Research Article

Evaluation of Indonesia's Scientific Publication Performance: Quantity, Quality, Open Access, and Comparison with ASEAN Countries

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Scientific publications are an important pillar in the development of national science and innovation. Indonesia has shown a rapid increase in the quantity of publications, fuelled by pro-publication government policies, and has a very high open access (OA) ratio (>90%), reflecting a commitment to open knowledge dissemination. However, a crucial question arises as to whether this growth in quantity is matched by an increase in quality and global scientific impact. This study aims to evaluate Indonesia's scientific publication performance by analysing its quantity, quality (citations), and open access indicators and comparing them with selected ASEAN countries. Researchers conducted analyses using a quantitative descriptive approach and secondary data from global publications over five years, employing Python to examine distributions, correlations, and regional comparisons. The results confirm that Indonesia excels in publication quantity (ranked 5th globally) and has a very high OA ratio. However, the average citations per article are still very low (around 18.3), far below ASEAN countries such as Singapore (298.3) and Malaysia (76.5). A significant negative correlation was found between the OA ratio and average citations per article (r=-0.44), suggesting that the current high open access has not automatically increased scientific impact or visibility globally, possibly because many publications are in journals with limited reputation and reach. Comparison with ASEAN countries highlights the gap between Indonesia's dominance in quantity and its lagging behind in citation quality/impact. These findings imply the need for a strategic reorientation in Indonesia's research ecosystem, moving away from a focus solely on quantity towards improving the quality of research substance, publishing in internationally reputable journals, strengthening global collaborations, and integrating open access policies with efforts to improve the quality of scientific content and visibility to strengthen Indonesia's contribution to the global science scene.

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1. Introduction

Scientific publications are a crucial element in the development of science and innovation in a nation. Through publications, researchers can disseminate research results, build cross-national collaborations, and contribute to the development of evidence-based technologies and policies. In a global context, an increase in the quantity and quality of a country's publications is often used as an indicator of the strength of the research ecosystem and the national capacity to produce knowledge[1].

Indonesia, as the country with the largest population in ASEAN and the fourth largest in the world, has great potential to become an important factor in the international scientific scene. In recent years, the growth in the number of scientific publications from Indonesia has increased rapidly, along with national policies that encourage publication as an academic requirement, both for lecturers and students[2]. Policies such as the obligation of scientific publication in the completion of studies[3], increasing incentives for authors, and strengthening electronic journal infrastructure (OJS) have accelerated the increase in the volume of articles published in various journals, both national and international.

However, an important question that needs to be assessed is whether this surge in publication quantity is also accompanied by an increase in quality and impact on the global scientific community[4]. Indicators such as the ratio of citations per article, the level of open access, and the adoption of preprint practices are crucial to evaluate as a representation of the readability, relevance, and transparency of Indonesian research at the international level[5].

In a regional context, ASEAN provides a relevant landscape for comparison. Countries such as Singapore and Malaysia, for example, have shown high achievements in terms of publication quality, despite having smaller quantities than Indonesia. On the other hand, countries such as Vietnam, Thailand, and the Philippines share a number of structural challenges with Indonesia, ranging from limited research funding to a lack of an open publication culture. By comparing Indonesia's performance within this regional framework, we can gain a deeper understanding of Indonesia's relative position and the direction it needs to take to improve the quality of national research.

This study aims to analyse Indonesia's scientific publication performance based on indicators of quantity, quality, and scientific openness. The analysis is conducted exploratively by comparing Indonesia's data with other ASEAN countries and global trends to identify strengths and weaknesses in the national

publication landscape. Through this approach, it is expected that data-based strategic recommendations can be formulated to strengthen Indonesia's scientific contribution in a sustainable manner.

