– Research Report – APRC-FY2023-RR-07

Asia and Pacific Research Center

R&D Trends and Science and Technology Governance Reform in Indonesia

March 2024

Japan Science and Technology Agency

Established in April 2021, the Asia and Pacific Research Center (APRC) of the Japan Science and Technology Agency (JST) aims to contribute to building a foundation for innovation in Japan by expanding and deepening science and technology cooperation in the Asia-Pacific region based on the three pillars of research, information dissemination, and networking.

This report is compiled as part of a research that surveyed and analyzed science and technology innovation policies, research and development trends, and associated economic and social circumstances in the Asia-Pacific region. It is being made public on the APRC website and portal site to enable wide use by policymakers, associated researchers, and people with a strong interest in collaborating with the Asia-Pacific region; please see the websites below for more details.

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Executive Summary

Indonesia, a Southeast Asian country showing high potential supported by its continuous high gross domestic product (GDP) growth and demographic bonuses, is, for Japan, a country that contributes a large scientific and technical talent pool. In the late 2010s, the country has rapidly enhanced its STI capacity in the wake of integration and restructuring of its STI related ministries and agencies. This report examines the country's current status and challenges from basic indicators, governance reform in the aforementioned period and its relevant regulations, to interviews with local stakeholders, and derives recommendations and opportunities for the future.

First, the report gives an overview on the status of the national STI sector from a variety of indicators. The national government is currently prioritizing socio-economic needs over R&D, while financial support for the sector remains poor, and its patent system has not been sufficiently utilized for the commercialization of basic research. Despite an increase in talent in higher education, enrolment rates in STEM are still low, and the exchange of human resources with foreign countries (Indonesians studying abroad) is the least proactive among SEA countries. Interviews with local policymakers, R&D personnel, supporting agencies such as national or private foundations revealed these analyses to be in-line with reality.

To remove bureaucratic inefficiencies and complexities of the policy processes underlying the current status, the National Research and Innovation Agency (BRIN) was established through the integration of science and technology ministries, which is leading the current STI governnance reforms.

Based on this survey, the following strategic approaches were deemed necessary to solve the aforementioned challenges:

1. Increase Research Funding: Aim to boost research investment to 1% of GDP to enhance support for innovation and technology development.
2. Enhance Collaboration between Research Institutions and Industry: Promote the commercialization of research outcomes, spurring economic growth.
3. Improve Research Infrastructure: Invest in advanced research facilities.
4. Establish Centres of Excellence: Focus expertise in critical areas like natural and biological resources by creating specialized research centres with Japan.
5. Expand access and participation in international cooperation programs: Encourage participation in international funding programs and foster international collaboration.
6. Strengthen Intellectual Property Rights (IPR) Protection: Enhance the intellectual property framework to protect and incentivize researchers, attracting more foreign investment.
7. Develop Science Communication Platforms: Increase the visibility and impact of research through dedicated platforms that engage policymakers, industry, and the public.

Along with strengthening domestic STI capacity, the following recommendations can be made in regard to science and technology cooperation with Japan, taking into account gaps that exist between the two countries:

1. Expand Collaborative Research Platforms: Indonesia and Japan should consider establishing joint research centres or platforms that focus on specific areas of mutual interest, such as renewable energy, biotechnology, or information and communication technology. These platforms can serve as hubs for collaborative research

projects, knowledge exchange, and capacity-building initiatives. By pooling resources and expertise, both countries can accelerate the development of innovative solutions to shared challenges.

2. Enhance Academic and Researcher Mobility: Promoting the mobility of academic and research talent between Indonesia and Japan can foster stronger ties and facilitate knowledge transfer. Initiatives such as joint degree programs, research fellowships, and exchange visits can provide opportunities for Indonesian and Japanese researchers to collaborate more closely and learn from each other's experiences. This can also help Indonesian researchers gain exposure to Japan's advanced research environment and technological capabilities.
3. Leverage Private Sector Engagement: Encouraging greater involvement of the private sector in R&D collaboration can lead to more practical and market-driven outcomes. Indonesia and Japan can explore mechanisms to incentivize private companies to invest in joint research projects, technology transfer, and innovation. Public-private partnerships can also be a valuable tool for addressing industry-specific challenges and developing technologies that have commercial potential.
4. Strengthen Strategic Communications. This will help in overcoming challenges in Indonesia-Japan STI cooperation, and accelerate the socio-economic growth of both countries. Possible actions include launching research centers, exchange programs, interdisciplinary projects, cultural exchange and language training.
5. Foster a Culture of Innovation: To sustain long-term collaboration and strengthen STI cooperation, both Indonesia and Japan should focus on cultivating a culture of innovation within their respective countries. This involves not only investing in research and development but also promoting entrepreneurship, creativity, and risk-taking. Educational institutions and government policies should encourage critical thinking, problem-solving, and interdisciplinary approaches to research. By nurturing a vibrant innovation ecosystem, Indonesia and Japan can create a conducive environment for scientific and technological advancement.

