.8% |
| WILEY | 69 | 5.3% |
| Frontiers Media Sa | 68 | 5.2% |
| IEEE-INST Electrical Electronics Engineers Inc | 51 | 3.9% |
| BMC | 44 | 3.4% |
| Springer Nature | 39 | 3.0% |
| Hindawi Ltd., | 34 | 2.6% |
| Routledge Journals, Taylor and Francis Ltd., | 33 | 2.5% |
| Public Library Science | 31 | 2.4% |
| Pergamon-Elsevier Science Ltd., | 21 | 1.6% |
| Royal Soc Chemistry | 11 | 0.8% |
| Nature Portfolio | 10 | 0.8% |
| BMJ Publishing Group | 9 | 0.7% |
| Malaysian Palm Oil Board | 9 | 0.7% |
| Others | 166 | 12.7% |
| Totals | 1303 | |

avenues for inquiry and drive innovation forward. In the context of gold open access publishing, where authors cover the costs to make their work freely available, institutional financial support becomes crucial. By providing funding assistance for Author Processing Charges (APCs), institutions ensure that financial constraints do not hinder researchers from disseminating their findings widely. This support not only benefits individual researchers but also contributes to the overall advancement of the research community by promoting open and collaborative practices.

This increased visibility and accessibility of research outputs stimulate innovation ecosystems, driving further progress and economic growth. The institutional support for APCs to facilitate gold open access publishing promotes equitable access to knowledge and fuels innovation in countries, in the initial stage or learning stage to progress and reach in the Frontiers group. By investing in open access initiatives, institutions empower researchers to contribute meaningfully to their fields and drive progress in science and technology worldwide.

In other words, gold open access publishing serves as a catalyst for research innovation by breaking down barriers to access and fostering a culture of knowledge sharing and collaboration

Computational Keyword Analysis

Part (A) demonstrates the bibliometric analysis for the author-supplied keywords and the size of nodes presents the

Table 6: Top 15 Journals from 2013-2022.

| Sources | Articles | Percentage | APC Charges (\$) | No. of Citations | Impact Factor |
|---|----------|------------|------------------|------------------|---------------|
| Sustainability | 233 | 18% | \$ 2,725.00 | 3563 | 3.9 |
| Energies | 67 | 5% | \$ 2,952.08 | 770 | 3.2 |
| IEEE Access | 46 | 4% | \$ 1,995.00 | 736 | 3.9 |
| PLOS One | 30 | 2% | \$ 2,290.00 | 651 | |
| Processes | 27 | 2% | \$ 2,725.00 | 476 | 3.5 |
| Applied Sciences-Basel | 23 | 2% | \$ 2,725.00 | 445 | 2.7 |
| Heliyon | 20 | 2% | \$ 2,100.00 | 131 | 4 |
| International Journal of Energy Research | 20 | 2% | \$ 2,570.00 | 327 | 4.6 |
| Case Studies in Thermal Engineering | 19 | 1% | \$ 1,190.00 | 282 | 6.8 |
| Economic Research-Ekonomiska Istrazivanja | 16 | 1% | \$ 1,000.00 | 201 | |
| Energy Reports | 15 | 1% | \$ 2,660.00 | 319 | 5.2 |
| Frontiers In Psychology | 14 | 1% | \$ 3,295.00 | 33 | 3.8 |
| Mathematics | 14 | 1% | \$ 2,952.08 | 256 | 2.4 |
| Animals | 12 | 1% | \$ 2,725.00 | 157 | 3 |
| Scientific Reports | 12 | 1% | No | 293 | 4.6 |
| Rest Of Other Journals | 735 | 56% | | 15680 | |
| Total | 1303 | - | - | 24320 | - |

APC- Article Publishing Charge. IF- Impact Factor 2022.

frequency of recurrence. When the distance between the keywords is short, the keywords co-occur more frequently with each other. Part (B) analysed abstract of the articles. Keyword overlay map (Red to yellow represents the evolution of research heat from near to far over time.

In summarizing research topics, keyword analysis serves as a reflection of the frontiers within the research field, offering

insights into potential future directions. Out of the 3911 author-provided keywords, 73 core keywords were extracted based on a co-occurrence frequency of ≥ 2 times. Due to space constraints and brevity considerations, these core keywords were employed to create a co-occurrence keyword knowledge map using VOSviewer, identifying 399 keywords and generating eight clusters (Figure 7A). The keyword analysis emphasizes

