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Reflecting on Indonesia's young academy movement

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In the past three decades, there has been a rise in young academy movements in the Global North and South. Such movements, in at least Germany and the Netherlands, have been shown to be quite effective in connecting scientific work with society. Likewise, these movements share a common goal of developing interdisciplinary collaboration among young scientists, which contributes to the growth of a nation's—but also global—scientific endeavors. This paper focuses on the young academy movement in the fourth-largest country hosting the biggest Muslim population in the world, which is also the third-most populous democracy: Indonesia. We observe that there has been rising awareness among the young generation of scientists in Indonesia of the need to advocate for the use of sciences in responding to upcoming and current multidimensional crises. Science advocacy can be seen in their peer-based identification of Indonesia's future challenges, encompassing the fundamental areas for scientific inquiry, discovery, and intervention. We focus on the Indonesian Young Academy of Sciences (ALMI) and its network of young scientists. We describe ALMI's science communication practice, specifically SAINS45 and Science for Indonesia's Biodiversity, and how they have been useful for policymakers, media, and school engagements. The article closes with a reflection on future directions for the young academy movement in Indonesia and beyond.

Indonesia | young academy movement | science advocacy | science communication | science to policy

There is currently a national young academy in more than 45 countries (1). Germany's Die Junge Akademie (the Young Academy), founded in 2000, was the pioneer for this young academy movement, followed by the forming of Netherland's De Jonge Akademie (the Young Academy) in 2005 (2). Both of these young academies, composed of early-career researchers, have been judged to represent the scientific communities of their respective nations in ways that have often been more effective than the more established academies, consisting primarily of senior professors (2). This finding is important for 14 young academies in Africa and 13 in Asia formed in the past 20 y (2).

To some extent, the focus of each young academy is different, and they have the purpose of tackling nation-specific issues. This can be seen in, among others, the Young Korean Academy of Science and Technology's (Y-KAST) and the Young Academy of Japan's (YAJ) common goal to identify and address the country-specific institutional challenges for young scientists (see refs. 3 and 4). But as a general pattern, young academies around the world are increasingly becoming the key contact for society and policymakers to get more involved in higher education and research. They are also generally robustly engaged with the media, policymakers, Civil Society Organizations (CSOs), businesses, as well as schools.

Some of the young academies, while vibrant and critical of the way nature and societies are being treated by decision-makers (1, 2, 5), operate in countries that do not score well in academic-freedom indices (5). Among these countries are Russia, scoring 0.24, Hungary, scoring 0.34, as well as Myanmar and Laos, both at 0.1—all on a scale of 0 to 1 (5). Importantly, academic freedom has fallen in 22 countries that are home to more than 50 percent of the world's population (5). In India and China, although the latter has yet to have a young academy, there has been a significant decline in academic freedom. In Eastern Europe, notably in Hungary and Russia (both hosting young academies), this decline has been linked with autocratization. But academic freedom is also weakening in liberal democracies, such as the United Kingdom and the United States (5).

This academic freedom setback is a challenge for young academies because "maintaining excellence in the global scientific enterprise will require constant adjustments to policies and programs" (see refs. 6 and 7). In order to make the young academy movement long-lasting, the public engagement of scientists must make science relevant for both the general public and governments, which is a challenge faced by young academies of the North and the South.

So, what can Indonesia, the most populous Muslim country in the world and the fourth-largest democracy, and its young academy, offer to our understanding of the global challenges we face? What kinds of actions has it carried out,

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and what are the impacts of its engagement? With these questions in mind, this paper aims to describe Indonesia's young academy movement.

The Hungarian young academy has operationalized its movement as science leadership through specific activities (1). Science leadership, as we adapt it from the Hungary young academy, involves the following:

1) Outreach: Making scientific work relevant to society and its decision-makers.
2) Open science: Finding ways to make scientific work freely accessible for everyone.
3) Science policy: Publishing not only for the scientific community but also for legislators, policymakers, funding agencies, etc.
4) Networking: Providing a multidisciplinary platform to exchange diverse views.
5) Mentoring and advocacy: Carrying out science communication, workshops, and seminars, as well as mentoring and counseling schemes.
6) Equality, diversity, and inclusion: Developing strategies and initiatives to reduce inequalities.

All of these points guide our paper. We reflect on outreach, attempts to open science, efforts to communicate science to policymakers, and the strategies for inclusion carried out by the Indonesian young academy movement. We structure the paper into four parts. In the first section, we provide an overview of Indonesia's science and research ecosystem. In the second section, we identify the types of scientific excellence Indonesian scientists have achieved. In the third section, we focus on the young academy movement of Indonesia's Young Academy of Science (ALMI) and its networks. We close with a conclusion and reflection on the future directions of the Indonesian young academy movement.

An Overview of Indonesia's Science Ecosystem

Indonesia is the largest economy in Southeast Asia, a G20 host, and ranks 16th among G20 countries in economic size. However, its science, technology, and innovation (STI) are struggling. In fact, the Indonesian government allocates less total funding (0.25 percent of its GDP) support for research and development (R&D) than Singapore (2.2 percent) and Malaysia (1.25 percent), much smaller nations (8). Moreover, lack of funding for R&D is exacerbated by inappropriate science governance and an ecosystem characterized by politicization and bureaucratization. Unfortunately, of course, this disconnect between science and policy-making has had severe repercussions on the country's overall STI ecosystem (9, 10).