Japan has a long history of friendship with Indonesia, taking into account not only its presence as an emerging country with strong demographic bonuses and economic development, but also the fact that foreign graduates to Japan have contributed to national STI development. Cooperation in the midst of this development is mutually beneficial in terms of deepening diplomatic relationships as well as sharing worthwhile scientific expertise. Advanced technology, research hubs utilising the natural and biological resources in which Indonesia has an advantage, and the initiation of research cooperation, are expected to be of particular mutual benefit. Futhermore, through the continued exchange of human resources, the legacy of the previous generation is expected to be passed on to the next.

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List of Abbreviations

AIPI (Akademi Ilmu Pengetahuan Indonesia)
ALMI (Akademi Ilmuwan Muda Indonesia)
ASEAN (Association of Southeast Asian Nations)
BAPPENAS (Badan Perencanaan Pembangunan Nasional / National Development Planning Agency)
BATAN (Badan Tenega Nuklir National / National Nuclerar Energy Agency)
BPPT (Badan Pengkajian dan Penerapan Teknologi / Agency for the Assessment and Application of Technology)
BRIDA (Badan Riset dan Inovasi Daerah / Provincial Research and Innovation Agency)
BRIN (Badan Riset dan Inovasi Nasional / National Research and Innovation Agency)
DIPI (Dana Ilmu Pengetahuan Indonesia / Indonesian Science Fund)
DRIN (National Research and Innovation Fund)
IPB (Institut Pertanian Bogor / Bogor Agricultural University)
IRIF (Indonesian Research and Innovation Fund)
ITB (Institut Teknologi Bandung / Bandung Institute of Technology)
Kemendikbudristek (Ministry of Education, Culture, Research, and Technology)
LAPAN (Lembaga Penerbangan dan Antariksa Nasional / Indonesian National Institute of Aeronautics and Space)
LIPI (Lembaga Ilmu Pengetahuan Indonesia / Indonesian Institute of Sciences)
LPDP (Lembaga Pengelola Dana Pendidikan / Indonesia Endowment Fund for Education)
PERSADA (Perhimpunan Alumni dari Jepang / Indonesian Alumni Association from Japan)
PPBT (Perusahaan Pemula Berbasis Teknologi / Technology-Based Start-up Company)
UGM (Universiti Gadjah Mada / Gadjah Mada University)
UI (Universiti Indonesia / University of Indonesia)
WEF (World Economic Forum)
WHO (World Health Organization)
WIPO (World Intellectual Property Organization)

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1 Introduction

This chapter clarifies objectives and background of the study, and designs its framework with the methodological details in each successive chapter.

1.1 Objectives and Background

Indonesia is expected to rank as the world's 7th largest economy by GDP in 2045, with its demographic bonus period projected to continue from the 2030s to the 2040s. The number of Japanese government-sponsored students from Indonesia was the highest in the world in 2020 (888 students) and was ranked as the second-largest country globally for Japanese-language learners (711,732 students), following China with 1,057,318 students, according to the 2021 "Survey of Japanese-Language Education Institutions Overseas". Thus, Indonesia can be considered an important talent pool country for human resources.

In addition to its economic potential and demography, Indonesia is on the verge of becoming a critical hub for science and technology due to its diverse research population and commitment. The establishment of the National Research and Innovation Agency (BRIN), established after integrating major governmental science agencies and institutes, not only underscores Indonesia's global tech potential but also its unique approach. The agency is committed to elevating Indonesia's technological standing, forging a path that is distinct from Japan's, and fostering a robust international alliance.

Given this background, Indonesia is now regarded as a prospective partner country for Japan in science, technology and innovation (STI) cooperation, making it crucial to gain a deeper understanding of the current situation. This report is the result of a foundational survey aimed at expanding and deepening STI cooperation between two countries. First, this report presents the status quo using a variety of data. Then, it overviews the recent governance reforms, centred on the reorganization of ministries into BRIN and BRIDA, and their implications for Indonesia's STI policies. Based on verification through interviews with local stakeholders, this report concludes with outlines of Indonesia's future possible roadmap and relevant recommendations for enhanced cooperation with Japan.

1.2 Conceptual Framework and Methodology

This study's framework, shown in Figure 1, is designed to explore Indonesia's STI landscape. The methodology outlined includes literature reviews and interviews, stressing the alignment with overarching research goals. It is structured around Inputs, Outputs, and Outcomes. Inputs focus on analyzing Indonesia's STI personnel, budget, and related policies. Outputs examine research productivity via publications and patents. Outcomes evaluate the broader impacts of Indonesia's STI initiatives, highlighting achievements in scientific and technological fields.

Secondly, this report will clarify the policies, the distribution of public funds, and the reality of international cooperation that promotes this development based on relevant legislation and policy documents. In the final step, our team conducted focus group discussions (FGDs) with local stakeholders in a round-table discussion format, and through individual interviews, and compared these results to verify the consistency with the actual situation, as well

as comprehensively verify the reality and extract issues. Based on this verification, this report proposes the potential for Indonesia to raise its STI level through partnerships and exchanges with Japan, and the opportunities for building mutually beneficial relationships through cooperation with major countries around the world.