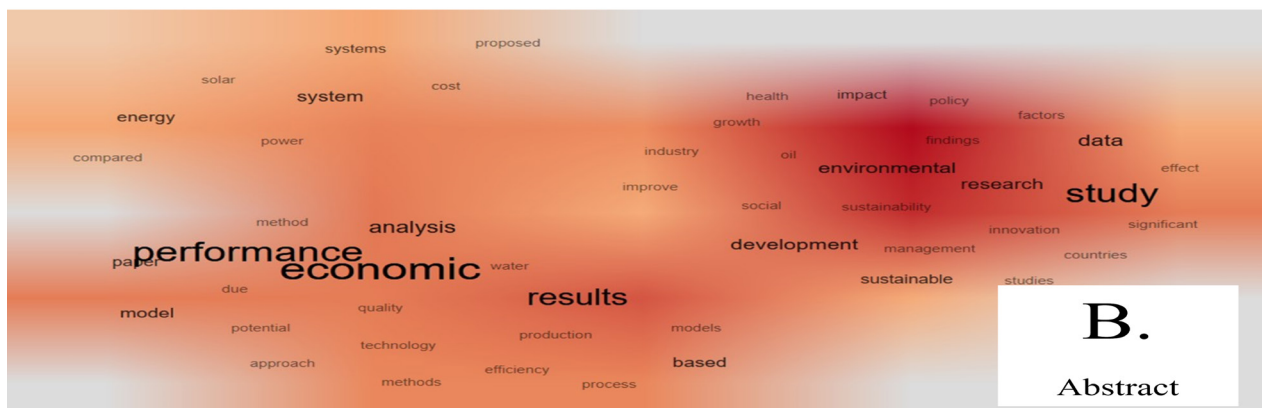
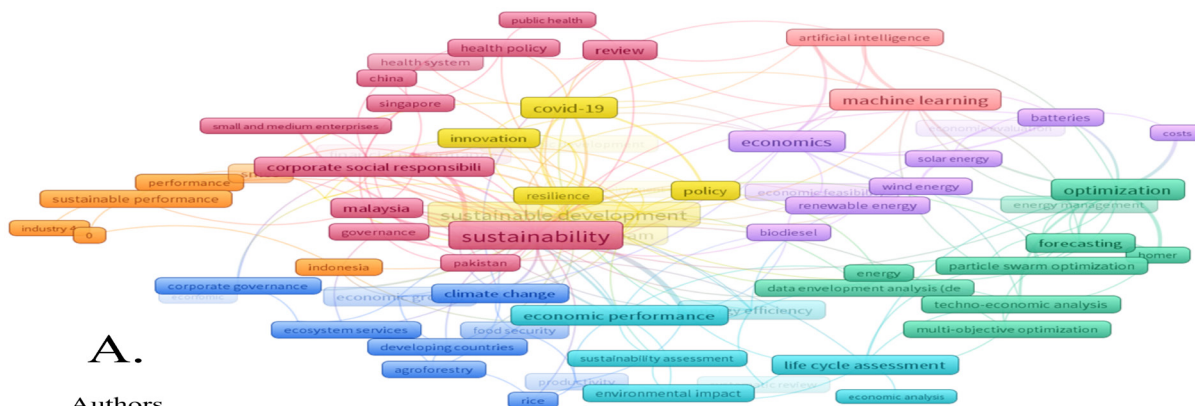


Figure 8: Computational keyword and abstract keyword analysis.

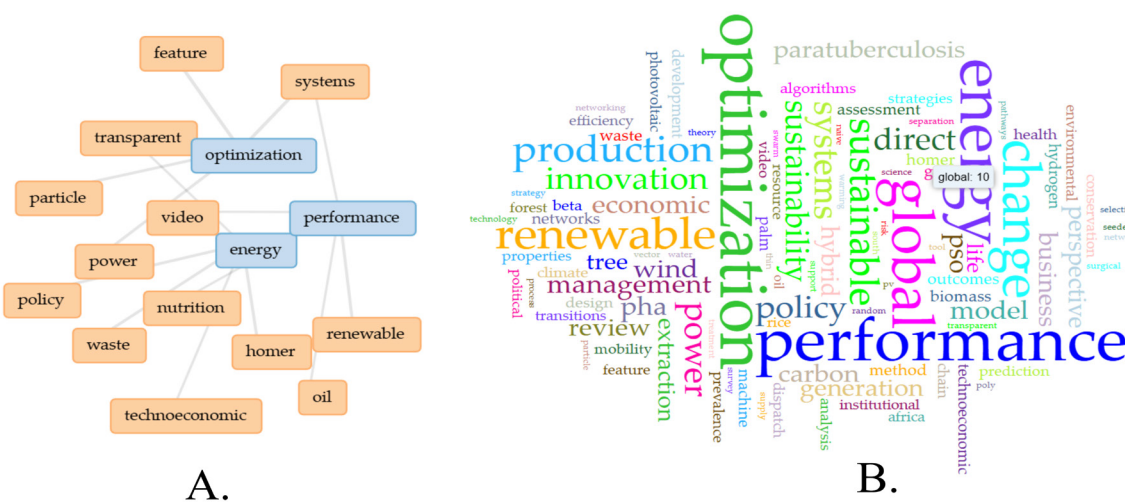


Figure 9: Analysis of Keywords from the Top 30 Most Cited Articles (Using Author Keywords and Keyword Plus from Web of Science). Part (A) shows the connections between leading keywords. (B) presents a word cloud of the top 100 keywords.