1.1. Literature review

Studies on the dynamics of scientific publications in the ASEAN region have attracted attention in the scientometrics literature, with a diverse focus ranging from open access to national productivity and economic impact. Research by Awasthi, Das, and Tripathi[6] demonstrates the strategic role of Gold-type open access publishing in increasing the visibility and inclusiveness of research in ASEAN. They emphasise that open access, especially those supported by public funding for article processing charges (APCs), not only expands the dissemination of research results but also supports national innovation systems by encouraging collaboration between ASEAN countries.

In the context of research funding, Mosleh, Roshani, and Coccia[7] showed quantitatively that funded articles receive more citations than unfunded ones, particularly in the life sciences. Using a computational scientometrics approach, they showed that the distribution of citations follows a power law and that research funding plays a key role in increasing the visibility and impact of science.

In terms of accessibility and equity of scientific impact, Huang et al.[8] showed that open access publications are not only more highly cited but also cited by a more geographically diverse and cross-disciplinary community. This study confirms that the impact of open access lies not only in the number of citations but also in their distribution, making an important contribution to the global and equitable use of research.

Meanwhile, Sukoco et al.[9] conducted a comparative study of research productivity in ASEAN countries over the past decade. Their findings show that while Malaysia excels in the number of publications, Singapore remains dominant in quality through citations and patents. Indonesia, despite showing the fastest growth in publications, has not been matched by an equivalent increase in citations. The study also highlights the importance of engineering and life sciences as key drivers of regional scientific productivity.

However, existing literature rarely integratively links scientific productivity, open access, and funding mechanisms in a comparative context across ASEAN countries. In addition, the use of new indicators, such as preprint adoption or the impact on citation diversity, is limited.

Thus, this study is important as it offers a more comprehensive comparative analysis of Indonesia's position in the ASEAN scientific publication landscape. This research integrates the dimensions of

productivity, open access, and impact with data-driven approaches and explorative visualisations relevant to capturing large-scale and complex scientific dynamics.

2. Methodology

This study uses a descriptive quantitative approach based on secondary data to evaluate Indonesia's scientific publication performance globally and regionally. This approach enables a thorough analysis of the quantity, quality, and openness indicators of scientific publications by leveraging data analysis and statistical visualisation. The main focus is on identifying Indonesia's position compared to other ASEAN countries with different research dynamics.

2.1. Data Source and Characteristics

The data analysed is sourced from the https://www.scilit.com/[10], which contains publication information from 218 countries over the past five years. The main variables examined include the total number of scientific articles, OA articles, preprint publications, cited articles, and the total number of citations received. This data provides a quantitative framework for measuring a country's scientific productivity and impact.

Each variable has different characteristics in describing publication performance. The number of articles and OA reflect the quantitative dimension and openness, while the number of citations and cited articles are indicators of quality and scientific impact. The preprint variable, which is still relatively recently adopted in many developing countries, gives an indication of the adoption of an open publication culture before formal peer review. The data in the file not only provides a global picture but is also quite representative for regional analysis, particularly ASEAN.

2.2. Data Analysis Technique

Analyses were conducted using the Python programming language within the Jupyter Notebook platform, which allows for systematic documentation and replication of the analysis process. The data exploration phase began with a data completeness check to identify empty values or outliers, followed by a descriptive statistical analysis to understand the distribution and spread of values for each variable.

Several data transformations were performed to obtain more informative indicators, such as calculating the ratio of OA articles to total articles, the ratio of preprints to total articles, and the average citations per article. These ratios are used to evaluate a country's publication efficiency, not only in terms of quantity

but also in terms of openness and scientific impact. Data visualisations, such as scatter plots, box plots, bar charts, and correlation heatmaps, are used to clarify the pattern of relationships between variables and to show Indonesia's position in the international publication landscape.

The analyses were also geared towards comparisons with ASEAN countries, including Singapore, Malaysia, Thailand, Vietnam, and the Philippines. These countries were chosen because they have relatively active publication profiles and can represent the spectrum of the region's research dynamics. Visualising trends and distributions on each indicator helps highlight Indonesia's relative strengths and weaknesses. The Python notebook used for the entire analysis is included in the appendix (eda.ipynb), which contains the data cleaning process, metric calculations, and comparative visualisations that support a transparent interpretation of the results.