Over the past 30 y, the country has been striving to achieve scientific excellence through a multitude of policies and institutional reforms. But the country's science ecosystem sector has been shadowed by colonial and authoritarian legacies that tend to produce results that are short term, myopic, and reactive. In terms of scientific productivity, Indonesia is lagging behind its neighboring countries. During 1996 to 2010, Indonesia had only 13,047 published scientific documents—far below its neighbors Thailand, Malaysia, and Singapore and below countries with lower GDP per capita and Human Development Index such as Bangladesh, Kenya, and Nigeria (10).

The regulatory framework and institutionalization of STI face a number of challenges that hinder their effective development and implementation. These problems can be attributed to a range of factors, including bureaucratic complexities, inadequate resources (particularly funding), limited collaboration, and a lack of clear policies (8–10). One of the significant issues in the regulatory framework is the complexity and redundancy of administrative procedures. Scientific undertakings in many aspects have become bureaucratized. Multiple agencies and departments often have overlapping responsibilities and requirements that not only lead to confusion and delays in obtaining necessary approvals and permits for research and innovation but also create unnecessary hindrances to academic work in campuses and research agencies (11). Scientists face a cumbersome process to navigate through various permits, licenses, and regulations, and this severely hampers the timely implementation of scientific projects.

Inadequate resources present another pressing challenge. Despite acknowledging the importance of scientific research and technological development, the allocation of financial resources for sciences remains relatively low compared to other countries (8–10). Limited funding affects research institutions' capacity to carry out cutting-edge research, often preventing the acquisition of essential advanced equipment and technologies, and it restrains the recruitment and retention of talented researchers. It is well known that a nation's investment in the development of science, both from public and private sources, is crucial to foster innovation through improving research infrastructure and for attracting and retaining skilled scientists and technologists. Unfortunately, this has not been reflected in the national state budget (8).

While there are various policies and initiatives related to science development, including the new Law on the National System of Science and Technology, they often lack a unified framework and strategic direction (12). In fact, the new law has posed challenges for the nurturing of scientific excellence. In 2017, the former research ministry was disbanded and reabsorbed into the Ministry of Education and Culture, while the law guided the formation of a science superagency (9), called the National Research and Innovation Body (BRIN). The move to form this superagency was opposed by the Indonesian Academy of Sciences (AIPI) and the Indonesian Young Academy of Sciences (ALMI). Nevertheless, BRIN continued to absorb formerly stand-alone government research organizations—including the Space and Aeronautical Agency and the National Nuclear Energy Agency. It even closed highly performing research organizations, such as the Eijkman Institute for Molecular Biology (13–15). Rather than making the research bureaucracy more efficient, it has been reported to be reckless in its spending policies and to lack any clear science development strategy (16). As the only legally acknowledged state body for approval of foreign research permits for scientific collaboration, BRIN has also created new barriers to open science (17).

Realizing these challenges, Indonesia's young scientists and academics have been engaged in efforts to strengthen the regulatory framework and the institutionalization of science development in Indonesia (18–20). But who exactly is producing scientific work in Indonesia? What are Indonesia's young scientists interested in and how do they fare compared to other Southeast Asian countries? The next section aims to answer these questions.

Young Scientist Publication Trend by Fields

This section aims to describe the scientific fields (subject heterogeneity) of Indonesian young scientists. To do so, we use publication data. We find that there have been major changes over time in some disciplines—both within Indonesia and in comparison, with neighboring countries. We close this section by considering how the current occupancy of scientific fields aligns with the pressing demands of tomorrow.

We scrutinize the trends in Indonesian authors' scientific publications to discern whether they are gravitating toward disciplines that have the objective potential for science productivity. We assume that optimizing the benefits of biodiversity, sustainable energy, environmental conservation, food sovereignty, and advancements in health and well-being are critical areas for Indonesia's progress (21–23). Is the Indonesian scientific community dedicating significant attention to these strategic domains and are they actively contributing to them? To examine this question, we analyze bibliographic databases, specifically the distribution of scientific publications among Indonesian researchers and the duration with which they have been publishing. We use these data to identify potential shifts in research interests across different generational cohorts, providing insights into the evolving scientific landscape (1, 2).

The data are presented in two tables that use an Indonesian author's first year of publication as a proxy for the addition of new Indonesian scientists to a scientific field. Table 1 uses the entire set of Scopus journals to produce this distribution of scientific fields, with the new scientists grouped into cohorts by the indicated set of years. Table 2 shows the same data derived from publications in only the top 5 percent of journals. Note that we are using the first year that an Indonesian scientist publishes to derive the field of scientific research interest for the new scientists of different generations. While this approach has its problems, as we acknowledge it in footnote [*], the data provide useful information for reflection.