This study delves into qualitative aspects, offering a nuanced view beyond quantitative metrics. It emphasizes interdisciplinary approaches to societal challenges like research personnel, gender issues, and infrastructure. The findings inform Indonesia's human resource development and R&D strategies, suggesting alignment with emerging challenges. Also, the study compares Indonesia's STI capabilities internationally, particularly with ASEAN member states and Japan, to devise tailored collaboration strategies, focusing on technology transfer and sustaining joint efforts for strategic STI alliances.

This study's literature review method analyzes diverse scholarly materials, reports, and articles to understand trends in Indonesia's STI. Additionally, it examines policies related to education and social development, and summarizes Indonesia's development history to date. By interviewing key stakeholders, we verify the validity of the findings obtained through the literature survey.

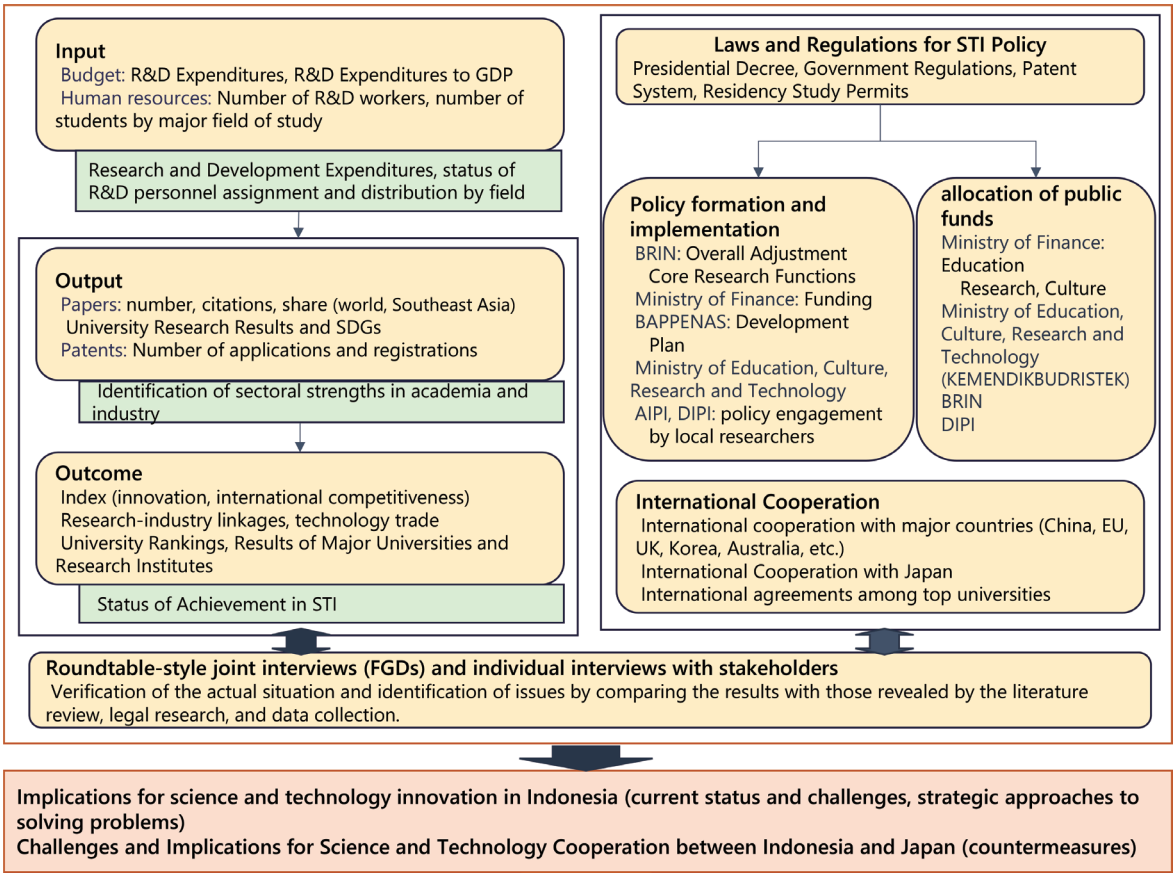


Figure 1 Conceptual Framework

Also, individual interviews and a FGD were conducted to fill gaps in official data, capturing expert insights not found in public sources. This approach ensures comprehensive stakeholder engagement, providing relevant data to assess Indonesia's R&D status, challenges, and future directions.

As well, detailing policies and institutions which contributes to this survey are digested in the Annex. 10.8.

2 Indonesia's Scientific and Technological Capabilities: Challenges and Prospects

In this chapter, we first overview Indonesia's R&D capabilities in terms of challenges and prospects on the key science and technology indicators to investigate and analyse the development and securing of human resources in science and technology in Indonesia. In this section, we look at inputs (human resources and R&D expenditures), outputs (publications and patent applications/registrations), as well as outcomes, namely scientific and technological awards, technology intensity and innovation, innovation power, research industry connection and trade balance, and rankings of top research institution in Indonesia.