3. Results and Discussion

This chapter presents the findings of the data analysis and interpretation of the patterns that emerge based on the global scientific publication indicators. Each visualisation and table presented in this chapter aims not only to illustrate Indonesia's position on the world science map but also to reveal various challenges and opportunities in the national publication system. The discussion will focus on aspects of open access, the number and impact of publications, the relationship between publication variables, and Indonesia's comparison with other countries in the Southeast Asian region. An in-depth understanding of these results is important for formulating strategies to improve the quality and competitiveness of Indonesian research globally.

3.1. Distribution of the Open Access (OA) Ratio

OA has become an important indicator in assessing the openness and availability of scientific knowledge globally. The OA ratio describes the proportion of scientific articles that can be accessed freely without paid barriers, which is a manifestation of a country's commitment to the dissemination of knowledge. In a global context, the distribution of OA ratios shows significant variation between countries, reflecting differences in national policies, the availability of digital infrastructure, and the level of awareness of the importance of open access. To provide a clearer picture of the distribution of OA ratios around the world, see Figure 1.

Figure 1 shows that most countries have an OA ratio between 0.6 and 0.9. Indonesia is considered one of the countries with the highest OA ratio, at 0.93. This figure shows that more than 90% of scientific articles

published in Indonesia are openly accessible. This success is most likely influenced by national policies such as regulations that encourage the publication of OA journals at the university level and government support for open access-based national journals through accreditation and indexation in the Directory of Open Access Journals (DOAJ). This finding is important because it reflects the spirit of democratising science in Indonesia, although it is not necessarily accompanied by an increase in quality in terms of scientific impact.

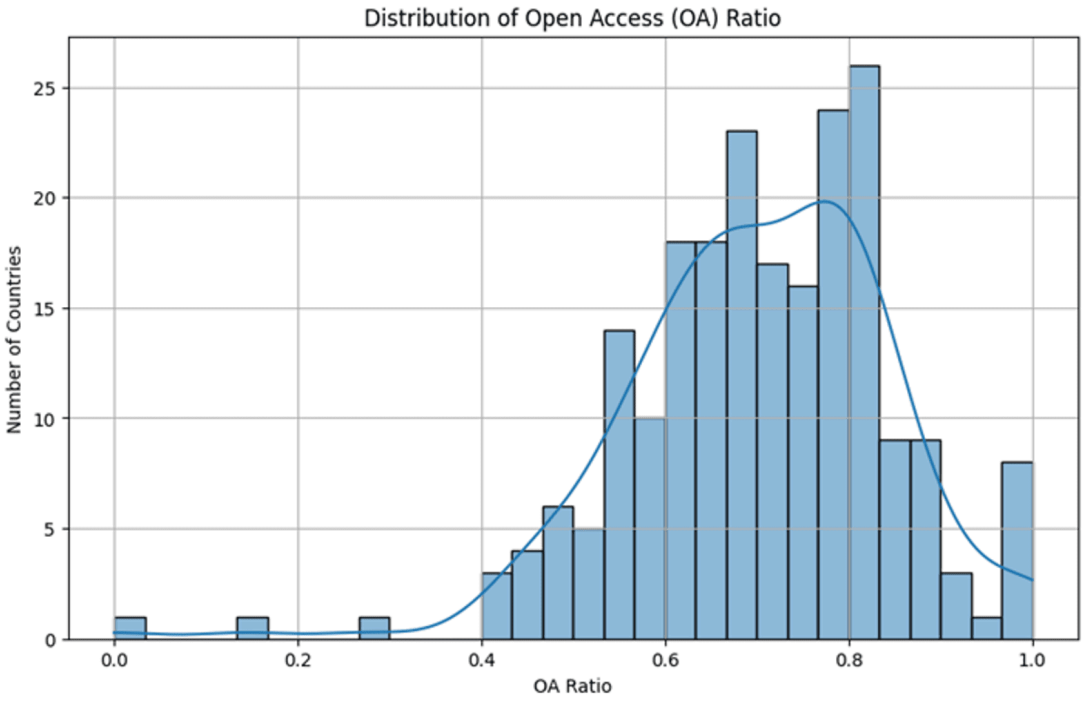

Figure 1. Distribution of global OA ratio.