From Table 1, for instance, we can see that the 1990 to 1994 cohort (i.e., all Indonesian authors who had their first paper published between the years 1990 and 1994) published predominantly in Life Sciences (33.8 percent) followed by Health Sciences (28.2 percent). In contrast, the 2020 to 2022 cohort published predominantly in Physical Sciences (36.1 percent) followed by Life Sciences (22.0 percent). There is also a significant increase of interest in the proportion of Social Science and Humanities. Whereas only 5.2 percent of publications by the cohort of 1990 to 1994 were in the field of Social Science and Humanities, the proportion published by the youngest cohort of 2020 to 2022 was 20.3 percent. Previous studies align with our findings on the increase in social sciences (24).

By focusing on papers published in the highest-quality journals within respective fields, we aim to observe not only the interests of Indonesian scientists but also to gauge the strength of their contributions. How are the most exceptional talents in Indonesian science distributed across diverse scientific subjects? As shown in Table 2, there has been a striking shift in the composition of subject areas from the 1995 to 1999 cohort to more recent cohorts (e.g., the 2020 to 2022 cohort). Within the 1995 to 1999 cohort, the distribution of subjects for papers published in the top 5 percent of journals was generally balanced across our four broad domains: Health, Life Sciences, Physical Sciences, Social Sciences, and Humanities. But for the 2020 to 2022 cohort, Physical Sciences dominates with 48.5 percent representation, followed by Social Sciences at 29.2 percent; Life Sciences and Health Sciences account for only 14.8 percent and 10.2 percent, respectively. Since this analysis focuses on publications in the top 5 percent of journals in terms of citation impact, we suggest that this subject composition reflects how the most talented Indonesian scientists are distributed across scientific fields and thus how this distribution has shifted over generations.

In Table 2, we include Thailand and Vietnam as reference countries, selected based on their similar levels of development, population size (72 and 99 million, respectively, compared to Indonesia's 279 million), and proximity to Indonesia. The focus is placed solely on papers published in journals belonging to the top 5 percent in terms of citation impact. Similar to Indonesia, Physical Sciences dominate the research landscape in both countries. In the cohort of 2020 to 2022, Physical Sciences account for 53.4 percent in Thailand and 60.9 percent in Vietnam. But Indonesia stands out with a relatively unique share of 26.2 percent in terms of Social Sciences and Humanities publications among the most talented younger generation of scientists (compared to 10.5 percent in Thailand and 14.6 percent in Vietnam).

A close look at the Scopus bibliometric database shows the categorization of subjects into 27 distinct fields, including five subjects within the broad Health domain, seven subjects in Life Sciences, eight subjects in Physical Sciences, six subjects in Social Sciences and Humanities, and a single multidisciplinary category (Tables 1 and 2).

Taking the 2020 to 2022 cohort as representative of Indonesia's most talented and youngest (or more precisely, early-career) scientists, we observe the strength of the specific social science field (14.4 percent of the total share). Following are the fields of environmental sciences (11.5 percent) and medicine (7.6 percent). By comparison, the high-quality publications of Thailand's youngest cohort (Table 2) are in the field of environmental sciences (12.4 percent),

[*]The process of the analysis can be summarized in the following steps. a) We extract data on journal article publications authored by individuals affiliated with Indonesian institutions, noting the specific subject areas covered in these publications. It is important to highlight that these papers may also have coauthors from non-Indonesian institutions (This will be addressed later). Furthermore, it is worth noting that an article can fall under multiple subject areas simultaneously. b) We extract data on authors affiliated with Indonesian institutions using SciVal, a part of Scopus. These data will be employed to filter out non-Indonesian authors from the previously extracted journal articles record. c) We download the database of journal titles, which serves two purposes. First, it allows us to exclude journals of questionable quality that have been discontinued by Scopus due to ethical publication concerns. Second, it enables us to categorize journals based on their impact-related metrics, specifically using Scopus CiteScore. d) The identity of a particular publication record, including its name and author ID, is stored within a single variable. To determine the affiliations of each coauthor, we must separate this information into distinct variables for each coauthor. e) We merge the database of journal articles with our database of authors affiliated with Indonesian institutions. During this process, authors who do not have a match within the Indonesian author's database are excluded from the final dataset. f) We merge the journal's database that contains more information about the journal particularly the citation metrics with the overall database. g) Within the database, we ascertain the year in which each unique author first published their work. This information serves as a proxy for evaluating the seniority of authors. While age-based categorization would be ideal, unfortunately, such data are unavailable within the database. It is important to note that utilizing the year of first publication as a measure of seniority is not without limitations. For instance, it does not account for scenarios where scientists commence their publishing endeavors later in their academic careers. Nonetheless, given the available data, this approach represents the most viable means of assessing seniority.