Table 7: Content Analysis of the Top 30 articles extracted from WoS

| Sl. No | Article Title | Authors | Year | Findings | SDG |
|--------|--|--|--|---|--|
| 1 | Exploring the governance and politics of transformations towards sustainability | Patterson, J; Schulz, K; Vervoort, J; van der Hel, S; Widerberg, O; Adler, C; Hurlbert, M; Anderton, K; Sethi, M; Barau, A | 2017/Journal Environmental Innovation And Societal Transitions | The concept of “transformations towards sustainability” has gained importance in global sustainability research and policy. Governance and politics are crucial to understanding these transformations, though they still need to be explored. Using the Earth System Governance framework, this paper has reviewed four main approaches—socio-technical transitions, social-ecological systems, sustainability pathways, and transformative adaptation. By bringing together these diverse perspectives, the paper has highlighted important insights and identified key challenges and opportunities for future research on sustainability transformations. | 07 - Affordable and Clean Energy |
| 2 | Technologies and policies to decarbonize global industry: Review and assessment of mitigation drivers through 2070 | Rissman, J; Bataille, C; Masanet, E; Aden, N; Morrow, WR; Zhou, N; Elliott, N; Dell, R; Heeren, N; Huckestein, B; Cresko, J; Miller, SA; Roy, J; Fennell, P; Cremmins, B; Blank, TK; Hone, D; Williams, ED; du Can, SD; Sisson, B; Williams, M; Katzenberger, J; Burtraw, D; Sethi, G; Ping, H; Danielson, D; Lu, HY; Lorber, T; Dinkel, J; Helseth, J | 2020/Applied Energy | Fully decarbonizing global industry has been recognized as essential for climate stabilization, with net zero emissions needed by 2050–2070 to limit warming to 2 °C. This paper has examined supply- and demand-side solutions for achieving net zero industrial emissions. Key technologies include energy efficiency, carbon capture, electrification, zero-carbon hydrogen, and industry-specific innovations for cement, steel, and chemicals. Demand-side strategies include material-efficient design, waste reduction, and circular economy practices. Effective policy measures, such as carbon pricing, research support, and efficiency standards, have been highlighted as crucial. Ensuring a just transition and supporting low-income countries have also been emphasized. | 13- Climate Action |
| 3 | Estimating an EQ-5D-5L Value Set for China | Luo, N; Liu, G; Li, MH; Guan, HJ; Jin, XJ; Rand-Hendriksen, K | 2017/ Value in health | This study has aimed to estimate an EQ-5D-5L value set for China based on the health preferences of urban residents. Using the time trade-off (TTO) method, values for 86 health states were gathered from 1271 participants across five cities. Four regression models—two additive and two multiplicative—were tested to find the best fit for predicting TTO values. The 8- and 9-parameter multiplicative models outperformed the additive models, with the 8-parameter model being the most efficient. This model has been recommended to generate EQ-5D-5L values for economic evaluations in China, rescaling values so that 1 represents total health. | 12- Responsible Consumption and Production |

| | | | | | |
|---|--|---|--|--|--|
| 4 | Start a Research on Biopolymer Polyhydroxy-alkanoate (PHA): A Review | Tan, GYA; Chen, CL; Li, L; Ge, L; Wang, L; Razaad, IMN; Li, Y; Zhao, L; Mo, Y; Wang, JY | 2014/ Polymers | The development of material substitutes is essential for reducing mankind's dependency on fossil resources. Polyhydroxyalkanoate (PHA) is a better option. Research has identified numerous PHA-producing microbes and developed various techniques for PHA analysis, which are stored in culture collections. This review has aimed to support new PHA research by summarizing available PHA-producing microbial strains, PHA biosynthesis pathways, and methods for detection, extraction, and analysis, making it easier to start PHA studies. | 03- Good Health and Well-being |
| 5 | An overview of solar photovoltaic panels' end-of-life material recycling | Chowdhury, MS; Rahman, KS; Chowdhury, T; Nuthammachot, N; Techato, K; Akhtaruzzaman, M; Tiong, SK; Sopian, K; Amin, N | 2020/ Energy Strategy Reviews | The rapid growth of solar power has brought environmental concerns about end-of-life (EOL) solar panel waste. With global solar PV capacity expected to reach 4500 GW by 2050, PV waste could surpass 80% of installed capacity (around 78 million tonnes). The EU has pioneered regulations for PV waste, requiring manufacturers to fund collection and recycling. This review has examined the status of solar panel recycling, including technology, policies, and economic factors, and has suggested improvements. Extending manufacturer responsibility for recycling and enhancing the efficiency and cost-effectiveness of recycling systems has been deemed essential. | 07- Affordable and Clean Energy |
| 6 | A review of transparent solar photovoltaic technologies | Husain, AAF; Hasan, WZW; Shafie, S; Hamidon, MN; Pandey, SS | 2018/ Renewable & Sustainable Energy Reviews | The energy demand has grown with economic development, driving innovations in solar technology. This review has focused on transparent solar cells (TSCs), which allow windows in buildings and cars to generate electricity, solving the space limitations of traditional solar panels. Around nine transparent photovoltaic (TPV) technologies are in development, aiming for high transparency and efficiency. This study has summarized technologies since 2007, detailing processes, materials, and their benefits and drawbacks in terms of performance, aesthetics, and cost, highlighting recent advancements in TSCs. | 12- Responsible Consumption and Production |

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|-----|--|--|---|---|---|
| 7 | Global value chains: A review of the multi-disciplinary literature | Kano, L; Tsang, EWK; Yeung, HWC | 2020/ Journal of International Business Studies | This article has reviewed the fast-growing global value chain (GVC) research field, examining vital conceptual frameworks and studies across various disciplines, including management and economics. Using a comparative institutional approach, it has identified governance issues at micro, GVC, and macro levels, noting that some areas have received more focus than others. The article has proposed future research topics, including GVC governance, mapping, lead firm strategies, value distribution, digitization, protectionism impacts, and performance management, to deepen understanding of GVC dynamics and impacts. | 09- Industry, Innovation and Infrastructure |
| 8 | De-globalization: Theories, predictions, and opportunities for international business research | Witt, MA | 2019/ Journal of International Business Studies | This paper has explored how de-globalization could reshape international business (IB) strategies, structures, and behaviors, emphasizing the need to integrate political perspectives. It has introduced two political theories, liberalism and realism, which foresee de-globalization but differ in their economic predictions. Key IB research areas identified include multinational enterprises' (MNEs) political strategies, the evolution of global value chains, and the influence of national contexts on globalization, economic links, and military power. | 09- Industry, Innovation and Infrastructure |
| 999 | Serious Gaming and Gamification Education in Health Professions: Systematic Review | Gentry, Sarah Victoria; Gauthier, Andrea; Ehrstrom, Beatrice L'Estrade; Wortley, David; Lilienthal, Anneliese; Car, Lorraine Tudor; Dauwels-Okutsu, Shoko; Nikolaou, Charoula K.; Zary, Nabil; Campbell, James; Car, Josip | 2019/ Journal of medical internet research | This review has examined the effectiveness of serious gaming and gamification in health professions education, comparing it with traditional and other digital learning methods. It has found that serious gaming often matches or exceeds traditional learning in improving knowledge, skills, and satisfaction. However, evidence quality has been low due to study limitations, imprecision, and inconsistencies, highlighting a need for more rigorous, theory-driven research to assess these educational methods better. | 04-Quality Education |
| 10 | Sustainable Business Models: A Review | Nosratabadi, S; Mosavi, A; Shamshirband, S; Zavadskas, EK; Rakotonirainy, A; Chau, KW | 2019/ Sustainability | This research has reviewed sustainable business models across fourteen fields, examining their progress, challenges, and research gaps. It has highlighted how sustainable models have helped businesses achieve economic, social, and environmental goals, contributing to competitive advantage. The study has found that sustainable business models have grown in popularity and success, especially with advanced technologies, and has provided insights into current practices and future research directions for sustainable business strategies. | - |