3.2. Analysis of Number of Articles and Citations per Article

A country's publication productivity is not solely determined by the number of articles produced; it is also influenced by the impact and significance these articles have within the global scientific community. The average number of citations per article serves as a crucial indicator for assessing the quality and relevance of a country's publications. Thus, it's vital to analyse the correlation between each country's publication quantity and quality. The visualisation in Figure 2 illustrates this relationship on a global scale, highlighting both the number of articles and the average citations per article.

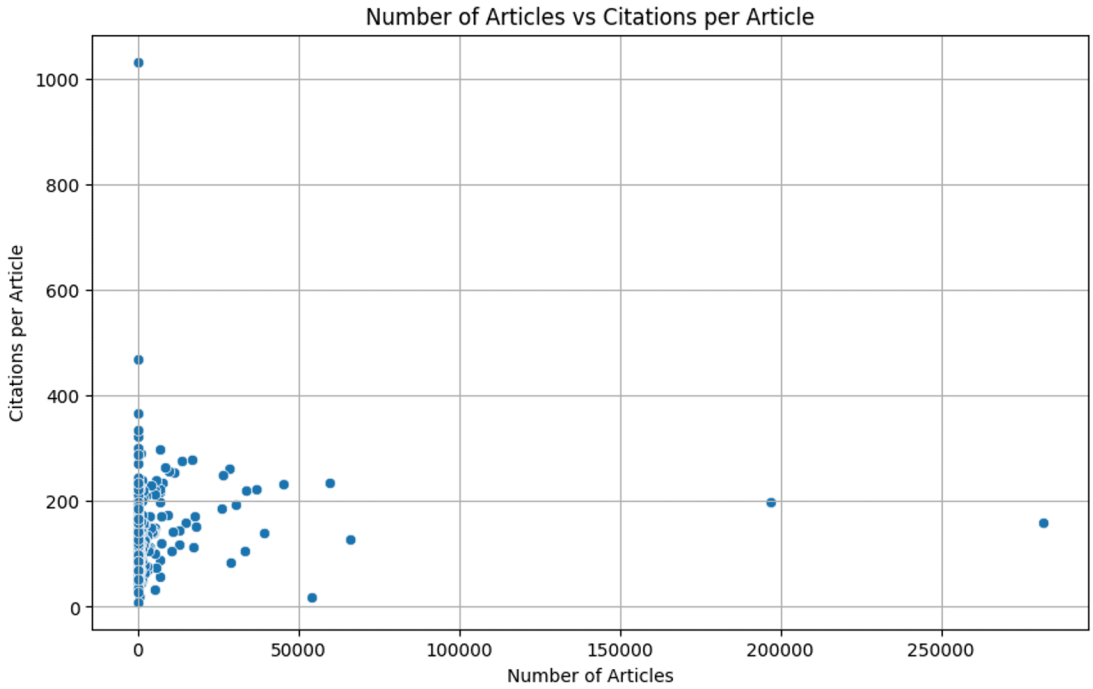

Figure 2. Relationship between number of articles and citations per article.

Figure 2 shows that countries such as the United States, the United Kingdom, and Germany, despite having high publication volumes, are still able to maintain a high average number of citations per article. In contrast, countries with large article volumes such as India and China show a lower ratio of citations per article. Indonesia's position on the graph shows an imbalance between quantity and quality. Despite being the fifth highest in the number of scientific publications, Indonesia only records an average of around 18.3 citations per article, far below Singapore, which has an average of 298.3 citations per article. This fact raises strategic questions about the focus and impact of research conducted in Indonesia and highlights the importance of improving the quality of research through international collaboration and publication in highly reputable journals.