Table 1. Distribution of scientific fields of publication in all journals in the Scopus database by the cohort of the year of authors' first publication, Indonesia, Thailand, and Vietnam*

	Cohort of authors' first year of publication										
	Indonesia							Thailand		Vietnam	
	1990 to 1994	1995 to 1999	2000 to 2004	2005 to 2009	2010 to 2014	2015 to 2019	2020 to 2022	1990 to 1994	2020 to 2022	1990 to 1994	2020 to 2022
Health	28.2	22.9	20.0	16.4	14.2	17.3	19.9	24.8	13.0	5.7	13.4
Medicine	24.0	18.0	15.5	12.3	9.7	10.7	13.5	22.5	9.3	2.8	6.3
Nursing	1.8	1.6	1.1	1.1	1.1	2.0	2.2	0.6	1.1	0.0	0.3
Veterinary	1.8	2.2	1.9	1.8	2.1	1.6	1.3	1.5	1.7	0.0	0.3
Dentistry	0.4	0.9	0.9	0.8	0.6	2.2	1.3	0.0	0.0	0.0	0.1
Health Professions	0.3	0.3	0.6	0.5	0.6	0.8	1.6	0.2	0.9	2.8	6.3
Life Sciences	33.8	33.1	33.6	31.5	25.9	23.5	22.0	34.4	18.6	6.7	11.9
Agricultural and Biological Sciences	13.9	15.8	15.6	14.4	12.4	10.5	8.7	8.9	7.7	1.3	5.2
Biochemistry, Genetics, and Molecular biology	10.0	10.1	10.2	9.7	7.2	6.7	6.9	11.7	5.4	3.2	3.9
Immunology and Microbiology	4.0	3.7	3.4	2.3	1.8	1.5	1.6	7.6	2.3	0.7	1.1
Neuroscience	0.5	0.4	0.3	0.4	0.3	0.3	0.4	0.7	0.4	0.3	0.3
Pharmacology, Toxicology, and Pharmaceutics	5.4	3.2	4.1	4.7	4.2	4.5	4.4	5.6	2.7	1.2	1.3
Physical Sciences	31.2	37.1	38.9	42.9	47.2	39.3	36.1	36.3	51.3	83.4	62.4
Chemical Engineering	1.5	2.7	3.5	3.8	3.9	2.8	2.6	3.3	3.5	2.0	4.9
Chemistry	5.1	5.5	5.4	5.7	4.7	3.4	3.2	7.9	5.1	8.2	6.3
Computer Science	1.0	1.9	2.5	3.5	5.8	5.6	5.3	2.4	7.6	6.0	10.5
Earth and Planetary Sciences	4.0	2.6	2.4	2.3	2.2	2.1	1.8	1.6	1.7	1.5	2.6
Energy	1.3	2.2	2.2	2.3	3.1	2.4	2.5	1.8	3.4	0.7	3.2
Engineering	4.3	6.4	7.1	9.4	11.6	10.2	8.0	5.9	10.4	11.0	13.7
Environmental Science	5.3	5.8	5.6	5.7	6.1	5.8	5.8	3.6	5.5	2.6	6.1
Materials Science	2.3	4.1	4.2	4.4	3.8	2.9	2.8	4.5	5.7	13.8	5.8
Mathematics	1.9	1.6	2.1	2.6	3.1	2.3	2.3	1.2	3.3	16.7	4.4
Physics and Astronomy	4.4	4.3	3.9	3.3	2.8	1.8	1.7	4.2	5.1	20.9	4.9
Social Sciences and Humanities	5.2	5.0	5.7	7.3	10.9	18.5	20.3	2.5	13.8	3.9	11.2
Arts and Humanities	0.4	0.5	0.3	0.6	0.9	1.6	1.8	0.2	1.9	0.1	0.6
Business, Management, and Accounting	0.7	1.0	1.4	1.9	2.8	4.3	3.7	0.4	1.9	0.2	2.5
Decision Sciences	0.1	0.4	0.5	0.4	0.7	0.9	1.2	0.2	1.9	2.4	2.0
Economics, Econometrics, and Finance	0.6	0.5	0.6	0.7	1.3	2.4	2.2	0.2	1.1	0.4	1.9
Psychology	0.4	0.2	0.2	0.4	0.4	0.6	0.8	0.2	0.5	0.0	0.5
Social Sciences	3.1	2.5	2.7	3.3	4.7	8.6	10.6	1.4	6.5	0.6	3.8
Multidisciplinary	1.6	1.9	1.8	1.8	1.7	1.4	1.6	2.0	3.3	0.3	1.0
	100	100	100	100	100	100	100	100	100	100	100

*We use the Scopus database as the source of data in this analysis. We use three different sets of data: a) database of scientific papers published in academic journals (we exclude conference papers proceedings); b) database of journals or source titles because we also want to filter journals by its quality; and c) database of authors because we need to include only authors affiliated to institutions located in the country of interest.

followed by agriculture and biological sciences (10.0 percent), medicine (9.1 percent), and engineering (8.9 percent). In Vietnam, the largest share comes from the engineering field (11.3 percent), followed by environmental sciences (9.4 percent), material science (7.6 percent), and chemistry (7.1 percent).

It is important to note that there is no consensus on the optimal distribution of a nation's scientists between scientific fields, as it will depend on the unique needs of each country. The dominance of social sciences among Indonesia's early-career cohort of scientists sets it apart from at least Thailand and Vietnam. This may reflect a combination of the strengths and interests of young Indonesian scientists, and it could be a positive indication if it aligns with the future challenges faced by the country. However, it also raises questions about the progress and level of interest in non-social sciences fields.