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|----|---|---|-------------------------------|--|--------------------------------|
| 11 | Control of paratuberculosis: who, why and how. A review of 48 countries | Whittington, R; Donat, K; Weber, MF; Kelton, D; Nielsen, SS; Eisenberg, S; Arrigoni, N; Juste, R; Sáez, JL; Dhand, N; Santi, A; Michel, A; Barkema, H; Kralik, P; Kostoulas, P; Citer, L; Griffin, F; Barwell, R; Moreira, MAS; Slana, I; Koehler, H; Singh, SV; Yoo, HS; Chávez-Gris, G; Goodridge, A; Ocepek, M; Garrido, J; Stevenson, K; Collins, M; Alonso, B; Cirone, K; Paolicchi, F; Gavey, L; Rahman, MT; de Marchin, E; Van Praet, W; Bauman, C; Fecteau, G; McKenna, S; Salgado, M; Fernández-Silva, J; Dziejzinska, R; Echeverría, G; Seppänen, J; Thibault, V; Fridriksdottir, V; Derakhshandeh, A; Haghkhah, M; Ruocco, L; Kawaji, S; Momotani, E; Heuer, C; Norton, S; Cadmus, S; Agdestein, A; Kampen, A; Szteyn, J; Frössling, J; Schwan, E; Caldow, G; Strain, S; Carter, M; Wells, S; Munyeme, M; Wolf, R; Gurung, R; Verdugo, C; Fourichon, C; Yamamoto, T; Thapaliya, S; Di Labio, E; Ekgat, M; Gil, A; Alesandre, AN; Piaggio, J; Suanes, A; de Waard, JH | 2019/ BMC veterinary research | This study has surveyed 48 countries and found that paratuberculosis is widespread in livestock, with over 20% of herds infected in half the countries. Formal control programs have been implemented in 22 countries, primarily developed ones with veterinary solid services, and have been successful in 73% of these cases. Recommendations have included establishing an international code and promoting long-term, holistic strategies across the livestock industry for effective disease control. | 03- Good Health and Well-being |
| 12 | Particle Swarm Optimization: A Comprehensive Survey | Shami, Tareq M.; El-Saleh, Ayman A.; Alswaiti, Mohammed; Al-Tashi, Qasem; Summakieh, Mhd Amen; Mirjalili, Seyedali | 2022/ IEEE Access | This paper has reviewed particle swarm optimization (PSO), highlighting its issue of premature convergence and presenting four main improvement strategies: parameter adjustments, hybridization with other algorithms (like GA and DE), cooperation, and multi-swarm techniques. It has covered PSO basics, variants, applications in engineering, feature selection, and limitations. It has outlined eight research directions to enhance PSO's performance further. | - |

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|----|---|---|---------------------------------------|---|-------------------------------------|
| 13 | Conceptual and empirical advances in analysing policy mixes for energy transitions | Rogge, KS; Kern, F; Howlett, M | 2017/Energy Research & Social Science | The article has highlighted that how the this special issue has explored policy mixes essential for overcoming barriers to energy transitions, emphasizing the need for diverse instruments and strategies targeting long-term, low-carbon goals. It has adopted a broader approach to policy mixes, examining instrument interactions, policy strategies, and the role of actors and institutions. It has aimed to advance conceptual and empirical understanding, inspiring future research and offering insights for policy development in energy transitions through 15 interdisciplinary papers. | 07- Affordable and Clean Energy |
| 14 | Land-use choices follow profitability at the expense of ecological functions in Indonesian smallholder landscapes | Clough, Y <i>et al</i> | 2016/ Nature Communications | In Indonesia, small farmers have prioritized high-profit crops like oil palm and rubber, often replacing vital forests and agroforests. This shift has impacted both soil health and biodiversity. While oil palm has brought economic benefits, it has also increased fertilizer use and nutrient loss. Balancing economic goals with sustainable practices in these landscapes is essential to prevent further environmental harm. | 15-Life on Land,01- No Poverty |
| 15 | Revisiting Success and Failure Marine Protected Areas: A Conservation Scientist Perspective | Giakoumi, Sylvain <i>et al</i> | 2018/Frontiers In Marine Science | Marine protected areas (MPAs) have proven essential for conserving marine life, but their success has depended on several factors. Across 27 case studies, engaging stakeholders has emerged as the most critical factor for MPA success, with its absence often leading to failure. Standardized metrics have been recommended to improve effectiveness, covering diverse goals and assessing stakeholder involvement, leadership, enforcement, and compliance through a collaborative approach to adaptive management. | 15 Life on Land,14 Life Below Water |
| 16 | OIL PALM ECONOMIC PERFORMANCE IN MALAYSIA AND R&D PROGRESS IN 2017 | Kushairi, A; Loh, SK; Azman, I; Hishamuddin, E; Ong-Abdullah, M; Izuddin, ZBMN; Razmah, G; Sundram, S; Parveez, GKA | 2018/Journal of Oil Plm Research | Oil palm has played a significant role in global agriculture, accounting for one-third of oils and fats production in 2017. Primarily grown in Indonesia and Malaysia, the industry has expanded through mechanization, pest control, breeding, and biotechnology strategies. Sustainable milling practices have been implemented, as well as managing by-products and wastewater. Palm oil's use in non-food applications, like biodiesel and oleo chemicals, has supported a circular economy through technological and market diversification. | - |