2.1 Input to Research and Development

This section explores crucial inputs for assessing R&D in STI in Indonesia, focusing on budget and personnel. It analyzes R&D expenditures as a percentage of GDP and compares them with ASEAN's six countries (Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam) to gauge Indonesia's investment in innovation. It details funding sources and allocation across sectors, examining government and university R&D budget management and private sector contributions, particularly from startups. Simultaneously, the study assesses R&D personnel distribution and density, comparing it with ASEAN 6 countries to contextualize Indonesia's regional research talent. It also explores tertiary graduates' fields of study as of 2015 and the composition and qualifications of public institution researchers, providing insights into the expertise and structure of the R&D workforce.

2.1.1 R&D Budgets: Chronic deficit owing to inefficient bureaucracy

Identifying the R&D budget is essential to evaluating Indonesia's investment in the educational and STI.According to the World Bank, Indonesia's R&D expenditure was 0.28 % of GDP in 2020, as shown in Figure 3 (World Bank, 2023b). Historically, from 2000 to 2020, the average R&D expenditure was only 0.17%, with lows of 0.05% in 2001 and highs of 0.28% in 2020 (World Bank, 2023b). Meanwhile, the average investment for 2010-2020 was 0.38%, highlighting the need for increased investment in R&D to drive economic growth (Sumahir et al., 2022). However, the budgeting process is often hampered by bureaucracy, inefficiency, and political interference, which can lead to frequent adjustments to initial budget plans and reduce the effectiveness of resource allocation (Firmansyah, 2021).

Despite annual fluctuations, total R&D expenditures have shown an upward trend through 2020.

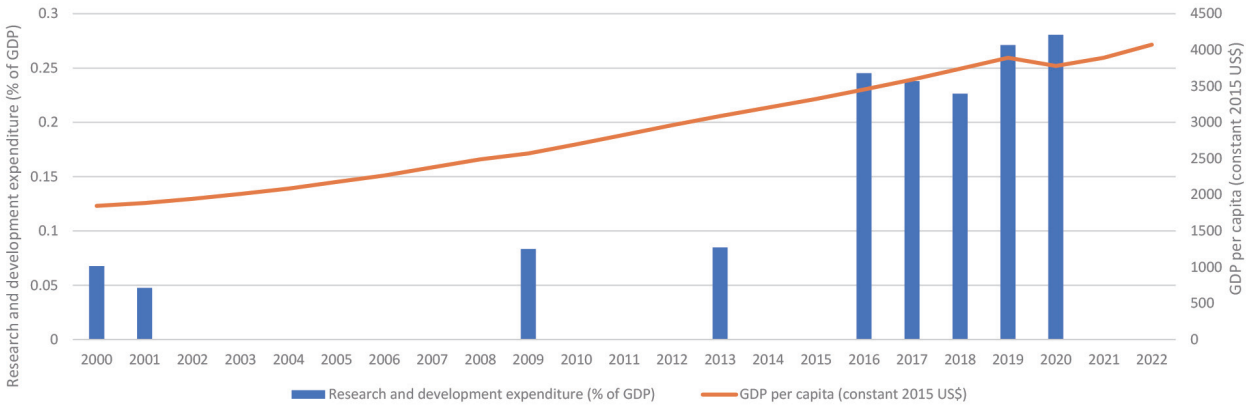


Figure 2 R&D Expenditures and their Ratio to GDP

Source: (World Bank, 2023)

Indonesia's R&D budget is notably lower compared to both other Southeast Asian and advanced economies (Figure 3). For instance, in 2020, Indonesia's investment persentage of its GDP in R&D (0.28%), significantly less than countries like Japan (3.27%), Germany (3.11%), and the United States (3.42%), as well as Korea (4.80%), highlighting a vast gap in commitment to research and innovation (World Bank, 2023b). To enhance competitiveness and foster innovation, Indonesia needs to increase R&D investment, drawing lessons from countries with higher investment ratios (Gümüş & Çelikay, 2015; Moustapha & Qian, 2021).