Some scientific fields are more conducive to supporting disciplines essential for the development of technologies in the private sector. Vietnam demonstrates a higher share of engineering publications (11.3 percent) among their young scientists in comparison to Indonesia (7.5 percent). Similarly,

Table 2. Distribution of scientific fields of publications in the top 5 percent of journals in the Scopus database by the cohort of the year of authors' first publication, Indonesia, Thailand, and Vietnam

	Cohort of author first year of publication										
	Indonesia							Thailand		Vietnam	
	1990 to 1994	1995 to 1999	2000 to 2004	2005 to 2009	2010 to 2014	2015 to 2019	2020 to 2022	1990 to 1994	2020 to 2022	1990 to 1994	2020 to 2022
Health	29.3	26.8	22.6	21.1	12.2	11.8	10.2	37.0	12.6	35.7	11.7
Medicine	22.6	24.4	19.5	19.1	9.8	9.1	7.6	30.7	9.1	17.9	5.5
Nursing	4.1	1.6	0.8	0.4	0.9	0.9	1.0	1.0	0.9	0.0	0.4
Veterinary	0.4	0.5	1.9	1.3	0.7	1.1	1.2	4.7	2.0	0.0	0.4
Dentistry	2.2	0.3	0.4	0.2	0.4	0.2	0.1	0.0	0.0	0.0	0.0
Health Professions	0.0	0.0	0.0	0.2	0.4	0.5	0.3	0.6	0.6	17.9	5.5
Life Sciences	15.9	26.3	27.4	22.0	19.0	19.5	14.8	29.0	23.3	7.1	12.8
Agricultural and Biological Sciences	8.5	13.8	10.4	9.2	10.0	10.1	6.2	6.4	10.0	0.0	5.2
Biochemistry, Genetics, and Molecular Biology	2.2	4.1	6.0	7.2	4.3	5.0	4.3	12.3	7.0	3.6	4.7
Immunology and Microbiology	3.7	4.6	9.0	5.0	3.7	2.9	2.7	8.3	3.3	1.8	1.4
Neuroscience	0.0	0.0	0.2	0.4	0.7	0.6	0.5	1.0	0.6	1.8	0.5
Pharmacology, Toxicology, and Pharmaceutics	1.5	3.8	1.8	0.3	0.4	1.0	1.1	1.1	2.4	0.0	1.0
Physical Sciences	33.3	30.1	35.3	41.7	52.9	46.6	48.5	24.5	53.4	57.1	60.9
Chemical Engineering	2.6	0.8	1.8	3.3	5.3	2.5	3.8	1.5	4.0	0.0	4.8
Chemistry	3.7	4.6	3.5	5.0	5.2	3.9	3.7	2.3	7.3	5.4	7.1
Computer Science	1.1	1.1	1.8	2.3	2.2	3.7	6.2	1.3	3.7	0.0	6.1
Earth and Planetary Sciences	1.9	4.3	2.7	2.3	3.1	3.6	3.8	1.1	2.0	0.0	2.6
Energy	1.1	0.8	2.6	2.6	7.6	5.4	6.6	4.0	5.5	0.0	3.4
Engineering	2.6	3.5	6.8	7.9	9.2	8.0	7.5	4.0	8.9	19.6	11.3
Environmental Science	16.3	12.5	9.1	9.7	13.8	12.8	11.5	8.4	12.4	12.5	9.4
Materials Science	2.2	0.8	2.5	5.2	3.4	3.0	1.3	0.9	4.4	19.6	7.6
Mathematics	0.7	0.0	1.6	1.2	1.3	1.4	2.4	0.9	1.6	0.0	3.6
Physics and Astronomy	1.1	1.6	2.9	2.3	1.8	2.3	1.7	0.2	3.5	0.0	5.0
Social Sciences and Humanities	20.7	16.8	14.2	15.1	15.7	22.0	26.2	9.4	10.5	0.0	14.6
Arts and Humanities	0.4	3.3	1.4	1.7	1.5	1.2	1.7	1.7	0.8	0.0	1.1
Business, Management, and Accounting	3.3	1.9	3.4	1.1	2.9	3.9	4.4	1.1	2.6	0.0	3.4
Decision Sciences	0.7	1.1	1.8	0.6	0.9	1.8	2.6	1.0	0.4	0.0	1.0
Economics, Econometrics, and Finance	1.9	1.1	1.6	2.2	2.1	3.9	2.2	1.1	1.6	0.0	2.3
Psychology	0.0	0.3	0.4	0.6	1.0	0.6	0.8	0.6	0.3	0.0	0.7
Social Sciences	14.4	9.2	5.5	8.9	7.3	10.6	14.4	3.9	4.7	0.0	6.0
Multidisciplinary	0.7	0.0	0.4	0.1	0.3	0.2	0.3	0.1	0.2	0.0	0.0
Total	100	100	100	100	100	100	100	100	100	100	100

Top 5 percent is based on Scopus CiteScore; source: Scopus Database.