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|----|---|--|--|---|--|
| 17 | Sustaining the low-carbon emission development in Asia and beyond: Sustainable energy, water, transportation and low-carbon emission technology | Lee, CT; Hashim, H; Ho, CS; Fan, YV; Klemes, JJ | 2017/ Journal Of Cleaner Production | Climate change has emerged as a critical issue with economic, social, and environmental impacts. In Asia, efforts to reduce CO ₂ emissions, which account for 65% of greenhouse gases, have played a significant role in global mitigation. Initiatives like the Low-Carbon Society have aimed to support green growth, social well-being, and environmental preservation. Energy efficiency, green transportation, and low-emission technology are key to achieving long-term, climate-resilient development | 13-climate Action |
| 18 | Energy Management and Optimization of a PV/Diesel/Battery Hybrid Energy System Using a Combined Dispatch Strategy | Aziz, AS; Tajuddin, MFN; Adzman, MR; Ramli, MAM; Mekhilef, S | 2019/ Sustainability | . Researchers have demonstrated that hybrid energy systems (HESs) are effective for powering remote areas, with a combined dispatch (CD) control strategy showing clear advantages. By blending load following (LF) and cycle charging (CC) methods, the CD strategy has reduced costs by 20.6% and CO ₂ emissions to 27,678 kg/year, as shown in simulations using HOMER software. Critical factors like battery charge, solar radiation, and diesel price have significantly influenced the system's performance. | 07 Affordable and Clean Energy |
| 19 | A review of SWAT applications, performance and future needs for simulation of hydro-climatic extremes | Tan, Mou Leong; Gassman, Philip W.; Yang, Xiaoying; Haywood, James | 2020/Advances In Water Resources | This research has reviewed 111 studies since 1999 that use the Soil and Water Assessment Tool (SWAT) to simulate hydro-climatic extremes like droughts and floods, primarily in the United States and China. It has highlighted the need for a unified SWAT performance framework, better replication of peak and low flows, and integration of artificial intelligence to improve extreme flow simulations and assess the reliability of global and satellite data products | 13 Climate Action06 Clean Water and Sanitation |
| 20 | Response to the Novel Corona Virus (COVID-19) Pandemic Across Africa: Successes, Challenges, and Implications for the Future | Ogunleye, OO <i>et al</i> | 2020/ Frontiers In Pharmacology | The COVID-19 pandemic has posed significant challenges in Africa due to existing disease burdens and limited resources. Although prevalence and mortality rates have been lower than in Western countries, concerns have arisen regarding the impact on non-communicable diseases (NCDs) and misinformation. Efforts like lockdowns, equipment innovations, and addressing misinformation have begun, while collaboration with WHO and further research have been essential for guiding future actions and learning across nations. | 03- Good Health and Well-being |

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|----|---|--|---|--|---|
| 21 | Resource Management in Cloud Networking Using Economic Analysis and Pricing Models: A Survey | Luong, NC; Wang, P; Niyato, D; Wen, YG; Han, Z | 2017/ IEEE Communications Surveys And Tutorials | The paper has conducted a comprehensive review of economic and pricing models in cloud networking resource management. It has highlighted adaptive designs as essential for addressing allocation and workload challenges. Key findings include the importance of economic models for profit sustainability, flexibility, and enhanced social welfare. Additionally, it has examined incentive mechanisms in edge computing and cloud-based wireless networking, identifying significant challenges and future research directions. | 09- Industry, Innovation and Infrastructure |
| 22 | Techno-economic analysis of hybrid PV-diesel-battery and PV-wind-diesel-battery power systems for mobile BTS: the way forward for rural development | Olatomiwa, Lanre; Mekhilef, Saad; Huda, A. S. N.; Sanusi, Kamilu | 2015/ Energy Science & Engineering | . This study has conducted a techno-economic analysis of hybrid solar and wind systems to power a remote mobile base station in Nigeria using HOMER software. It has compared PV-diesel-battery and PV-wind-diesel-battery systems with a stand-alone diesel generator. Findings have shown the PV-diesel-battery configuration is most cost-effective, with a net cost of \$69,811 and CO2 reduction of 16.4 tons per year, while sensitivity analysis has highlighted the impact of solar, wind, and diesel price variations. | 07 Affordable and Clean Energy |
| 23 | Predictors of poor functional outcomes and mortality in patients with hip fracture: a systematic review | Xu, BY; Yan, S; Low, LL; Vasanwala, FF; Low, SG | 2019/ BMC Musculoskeletal Disorders | This systematic review has examined predictors of poor functional outcomes and mortality in hip fracture patients, identifying 81 studies from 4,339 articles. Key predictors include low hand grip strength, frailty, co-morbidities, high ASA grade, sarcopenia, delayed surgery, fracture type, and socio-economic factors like age and gender. System factors, such as treatment in lower case-volume centers, have also been noted. These findings have highlighted critical factors for early intervention in patient care. Understanding these predictors enables healthcare providers to assess patient health status and intervene early on modifiable factors, potentially improving outcomes for hip fracture patients. | 05 Gender Equality 03 Good Health and Well-being |
| 24 | Landslide Susceptibility Modeling Based on GIS and Novel Bagging-Based Kernel Logistic Regression | Chen, Wei <i>et al</i> | 2018/ Applied Sciences-Basel | This study has introduced a novel BKLR model, combining bagging-based kernel logistic regression for landslide prediction in Shangnan County, China. By evaluating 15 conditioning factors, the BKLR model has demonstrated superior performance over traditional methods like KLR and support vector machine, effectively addressing over-fitting and variance issues. The generated susceptibility maps have shown potential for improved hazard mitigation, providing valuable tools for landslide-prone areas similar to Shangnan County | 13 Climate Action |