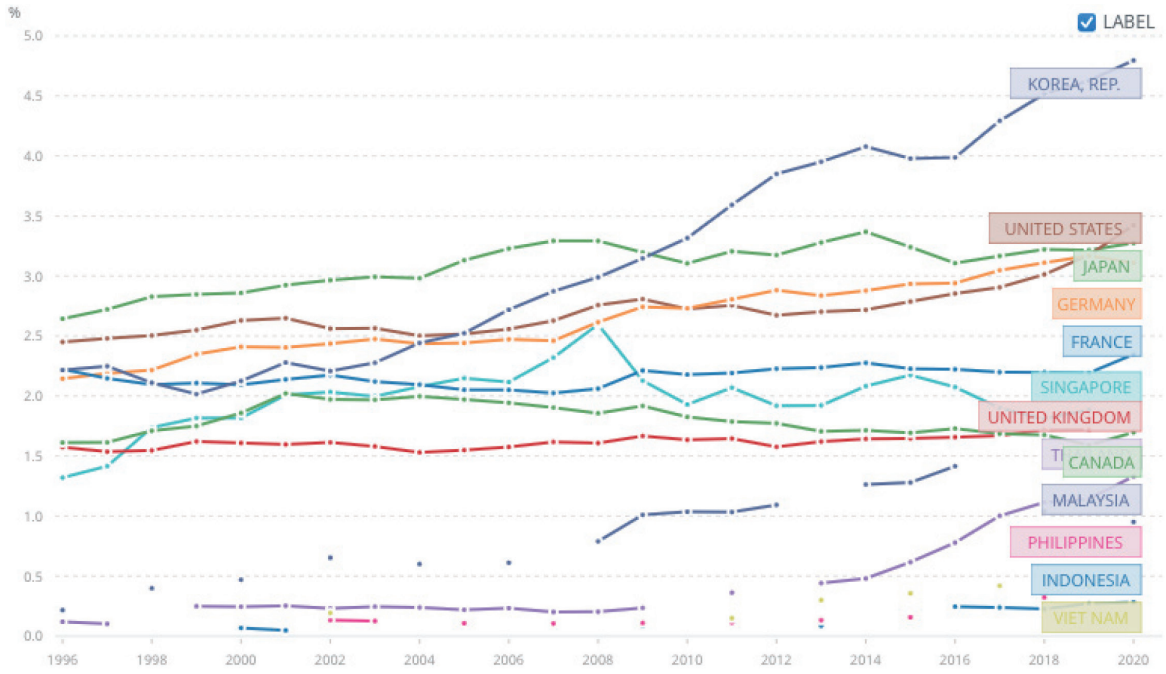


Figure 3 Comparison of R&D Expenditures (% to GDP) between Indonesia, Asia, and advanced economic countries

Source: (World Bank, 2023)

2.1.2 R&D Personnel: Shortage in STEM fields amid constant increase in total

Understanding the density of researchers per million people in Indonesia is crucial for gauging the country's commitment to advancing knowledge and innovation. Figure 4 shows a significant increase in this metric, reflecting an enhanced focus on R&D. From 179 researchers per million in 2016 to 396 in 2020, Indonesia has shown remarkable growth in building a robust research ecosystem, with the trend reaching its peak in 2020 (World Bank, 2023a).

Initially, in 2009, the density was at a low of 89 researchers per million, indicative of the lesser priority given to developing research personnel at the time (Andhina Ratri et al., 2020). This trend reversed with increased national research funding, with 20% allocated towards disaster management research (Rakhmani & Siregar, 2016). The Directorate General of Higher Education integration with the Ministry of Research and Technology in 2014 under President Joko Widodo's administration marked a significant shift, aligning higher education with the national research agenda (Rosser, 2016).

If Indonesia continues its current policies aimed at human capital improvement, the number of researchers is expected to rise steadily. Projections suggest reaching 458 researchers by 2025, 587 by 2030, and 716 by 2035, indicating an ongoing commitment to fostering a dynamic research environment (Huda et al., 2020). This strategic planning underscores Indonesia's ambition to enhance its position in the global innovation landscape.

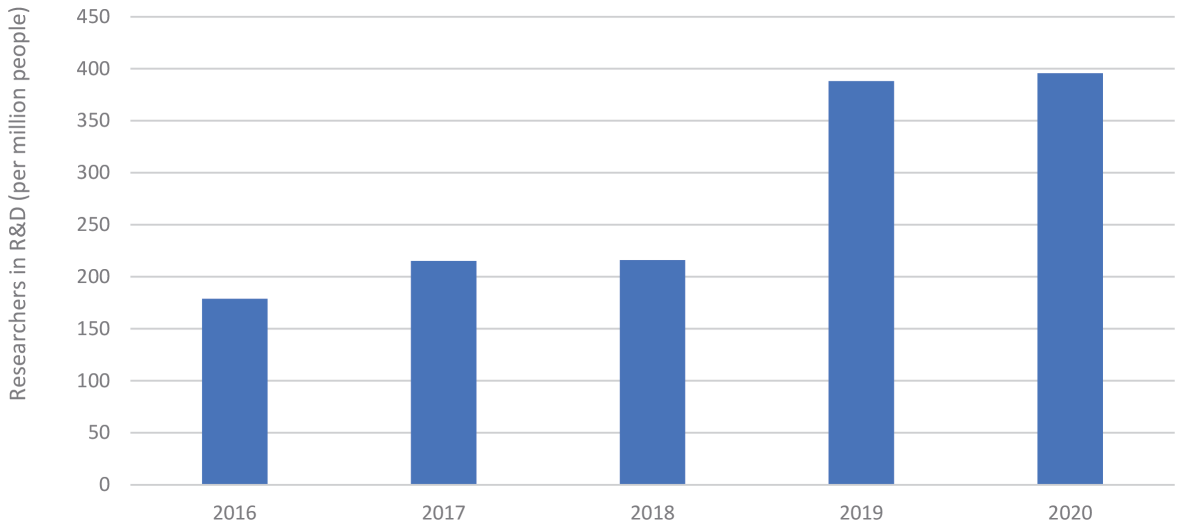


Figure 4 Researchers in R&D per million people

Source: (World Bank, 2023)

When comparing Indonesia's R&D personnel density with other countries, it is clear that Indonesia lags advanced economies and some Asian neighbours in R&D workforce density (Figure 5). As of 2020, Indonesia has 396 researchers per million people, while Japan has 5,455 (World Bank, 2023a). Similarly, compared to Singapore and Korea, Indonesia's figures are much lower, underscoring the need for significant investment in R&D personnel and infrastructure to boost competitiveness and innovation.