Vietnam outperforms Indonesia in material sciences with a share of 7.6 percent compared to Indonesia's mere 1.3 percent. But what about the total number of publications from these three nations in the top 5 percent of journals? Table 3 displays these numbers in the period of 2020 to 2022.

In short, Indonesian young scientists are performing less compared to its neighboring countries. In terms of quantity, the total number of publications by Indonesian scientists in top journals is 70 percent of Thailand's and 29 percent of Vietnam's, even though these countries have considerably smaller populations. In fact, the higher up the journals' tiers, the more we see less and less of Indonesian scientists. The next section specifically discusses this by reflecting on the roles, aspirations, and the dynamics of young scientists in Indonesia.

Indonesia's Young Scientists' Movement

This section focuses on Indonesia's young scientists' movement, specifically by focusing on the country's most established interdisciplinary association for early to midcareers: the Indonesian Young Academy of Scientists (ALMI). ALMI is an organization under the auspices of the Indonesian Academy of Sciences (AIPI), which was established in 1990 by the Indonesian government. AIPI, ALMI, and another organization

Table 3. The total number of publications in the top 5 percent of journals in the Scopus database for Indonesia, Vietnam, and Thailand during 2020 to 2022

Fields	Indonesia	Vietnam	Thailand
Medicine	432	1,068	735
Nursing	54	80	75
Veterinary	70	75	160
Dentistry	4	4	
Health Professions	18	1,068	50
Agricultural and Biological Sciences	350	1,018	810
Biochemistry, Genetics, and Molecular Biology	243	930	567
Immunology and Microbiology	154	276	270
Neuroscience	30	91	48
Pharmacology, Toxicology, and Pharmaceutics	62	193	190
Chemical Engineering	217	941	325
Chemistry	207	1,393	592
Computer Science	352	1,201	300
Earth and Planetary Sciences	215	517	161
Energy	371	663	448
Engineering	423	2,208	719
Environmental Science	650	1,843	1,006
Materials Science	73	1,487	353
Mathematics	138	696	129
Physics and Astronomy	95	980	283
Arts and Humanities	98	216	64
Business, Management, and Accounting	251	662	210
Decision Sciences	147	205	36
Economics, Econometrics, and Finance	122	457	132
Psychology	48	137	24
Social Sciences	816	1,179	381
Multidisciplinary	15	8	14
Total	5,655	19,596	8,082

also under AIPI, the Indonesian Science Fund (DIPI), consist of a collective of scientists who actively promote scientific culture. AIPI, along with ALMI and DIPI, are the only independent scientific institutions formally acknowledged by the Indonesian state through Presidential Decree No. 9/2016. For decades, AIPI has provided recommendations on science and technology for policymakers and the public.

AIPI has organized various activities to empower the Indonesian young scientist movement. We recognize the 2010 Wallacea Conference for young scientists as one of the formative moments for the movement's momentum. The conference was organized in Ternate, North Maluku, Indonesia, an historically significant location for the establishment of scientific exploration in the Malayan archipelago. It was the research field site of the young Alfred Russel Wallace who pioneered a description of the natural selection and evolution of species in a letter known as "Letter from Ternate," mailed to Charles Darwin and read before the Linnean Society in 1858.

Importantly, President Obama's Science Envoy, Dr. Bruce Alberts, renowned biochemist and former President of the US National Academy of Sciences (NAS) (25), had met with the Indonesian President, Susilo Bambang Yudhoyono. He was also in Ternate, along with US Ambassador Cameron Hume and a few senior scientists from AIPI, led by its president Sangkot Marzuki.

Alberts vowed his support for long-term science and technology cooperation, emphasizing the importance of international research collaboration in facing the world's shared challenges (25). As one outcome from the Ternate meeting, the US–Indonesia Frontiers of Science (FoSS) was announced as an annual program to be held in Indonesia, designed to foster scientific collaboration and the exchange of ideas among Indonesian and US young scientists in areas of mutual interest.

AIPI and NAS co-organized the 9th Indonesian-American Sciences symposium (FoSS) for young scientists in 2023 (26). Young scientists (under 45 y) are selected for their research excellence after the completion of their doctoral programs, specifically by demonstrating the publication of important scientific work. These symposia, together with a few of AIPI's own initiatives such as the Indonesian Frontiers of Social Sciences and Humanities Symposia, have formed and widened a network of young Indonesian scientists. These young scientists began working together at times in spite of the institutional and bureaucratic barriers they face.

Indonesian young scientists see a pressing need to create a nurturing scientific ecosystem that fosters the talents of those in early careers. A collaboration between Indonesian young scientists (Alumni of AIPI's Frontiers of Science Symposia (FoSS) and the Senior Academy (in advisory capacity) was initiated to formulate a future Indonesian Science Agenda. This agenda contained fundamental scientific questions for the future of the nation, as envisioned by young scientists.