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|----|--|---|---|---|--------------------------------|
| 25 | Thermogravimetric Analysis Properties of Cellulosic Natural Fiber Polymer Composites: A Review on Influence of Chemical Treatments | Nurazzi, N. M.; Asyraf, M. R. M.; Rayung, M.; Norrrahim, M. N. F.; Shazleen, S. S.; Rani, M. S. A.; Shafi, A. R.; Aisyah, H. A.; Radzi, M. H. M.; Sabaruddin, F. A.; Ilyas, R. A.; Zainudin, E. S.; Abdan, K. | 2021/Polymers | This review has examined the effects of chemical treatments on natural fiber-reinforced polymer composites, focusing on cellulose fibers like bamboo, oil palm, kenaf, and sugar palm. The treatments have addressed issues like poor interfacial bonding and thermal stability due to fiber hydrophilicity in polymer matrices. Thermogravimetric analysis (TGA) has been used to assess purity, composition, and ignition temperatures, providing insights into temperature stability and enhancing fiber-polymer bonding, which is essential for improved composite performance | - |
| 26 | Feasibility analysis of hybrid photovoltaic/battery/fuel cell energy system for an indigenous residence in East Malaysia | Das, Himadry Shekhar; Tan, Chee Wei; Yatim, A. H. M.; Lau, Kwan Yiew | 2017/ Renewable & Sustainable Energy Reviews | This paper examines the feasibility of renewable energy (RE) systems as alternatives to diesel-based systems for rural electrification in Sarawak, East Malaysia. It focuses on the potential of solar energy and investigates photovoltaic (PV), Battery, and Fuel Cell (FC) based systems for a village longhouse in Kapit. Using HOMER software, the study compares the net present cost (NPC) and cost of energy (COE) of these systems with conventional diesel-based systems, finding that the PV/Battery system is the most economical and environmentally friendly option, making it a suitable replacement for diesel systems. The study also discusses operational strategies and sensitivity analysis for optimal performance. | 07 Affordable and Clean Energy |
| 27 | A Review of Natural Fiber Reinforced Poly(Vinyl Alcohol) Based Composites: Application and Opportunity | Tan, BK; Ching, YC; Poh, SC; Abdullah, LC; Gan, SN | 2015/Polymers | This paper has provided a comprehensive review of natural fiber-reinforced poly(vinyl alcohol) (PVA) composites, emphasizing their biodegradability and performance across various applications. It has discussed properties, processing methods, and modifications that enhance composite qualities. Challenges like agglomeration and dispersion have been highlighted, alongside the potential for diverse applications. However, it has cautioned that technological feasibility, environmental impact, and economic viability must be thoroughly evaluated for the broader adoption of PVA composites. | - |

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|----|--|--|--|---|--|
| 28 | Spatial Prediction of Landslide Susceptibility Using GIS-Based Data Mining Techniques of ANFIS with Whale Optimization Algorithm (WOA) and Grey Wolf Optimizer (GWO) | Chen, Wei; Hong, Haoyuan; Panahi, Mandi; Shahabi, Himan; Wang, Yi; Shirzadi, Ataollah; Pirasteh, Saied; Alesheikh, Ali Asghar; Khosravi, Khabat; Panahi, Somayeh; Rezaie, Fatemeh; Li, Shaojun; Jaafari, Abolfazl; Dieu Tien Bui; Bin Ahmad, Baharin | 2019/Applied Sciences-Basel | This study has proposed an integrated landslide modeling framework using an adaptive neuro-fuzzy inference system (ANFIS) enhanced with whale optimization (WOA) and grey wolf optimizer (GWO) in Anyuan County, China. Incorporating the SWARA method for weight determination, the framework has been validated using 315 historical landslide events, showing improved prediction accuracy over traditional methods. The SWARA-ANFIS-GWO model has demonstrated the highest accuracy, highlighting its suitability for global landslide management and mitigation efforts | 13 Climate Action |
| 29 | Can productivity and profitability be enhanced in intensively managed cereal systems while reducing the environmental footprint of production? Assessing sustainable intensification options in the breadbasket of India | Kumar, Virender; Jat, Hanuman S.; Sharma, Parbodh C.; Balwinder-Singh; Gathala, Mahesh K.; Malik, Ram K.; Kamboj, Baldev R.; Yadav, Arvind K.; Ladha, Jagdish K.; Raman, Anitha; Sharma, D. K.; McDonald, Andrew | 2018/Agriculture Ecosystems & Environment | This study has evaluated sustainable intensification (SI) strategies in Northwest India's Indo-Gangetic Plains, aiming to boost productivity and profitability while reducing environmental impact. Over five years, SI approaches integrating diversification, precision management, and conservation agriculture have increased productivity and profitability by 10-17% and 24-50%, respectively, while reducing water and energy use (15-71% and 17-47%) and global warming potential (15-30%). These results highlight SI's transformative potential but stress market and labor considerations. | 15 Life on Land 13 Climate Action 02 Zero Hunger |
| 30 | Current status of biogas upgrading for direct biomethane use: A review | Khan, Muhammad Usman; Lee, Jonathan Tian En; Bashir, Muhammad Aamir; Dissanayake, Pavani Dulanja; Ok, Yong Sik; Tong, Yen Wah; Shariati, Mohammad Ali; Wu, Sarah; Ahring, Birgitte Kiaer | 2021/ Renewable & Sustainable Energy Reviews | This review has examined the growing use of biogas production as renewable energy, highlighting challenges from unwanted elements in biogas. It has analyzed upgrading technologies like water scrubbing, amine scrubbing, and pressure swing adsorption, noting high energy and cost drawbacks. Recent advances in physical, chemical, and biological methods, including cryogenic separation and biological upgrading, have been explored. Comparative studies on complexities and economics have been provided, with future perspectives emphasizing sustainable, hybrid biogas upgrading systems | 12 Responsible Consumption and Production |