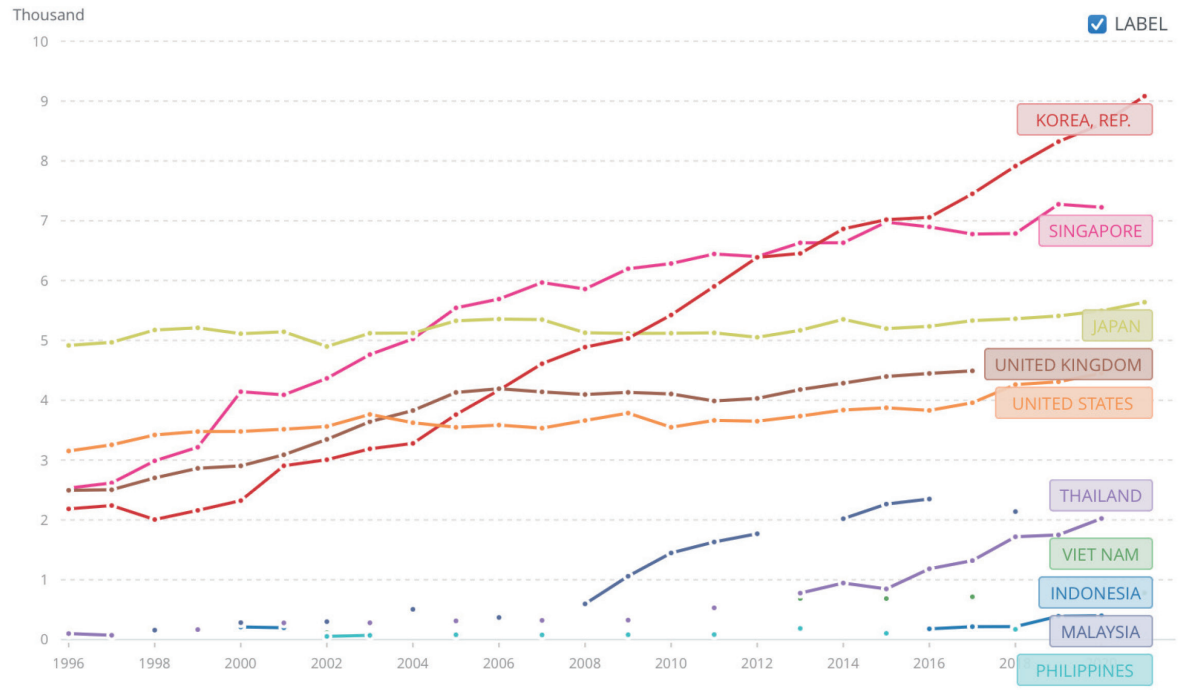


Figure 5 Comparison of researchers in R&D per million people between Indonesia, Asia, and advanced economic countries

Source: (World Bank, 2023)

Alongside the numeric growth of researchers, analyzing the distribution of tertiary graduates by field of study offers insights into Indonesia's capacity for scientific and technological workforce development. Data from 2020 on Figure 6 shows that bachelor's degree programs dominate with 83.86% of enrolments, while advanced degrees like Masters and Doctorates are less common, with 3.75% and 0.52%, respectively, reflecting the challenging nature of these programs (Kemendikbudristek, 2020).

In Indonesia's tertiary education, in addition to university education, which comprises bachelor's (S1: 4 years of standard course term), master's (S2: 2 years), and doctorate (S3: 3 years), professional education is conducted which consists of 4 diplomas (1~4 years of standard course term). Bachelor's degrees and 4 diplomas are ranked as post-secondary education. Those who graduated from diploma 4 are eligible to enter professional schools which are equivalent to a master's degree or doctor's degree in university education. The classifications of 4 diplomas are determined as follows:

- Diploma 1 (D1): An education program with 1 year of attendance (2 terms). It focuses on teaching basic professional skills that are relevant to job markets, accounting for 32 credits in total. D1 graduates earn the title of *Ahli Pratama* (A.P.).
- Diploma 2 (D2): An education program with 2 years of attendance (4 terms). Compared to D1, it consists of more curriculum with combination of theory and practice, and aims at deepening technological skill in particular field. Total amount of credits required credits are approximately 64. D2 graduates earn the title of *Ahli Muda* (A.Ma.).
- Diploma 3 (D3): An education program with 3 years of attendance (6 terms). The total amount of required credits is 112. Balancing theory and practice, it aims at fostering graduates who succeed professionally. D3

graduates earn the title of Associate Expert (A.Md.).

- Diploma 4 (D4): An education program with 3 years of attendance (6 terms). The program requires a total amount of 144 credits and puts more emphasis on practical or applied expertise than theory. D4 graduates are equivalent to a bachelor in applied science and earn the title of *Sarjana Sains Terapan* (S.ST.).