The project identified Indonesia's challenges and opportunities, which were synthesized into a science agenda called SAINS45 (Indonesian Science Agenda toward a Century of Independence) (21). Published in 2016, SAINS45 lays out the aspirations of Indonesian young scientists for the kind of future they want to see on the 100th anniversary of the country's independence in 2045. It contains 45 fundamental questions for the future of the nation, divided into eight clusters: I) Identity, Diversity, and Culture; II) Archipelago, Marine, and Bio-resources; III) Life, Health, and Nutrition; IV) Water, Food, and Energy; V) Earth, Climate, and Universe; VI) Disasters and Community Resilience; VII) Material and Computational Science; and VIII) Economy, Society, and Governance. SAINS45 also emphasizes the importance of working together across disciplines to create solutions to the complex problems facing the nation and the world.

SAINS45 essentially represents the thoughts and visions of Indonesian young scientists. It presents a voice of science for government policy formulations and decisions, and it has led to wider awareness of the role of science in society. Relevant documents published earlier include 125 key questions facing scientists and the public by the journal *Science* in 2005 (27) and 49 key questions facing scientists and the public in the Netherlands by The Royal Netherlands Academy of Arts and Sciences (KNAW) (28). SAINS45 was used as a framework by the Indonesian Science Fund (DIPI) on its first call for research proposals in 2016. DIPI focused this first research funding on two clusters: i) Life, Health and Nutrition and ii) Identity, Diversity, and Culture (29). The review of proposals was supported by scientists from within the country as well as the international science community, including a Nobel laureate and other prominent scientific prize winners.

After the formulation and launching of SAINS45, the authors and members of the Study Committee that produced this science agenda became the first members of the Indonesian Young Academy of Sciences (ALMI), established in 2016. ALMI has four missions: i) encouraging the creation of frontiers of science through multidisciplinary collaboration among young scientists; ii) encouraging the creation of a scientific temper and the development of a scientific culture of excellence in the younger generation; iii) encouraging the use of science as a basis of evidence in public policy formulation; and iv) being part of the global young scientist movement in responding to global challenges.

To this day, ALMI continues to promote the spirit of science and scientific literacy (scientific temper) to Indonesia's younger generations through a flagship program "Scientist goes to school". Many ALMI members regularly go back to their school to inspire the students to love science and nurture their curiosity. In a nation as diverse as Indonesia (genetically, geographically, socially, and culturally), a scientific culture that nurtures creativity, rationality, openness, and tolerance, traits that are inherent to science, is essential.

ALMI is also involved internationally. At the global level, the Global Young Academy (GYA) was formed in 2010, as the result of discussions of prominent young scientists and researchers from many countries who attended "Summer Davos" meetings facilitated by the InterAcademy Partnership (IAP) in 2008 and 2009 (30). GYA's membership is individual, but it also works with national young academies (NYAs) through involvement in projects, meetings, and dialogues. The grand challenges facing our society such as environmental degradation, climate change, conflicts, and pandemic require a global effort with a multidisciplinary approach.

Another formative moment for ALMI occurred when ALMI and AIPI worked together to build on SAINS45 by initiating a consensus report to formulate the pathways and find ways to inform policymaking on how Indonesia's mega biodiversity, a world laboratory that never ceases to inspire, can be utilized to aid the nation. ALMI, supported by AIPI, answered the challenge with the writing and publication of its second consensus report, a follow-up of SAINS45, Science for Indonesia's Biodiversity (SIB) (22).

A study committee was formed of members of ALMI plus a few members of AIPI in advisory roles. Over two hundred members of the Indonesian young scientists' network were also invited to provide input, comments, and criticism for the improvement of the document. SIB consists of three sections with the following aims i) to identify Indonesia's biodiversity richness, as well as to identify the challenges so that sciences can contribute to provide solutions; ii) to formulate a science-based policy strategy to achieve Sustainable Development Goals (SDGs) for life underwater and on land, as well as for life between them; and iii) to identify priority interventions and proposals for development steps and implementation plans. This document also provides a scale of priorities and ambitions, as well as the economic and scientific impacts arising from each priority. SIB was published in 2018.

This consensus report emphasizes the utilization of Indonesia's rich biodiversity as our comparative advantage for driving a transition from an economy based on extractive natural resources to a science and innovation-led economy. SIB explored what kind of sciences are needed to optimize benefits from Indonesia's biodiversity and recommended that three interdisciplinary sciences urgently needed to be strengthened: sciences related to bioprospecting for drug discovery, sciences related to better understanding the deep sea, and sciences to support ecotourism. Inherent to these recommendations is the need for multi-, inter-, and transdisciplinary sciences to help balance the economic and conservation aspects of Indonesia's mega biodiversity.

Both SAINS45 and SIB were published bilingually, in Bahasa Indonesia and English. Importantly, they were written in a popular language accessible to a wider nonspecialist audience (emphasizing science communication), through a strategic partnership between the Study Committee and several journalists from prominent Indonesian print media (Tempo magazine). The report was enriched with unpublished photo contributions by another prominent print media (the Kompas national daily).