3.3. Correlation between Publication Variables

A correlation analysis was conducted to understand the relationship between publication variables, including the number of articles, open access articles, preprints, citations, and OA ratio. This analysis aims to see the pattern of relationships between various indicators of scientific productivity to develop data-based policies in the management and development of national research. The correlation matrix between these variables is shown in Figure 3.

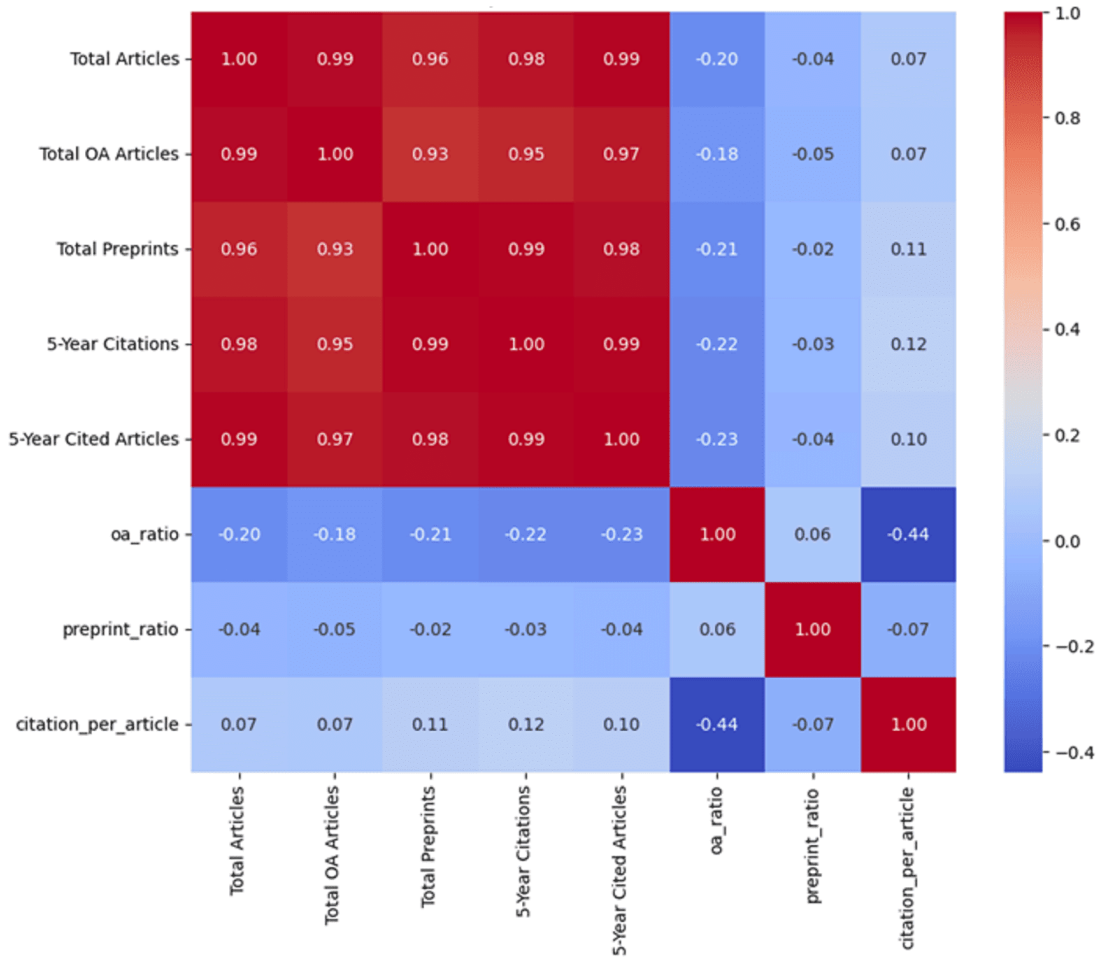

Figure 3. Correlation matrix between publication variables.