Indonesia's field of study distribution shows a notable focus on Education (21.59%), Economics and Social studies (20.89% and 19.43%, respectively), with Art having the lowest enrolment (0.97%). The low enrolment in Math and Natural Science (3.24%) is particularly concerning, contrasting global emphasis on STEM (Science, Technology, Engineering and Mathematics) education (Kemendikbudristek, 2020). This disparity is significant as STEM fields are crucial for innovation and economic growth, suggesting a potential workforce deficit.

Eurostat data for 2017 reveals that EU nations had 26% STEM graduates, which is consistent with previous years. Germany led with 36% STEM graduates, while Belgium, Cyprus, and the Netherlands had the lowest (17-15% STEM graduates) (Eurostat, 2020). In Indonesia, the enrolment rate in relevant fields (24.33%, the sum of "Engineering", "Agriculture", "Mathematic & Natural Science") (Kemendikbudristek, 2020) is below the average of EU member states. It is considered as important to keep the level of EU average to develop science and technology and its relevant industry (Eurostat, 2020).

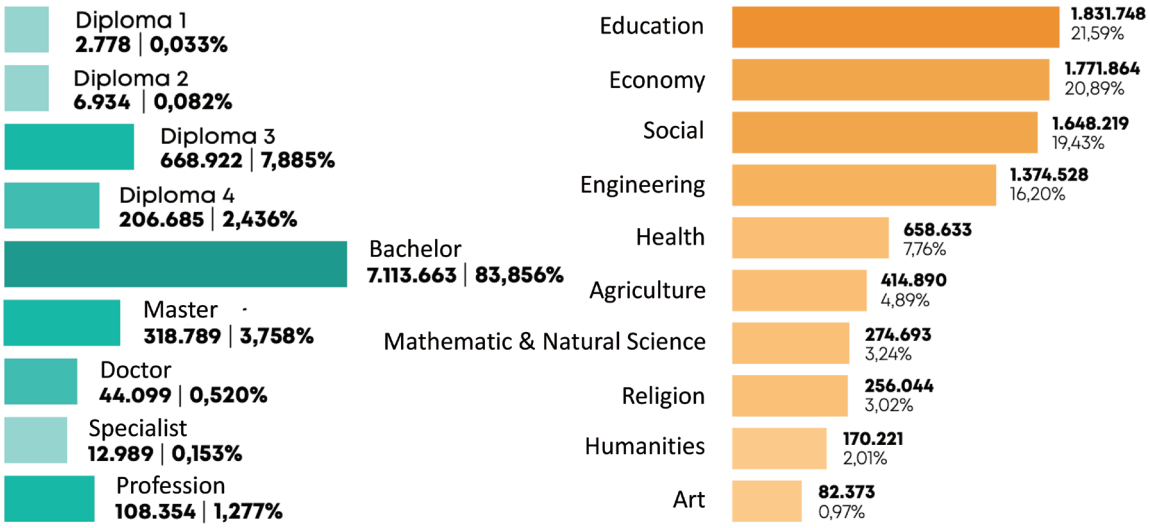


Figure 6 Number of enrolled students based on program of education (left) and number of enrolled students based on field of study (right) in 2020

Source: (Kemendikbudristek, 2020)

The section on R&D personnel in Indonesian government agencies details the distribution of researchers based on job levels and educational background, as shown in Figure 7. highlighting the diverse expertise in Indonesia's scientific and technological landscape. There are four job levels: *Pertama* (First), *Muda* (Junior), *Madya* (Intermediate), and *Utama* (Main), each reflecting increasing experience and qualifications.

Pertama researchers perform foundational tasks, with 1,434 in the Ministry, 153 in Bureaus, and 755 in other agencies. *Muda* researchers, totalling 1621, manage complex projects independently, showing advanced qualifications. *Madya* researchers, with a count of 1271, take leadership roles and mentor junior staff, influencing research strategies. *Utama* researchers, the most seasoned, include 494 in the Ministry, 160 in Bureaus, and 266 in other agencies, leading

significant projects and strategic advancements. (BRIN, 2023a).

The distribution of R&D personnel in Indonesian government agencies also sheds light on the educational qualifications required for different job levels. Notably, there are no D3 (Diploma) level researchers in the Ministry and Bureaus, with S1 (Bachelor's) being the minimum academic threshold. This underscores the emphasis on higher education in these agencies, with 2,500 researchers holding master's degrees. This commitment to advanced education is a testament to the agencies' efforts to enhance research capabilities and stay at the forefront of scientific and technological advancements (BRIN, 2023a).