Despite several examples of progress achieved through young scientist movements in Indonesia, various hindrances remain. There is a weak nexus between science and policy, solidified by the regulatory environment that recentralized research under one state body (the new Law on the National System of Science and Technology). BRIN, the science superagency described previously, reflects a continued politicization and bureaucratization of the research ecosystem in Indonesia that hinders the performance of researchers. Several of Indonesia's prominent mass media, including Tempo (31), Kompas (32), and The Jakarta Post (15) have recently reported on the serious impacts of BRIN to Indonesian researchers' performance, as well as on irregularities in this superagency.

The global COVID-19 pandemic and the associated government response toward it accentuated these problems. To some extent, Indonesia's initial poor responses to the pandemic reflected the lack of science-based public policies. Denialism, poorly coordinated and mismatched responses, as well as the widespread of misinformation and disinformation (an infodemic) characterized Indonesia's early responses to COVID-19 (33–37). Indonesian young scientists, including members of ALMI and Indonesia's Young Scientists Forum (IYSF), actively advocated for academic freedom and the need for more science-based responses to the pandemic (38, 39). Multistakeholder networks involving young scientists helped to monitor the government's performance, and Indonesia's responses to COVID-19 gradually improved (40, 41)

Indonesia's young scientists believe that their science advocacy must continue. There is a growing concern over scientific declining academic freedom due to government interference on the autonomy of research institutions and higher education in Indonesia. One notable example of such interference is on environmental issues.

In September 2022, the Indonesia Minister of Environment and Forestry (KLHK) responded to the Dutch scientist Erik

Meijaard and Julie Sherman's opinion article entitled "Orangutan Conservation Needs Agreement on Data and Trends" by issuing a letter stating that their study findings regarding the decline in the orangutan population were characterized with "negative intentions and could discredit the Indonesia government, particularly KLHK" (42).

Hence, KLHK ordered that the National Park Offices and the Ecosystem Natural Resource Conservation Offices not provide services to Meijaard and Sherman in all licensing/approval matters related to conservation activities that lay within the authority of the KLHK (43, 44). The KLHK's letter contradicted the principle of the independence of science which is the foundation of the search for objective scientific truth, in this case relating to the conservation of endangered species that are important for ecological balance and has global repercussions.

Realizing the kind of institutional and regulatory environment they work in, Indonesian young scientist organizations such as ALMI and the Indonesian Caucus for Academic Freedom (KIKA, whose several key members are also part of ALMI), occupy a unique position in fighting for greater academic freedom and holding the government accountable for its policies. Academic freedom is a key element of a thriving scientific ecosystem, where scientists can report their findings without fear of censorship or retaliation to better inform policy-making. Notwithstanding our findings on the surge in social science publications, young scientists are still faced with the challenge of translating their research into policy to improve societal conditions.

Concluding Remarks: Implications and Future Direction

The purpose of this article is to reflect on Indonesia's young academy movement. We have demonstrated the rising awareness of Indonesia's young scientists in advocating for the use of sciences in responding to crises. By taking the case of the Indonesian Young Academy of Sciences (ALMI) and its network of young scientists, we have described how ALMI's science communication practice, specifically SAINS45 (21) and Science for Indonesia's Biodiversity (22), have been useful for policymakers, media, and school engagements.

We have also shown how young scientists' movements comprise productive early to midcareer researchers whose fields of study need to be clearly linked with ALMI's identified science agenda. This is important for nurturing young scientists' potential (e.g., leveraging on the benefits of Indonesia's biodiversity, sustainable energy, environmental conservation, food sovereignty, health, and well-being advancement). Our findings show that there is a rise of social sciences in the 2020 cohort of new scientists. This increasing trend can be linked with Indonesia's strategic issues related to biodiversity (e.g., the need to strengthen ecotourism, the urgent need to balance economic and conservation aspects of Indonesia's biodiversity, inequality, diversity, and advancement of health and well-being all require the contributions of social sciences).

But there remains a gap between ALMI's science agenda, focused on Indonesia's basic problems in nature and people, with the kinds of research that young scientists are producing. In China, governments invested heavily in basic sciences throughout the 1980s, with a shift toward applied sciences emerging in the 1990s gearing technological development toward markets. But Indonesia's science ecosystem has never really made the investments in basic sciences that are required to support the type of advanced applied science that leads to technology transfer. The productivity of young scientists in Indonesia requires the kind of merit-based capacity building that nurtures scientific inquiry—so that applied research can be informed by basic sciences, as has occurred in other countries whose innovation systems support economic structures.

The government, universities, research institutions, and industries in Indonesia need to be cognizant of these discrepancies and work together to overcome them. Only by investing smartly and strategically in the scientific fields that are urgently needed to realize Indonesia's potential can we generate the knowledge-innovation-based economy that Indonesia seeks to escape a middle-income trap. What is required is not only a substantial increase in research funding but also a much more supportive ecosystem and governance for science and technology.

A clear roadmap for research and innovation activities, established priority areas, and set goals for the country's development must be established—and this should be informed by the fundamental questions in Indonesia's science agenda. The roadmap should emphasize the need for long-term investments in research and development, encourage interdisciplinary collaboration, and promote international cooperation to leverage global expertise and resources.

Data, Materials, and Software Availability. There are no data underlying this work.

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