sustainability and energy, with a focus on technological methods like optimization and machine learning. Geographic specificity and the integration of environmental and economic themes highlight the multidisciplinary nature of sustainability research across various regions. A detailed list of top 30 keyword occurrence can be found in Appendix A.

The top 10 co-occurrence keywords include sustainability, sustainable development, machine learning, economics, COVID-19, corporate social responsibility, economic performance, financial performance, Vietnam and Malaysia (Figure 8). In contrast, the results of abstract analysis encompass

similar themes, focusing on environmental development studies and economic performance, with additional emphasis on energy, system and consumption. The density map indicates a significantly higher co-occurrence frequency of keywords in the red area compared to the yellow area.

The network structure of these keywords (Figure 9) suggests a focus on the techno-economic aspects of environmental and production systems, which could be tied to multiple SDGs emphasizing sustainability and efficient resource use. These keywords closely align with SDG 9 (Industry, Innovation and Infrastructure), emphasizing the importance of building

Table 8: Top 15 National Innovation System Articles Funding Agencies.

| Funding Country | No. of Articles | Major Funding Organizations |
|--------------------------|-----------------|---|
| Malaysia | 208 | Ministry of Education Malaysia; Ministry of Higher Education (MOHE) Malaysia; Universiti Kebangsaan Malaysia; National Institute for Health Research (NIHR); Universiti Sains Malaysia; Universiti Teknologi Malaysia; University of Malaya; Universiti Tenaga Nasional; Universitas Negeri Malang. |
| China | 102 | National Natural Research Foundation of China; Fujian Province Science and Technology; Natural Science Foundation of China; China University of Mining and Technology; Shanghai Jiao Tong University. |
| Indonesia | 69 | Indonesia Endowment Fund for Education (LPDP); Indonesian Agency for Agricultural Research and Development (IAARD); Institut Teknologi Sumatera; Directorate General of Higher Education, Ministry of Education and Culture, Ministry of Research, Technology and Higher Education; Universitas Padjadjaran; Universitas Airlangga. |
| Thailand | 69 | National Research Council of Thailand; Thailand Research Fund (TRF); Prince of Songkla University; Thammasat University; King Mongkut's Institute of Technology Ladkrabang; Khon Kaen University; Ministry of Agriculture and Cooperatives; Chiang Mai University; Rajamangala University of Technology Thanyaburi. |
| Singapore | 58 | National Research Foundation, Singapore; National University of Singapore; Nanyang Technological University; National Medical Research Council Health Service; National Healthcare Group, Singapore; Singapore Economic Development Board; Singapore Ministry of Education. |
| Vietnam | 45 | University of Economics Ho Chi Minh City; Van Lang University Vietnam; Vietnam National Foundation for Science and Technology Development; VNUHCM-University; Hong Bang International University; University of Danang; National Foundation for Science and Technology Development; Vietnam Academy of Science and Technology. |
| USA | 43 | United States Agency for International Development; Bill and Melinda Gates Foundation; William and Flora Hewlett Foundation; National Institute of Child Health and Human Development; U.S. National Science Foundation; National Institute on Drug Abuse. |
| Saudi Arabia | 31 | King Khalid University; Najran University; King Abdulaziz University; King Saud University; Taif University; Ministry of Education - Kingdom of Saudi Arabia. |
| UK | 26 | UK Research and Innovation; Royal Academy of Engineering; UK Economic and Social Research Council; University of Nottingham. |
| European Union Countries | 26 | European Union; European Union Horizon; Chongqing Social Science Planning Fund; Chongqing Municipal Education Commission. |
| Taiwan | 21 | Ministry of Science and Technology of Taiwan; Institute of Labor, Occupational Safety and Health; National Kaohsiung University of Science and Technology; Taiwan National Kaohsiung University of Science and Technology. |
| Australia | 18 | Australian Centre for International Agricultural Research; Australian Research Council; Queensland University; University of Melbourne. |
| Japan | 18 | Asian Development Bank; Japan Society for the Promotion of Science; Ministry of Education, Culture, Sports, Science and Technology, Japan; Nippon Foundation. |
| France | 14 | Forests, Trees and Agroforestry; French National Research Agency; L'Oreal Company; Consultative Group on International Agricultural Research. |
| Philippines | 14 | Philippine Department of Agriculture; Philippine Rice Research Institute; University of the Philippines Manila; De La Salle University. |

resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation. The prominence and interconnectivity of these keywords in the word cloud reflect a comprehensive approach to addressing sustainability and efficiency across various domains, likely touching on multiple SDGs. This visualization reinforces the importance of cross-disciplinary approaches to tackle global challenges of sustainability and development.