The analysis indicates that there is a very strong positive correlation between the total number of articles and the number of open access and preprint articles. This means that countries that produce more scientific articles tend to also produce more OA and preprint articles. However, what is intriguing is the negative correlation between the OA ratio and citations per article (r = -0.44). The result suggests that countries with high OA ratios tend to have low citation rates per article. This finding is important, especially for Indonesia, as it indicates that, although open access is high, the quality or scientific visibility of the publications is still low globally. Therefore, it is important to encourage the number of OA publications and pay attention to the quality of their content and publication venues.

3.4. Comparison of Indonesia with ASEAN Countries

As part of the Southeast Asian region, it is important for Indonesia to compare its position with neighbouring countries in terms of productivity and quality of scientific publications. Table 1 presents a comparison between five major ASEAN countries based on the number of scientific articles published and the average citations per article.

Country	Total Number of Articles	Average Citations per Article
Singapura	12,432	298.3
Malaysia	15,876	76.5
Thailand	11,421	43.2
Vietnam	10,204	33.1
Indonesia	54,189	18.3

Table 1. Comparison of publications and citations in ASEAN countries.

Table 1 shows that Indonesia excels in terms of quantity but lags far behind other ASEAN countries in terms of citations per article. To clarify this visualisation, Figure 4 shows the comparison of average citations per article among ASEAN countries.

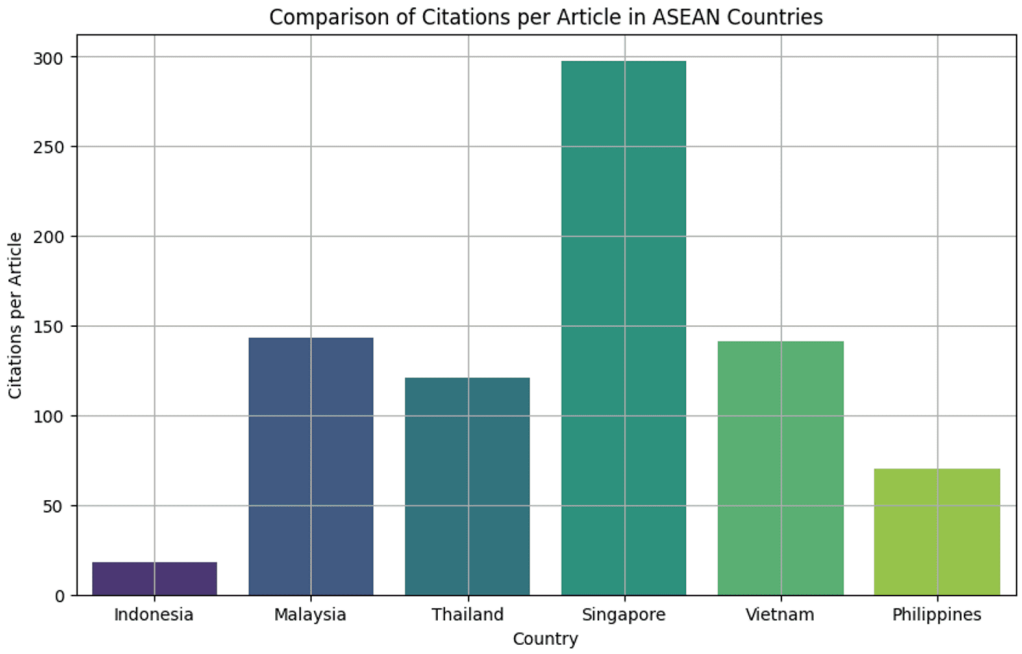

Figure 4. Average citations per article in ASEAN countries

Figure 4 confirms that Singapore is not only significantly ahead in terms of citations but also demonstrates much greater research quality and impact than other ASEAN countries. Meanwhile, Indonesia ranks lowest in terms of the quality of scientific impact based on citation metrics. The result reinforces the need for Indonesia to not only pursue productivity numbers but also improve the substance and visibility of its research to be more recognised globally.

3.5. Implications of the Findings

Based on the results of the analyses presented earlier, there are a number of important implications that can be used to formulate strategic policies and directions for national research development in Indonesia. The findings not only provide an overview of Indonesia's position in the global scientific publication landscape but also reveal the strengths and weaknesses of the developing research system. The gap between quantity and quality is a major issue that demands serious attention from all stakeholders in science and technology. Therefore, this discussion will highlight in more depth several key aspects that must be systematically addressed.

First, the high ratio of OA articles in Indonesia is an achievement that deserves to be appreciated. Indonesia's OA ratio of more than 90% shows a national commitment to the principle of open science and

equal access to scientific information for the wider community. This condition also reflects the success of national policies that encourage scientific publications through institutional repositories and national OA journals. However, this success in terms of quantity and accessibility should not be considered the sole indicator of scientific progress. Without an improvement in the quality of the research underlying these publications, the abundance of scientific articles will only lead to the accumulation of empty statistics that have no significant impact on the advancement of science, technology, or evidence-based policymaking. In other words, open access must go hand in hand with improving the quality of scientific content and contributions.

Secondly, findings related to the low average citations per article originating from Indonesia indicate a serious challenge in terms of visibility and international recognition. Despite the high volume of publications, the low citation rate indicates that these articles have not managed to attract the attention of the global scientific community. This is most likely related to various structural constraints, such as low publication rates in highly reputable journals with global reach, limited participation in international research collaborations that can expand academic networks, and weak dissemination strategies for research results carried out by researchers and institutions. In addition, language factors, research topics that are too localised without a clear comparative approach or theoretical contribution, and a lack of orientation towards global research trends can also hamper the competitiveness of Indonesian publications on the international stage.

Thirdly, the negative correlation between the OA ratio and average citations per article suggests that open access does not automatically guarantee increased scientific influence. Instead, this could signal that most OA publications in Indonesia may still be in journals with low visibility and reputation. Therefore, national publication strategies should not only focus on the quantity of OA but should also critically consider the quality of the journals in which articles are published. It is important for the government and educational institutions to integrate OA policies with efforts to increase the capacity of researchers, including in terms of scientific writing, selection of reputable journals, and understanding of editorial quality standards and international publication ethics. This effort should be accompanied by the provision of ongoing training, cross-institutional academic mentoring, and incentives that encourage high-quality publications.

Thus, these findings indicate the need for a more comprehensive, adaptive, and quality-oriented policy approach in the development of the national research ecosystem. The government must not only continue to support open access as a form of knowledge democratisation but also strengthen scientific infrastructure and a quality-based research culture. Synergies between research institutions, universities,

industry, and international partners are needed to create a conducive, collaborative, and competitive research environment. Publication incentive policies must also be redesigned so as not to encourage instant publication practices that ignore in-depth scientific processes. This strategic approach is crucial if Indonesia is to strengthen its position as a major player in an increasingly competitive and integrated global science ecosystem.

4. Conclusions and recommendations

This study analyses Indonesia's scientific publication performance based on indicators of quantity, quality (citations), and open access in a global and ASEAN regional context. The study results indicate that Indonesia has achieved a high volume of scientific publications, ranked fifth globally, and shows a very high OA ratio, reaching 93%. This reflects the success of national policies in encouraging productivity and widespread dissemination of knowledge.

However, this increase in quantity is not matched by a significant increase in quality and scientific impact. The average citations per article from Indonesia are still relatively low (around 18.3 citations per article), far below other ASEAN countries such as Singapore (298.3 citations per article) and Malaysia (76.5 citations per article). Further correlation analysis indicated a negative correlation between the OA ratio and average citations per article ($r=-0.44$). This finding indicates that high levels of open access in Indonesia do not necessarily correlate positively with global visibility and recognition, possibly due to the fact that many publications are still in journals with low international reputation and reach.