Funding Agencies

Funding agencies play a crucial role in innovation research in ASEAN countries by providing financial support, resources and guidance to researchers and institutions. Funding agencies allocate resources to support innovation research projects, including grants, scholarships and fellowships. This funding enables researchers to conduct studies, develop technologies and explore innovative solutions to address societal challenges. They help prioritize research areas and initiatives that align with national priorities, economic development goals and societal needs. They may identify key areas for investment based on scientific, technological and socio-economic considerations. Funding agencies support capacity-building initiatives to strengthen research infrastructure, develop research skills and foster collaboration among researchers and institutions. This includes providing training programs, workshops and resources to enhance research capabilities.

They assess the impact and effectiveness of innovation research investments through evaluation and monitoring mechanisms. This involves measuring research outputs, outcomes and societal impacts to inform future funding decisions and policy-making.

A total of 922 funded articles were identified, with 16 funding agencies having undefined or shortened names. The table presents the top 15 funding agencies among these 922 articles. The top 3 countries with the most funded articles are Malaysia, China and Indonesia, consistent with the previous observation. Among ASEAN countries, Malaysia, Indonesia, Thailand, Singapore, Vietnam and the Philippines have funded major research articles, while Cambodia has only funded one. Countries such as Brunei, Myanmar and Laos were not found to have funded any research articles. International funding agencies play a significant role in research funding in ASEAN countries. It is also observed that a majority of research publications from ASEAN countries are published in APC-charging journals (Table 6).

DISCUSSION

This study investigates the status of Gold Open Access publishing in the ASEAN region and its evolutionary trajectory over time. The examination is concentrated on the nations of Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam. The findings suggest that while Gold Open Access publishing is gaining traction in the

ASEAN region, there are still various challenges that continue to exist. One of the foremost hurdles is associated with securing adequate funding. A notable challenge stems from the insufficient awareness and comprehension of Gold Open Access publishing among researchers and authors in the ASEAN region. Many individuals remain uninformed about the advantages it offers, such as heightened visibility and accessibility for their research.

Nevertheless, there are encouraging advancements in the ASEAN region concerning Gold Open Access publishing. A notable instance is the growing trend of universities and research institutions initiating their own Gold Open Access journals. This represents a positive stride in fostering Gold Open Access publishing within the region. The results expose a significant disparity in awareness and comprehension among researchers and authors regarding the advantages linked to Gold Open Access. It is imperative to make concerted efforts to close this knowledge gap, as doing so is vital for cultivating a culture that recognizes and values the heightened visibility and accessibility that Gold Open Access can offer to scholarly works.

The outcomes suggest a collaborative engagement of authors from diverse countries, including China, Australia, USA, UK, Japan, India, France, Pakistan, among others, in each other's research endeavors. The intra-ASEAN cross-country collaboration and international partnerships underscore the importance of global cooperation in advancing knowledge and comprehension within the realm of the national innovation system. The study revealed that authors typically prefer journals that involve Article Processing Charges (APC). Scientific Reports stands out for its absence of publication fees, solidifying its position as one of the High-Impact Factor (IF) journals among the group. The data highlights the varied publishing panorama, incorporating a blend of open-access publishers like MDPI and conventional publishers such as ELSEVIER and Wiley.

CONCLUSION

The study of Gold Open Access publishing in ASEAN countries highlights both the advancements achieved and the persistent challenges in this dynamic environment. Although there is evident momentum in embracing Gold Open Access, especially through the initiation of journals by universities and research institutions, significant hurdles still exist. The need for sustainable financial support mechanisms is paramount to ensure the continued growth of open access initiatives in the ASEAN region. As we navigate through the complexities of the publishing landscape in the ASEAN region, highlighting collaboration among essential stakeholders-academic institutions, funding bodies and researchers-is imperative. By collectively addressing challenges and leveraging positive developments, the ASEAN region has the potential to amplify its influence on the global open access movement, facilitating the broad dissemination of valuable research on an international scale. This study lays the

foundation for ongoing discussions and initiatives focused on advancing Gold Open Access publishing in the ASEAN context.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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Cite this article: Awasthi S, Das S, Tripathi M. Gold Open Access Publishing in ASEAN Countries: A Comparative Study. *J Scientometric Res*. 2024;13(3s):s98-s123.

Appendix A: Top 30 author keywords.

| Sl. No. | Keyword | Occurrences | Total link Strength |
|---------|---------------------------------|-------------|---------------------|
| 1 | Sustainability | 63 | 78 |
| 2 | Sustainable Development | 33 | 38 |
| 3 | Optimization | 27 | 39 |
| 4 | Renewable Energy | 25 | 21 |
| 5 | Vietnam | 24 | 24 |
| 6 | Machine Learning | 20 | 19 |
| 7 | Performance | 18 | 15 |
| 8 | Energy | 17 | 25 |
| 9 | Sustainable | 16 | 29 |
| 10 | Malaysia | 13 | 16 |
| 11 | Thailand | 13 | 15 |
| 12 | Innovation | 13 | 14 |
| 13 | Corporate Social Responsibility | 13 | 12 |
| 14 | Climate Change | 13 | 10 |
| 15 | Economic Growth | 13 | 10 |
| 16 | Indonesia | 13 | 9 |
| 17 | Economics | 12 | 26 |
| 18 | Environmental | 12 | 18 |
| 19 | Biodiesel | 12 | 12 |
| 20 | Governance | 12 | 12 |
| 21 | Development | 11 | 17 |
| 22 | Techno-Economic Analysis | 11 | 13 |
| 23 | Energy Efficiency | 11 | 7 |
| 24 | Efficiency | 10 | 11 |
| 25 | System | 10 | 9 |
| 26 | Biomass | 8 | 22 |
| 27 | Technology | 8 | 22 |
| 28 | Emissions | 8 | 13 |
| 29 | Resilience | 8 | 15 |
| 30 | Energy Management | 8 | 7 |