Comparatively, at the ASEAN level, Indonesia excels in the number of publications but lags far behind in terms of quality and scientific impact based on citation metrics. This significant gap between quantity and quality is a major challenge for the national research ecosystem. The implications of these findings emphasise the need for a shift in policy focus from pursuing quantity targets to improving the substance of research, encouraging publication in highly reputable journals, and strengthening international collaboration, as well as improving researchers' capacity for scientific writing and the selection of appropriate publication channels. Open access should be integrated with strategies to improve content quality and global visibility to ensure Indonesia's scientific contributions are increasingly relevant and recognised internationally. This research underscores the urgency of strategic reorientation to strengthen Indonesia's position as a significant and quality contributor to global science.

From the findings of this study, there are several recommendations that can be considered to improve Indonesia's position in the global scientific landscape:

- Improving Research Quality: The government and higher education institutions need to strengthen research quality through increased research funding, methodological training, and international collaboration. A quality-based approach should be prioritised so that Indonesia's publications are not only numerous but also impactful.
- Strengthening the National Publication Ecosystem: Regular guidance and evaluation of national journals, especially those managed by higher education institutions, are needed to improve editorial standards and peer-review systems to compete at the international level.
- Strategic International Collaboration: Encourage Indonesian researchers to be actively involved in cross-country and cross-disciplinary collaborations. Such collaborations are proven to increase citation opportunities and visibility of research results.
- Open Access Policy Evaluation: Although OA provides wider access, it is necessary to further evaluate the effectiveness of this policy in encouraging publication quality. The OA incentive system should be based on quantity and consider quality metrics such as impact factor or citation rate.
- Strengthening Publication Literacy and Scientific Ethics: The number of publications does not necessarily indicate quality if it is not accompanied by a profound understanding of publication ethics, selection of credible journals, and effective scientific dissemination strategies.

With the implementation of these strategies, it is expected that Indonesia will not only become a country with many publications but also one with significant scientific influence in the global science community.

Appendix

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
df = pd.read_excel("data analisis.xlsx", sheet_name="Sheet3")
print(df.info())
print(df.describe())
print(df.isnull().sum())
df["OA_ratio"] = df["Total OA Articles"] / df["Total Articles"]
df["Preprint_ratio"] = df["Total Preprints"] / df["Total Articles"]
df["Citation_per_article"] = df["5-Year Citations"] / df["Total Articles"]
plt.figure(figsize=(10,6))
sns.histplot(df["OA_ratio"], bins=30, kde=True)
plt.title("Distribution of Open Access (OA) Ratio")
plt.xlabel("OA Ratio")
plt.ylabel("Number of Countries")
plt.grid(True)
plt.show()
plt.figure(figsize=(10,6))
sns.scatterplot(data=df, x="Total Articles", y="Citation_per_article")
plt.title("Number of Articles vs Citations per Article")
plt.xlabel("Number of Articles")
plt.ylabel("Citations per Article")
plt.grid(True)
plt.show()
plt.figure(figsize=(10,8))
corr_matrix = df[["Total Articles", "Total OA Articles", "Total Preprints", "5-Year Citations", "5-Year Cited Articles",
                  "OA_ratio", "Preprint_ratio", "Citation_per_article"]].corr()
sns.heatmap(corr_matrix, annot=True, cmap="coolwarm", fmt=".2f")
plt.title("Heatmap of Correlation Between Variables")
plt.show()
asean_countries = ["Indonesia", "Malaysia", "Singapore", "Thailand", "Vietnam", "Philippines"]
df_asean = df[df["Country"].isin(asean_countries)]
plt.figure(figsize=(10,6))
sns.barplot(data=df_asean, x="Country", y="Citation_per_article", palette="viridis")
plt.title("Comparison of Citations per Article in ASEAN Countries")
plt.ylabel("Citations per Article")
plt.grid(True)
plt.show()
```

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Declarations

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