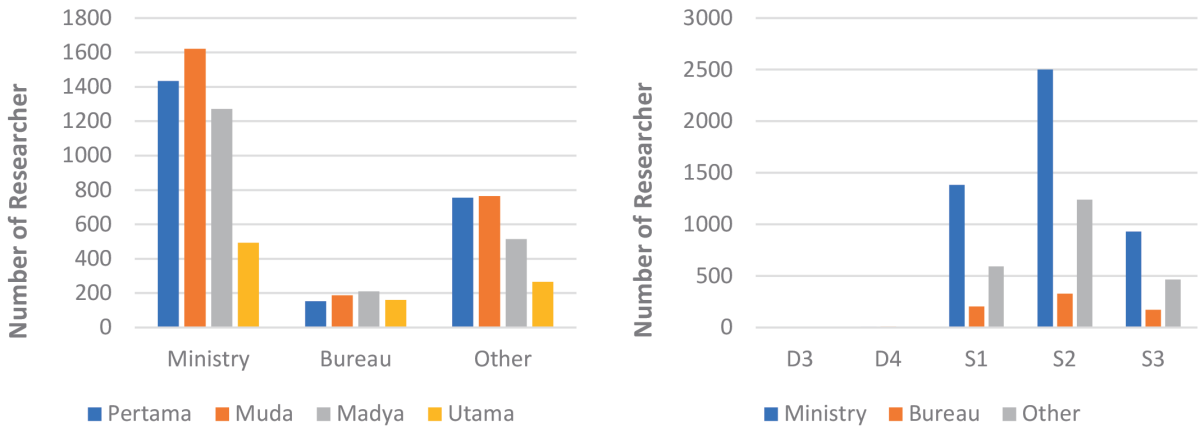


Figure 7 Number of researchers in public institutions by functional position level and degrees

2.2 Outputs from Research and Development

This section reviews R&D outputs, focusing on publications and patents to gauge productivity and innovation. It analyzes academic publications using data from SciVal and Scopus, evaluating the volume citations and comparing the impact to ASEAN 6 countries from SciVal and Scopus, including their alignment with SDGs (Sustainable Development Goals) and presence in Q1 journals. Patents are examined through the World Intellectual Property Organization (WIPO) data to identify sectors with significant legal protections for innovations, highlighting areas of robust technological progress.

2.2.1 Number of Papers and Shares (Overall)

Indonesia's research output from 2000 to 2023 consistently rose to 37,515 publications, indicating growth but still trailing some Asian countries, as shown in Figure 8. The trend reveals details this trajectory, illustrating Indonesia's active engagement in scientific efforts, although improvements are needed to match regional leaders.

The country's share in Southeast Asia's publication market (hereafter Asia Share) increased from 6% in 2000 to 27% in 2023. The rise correlates with initiatives like the World Class University program aimed at boosting international publications at state universities, reflecting Indonesia's strengthening presence in Asian academic community (Napitulu, 2022).

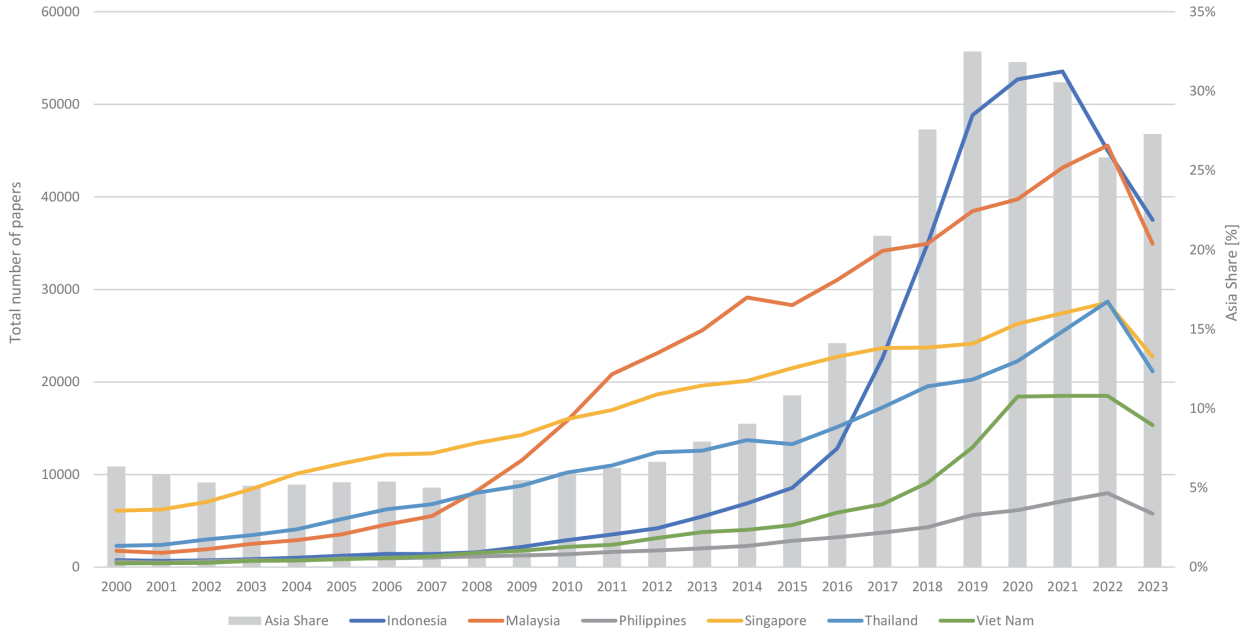


Figure 8 Total number of papers (All publication types) and Asia share (2000-2023)

Source: SciVal, based on Scopus Data

From 2000 to 2023, citation counts for Indonesian research peaked in 2019 at 233,688 (Figure 9). Still, they fell to 15,271 by 2023, possibly due to its nature as a lagging indicator. Despite growing publication numbers, citation counts have fluctuated, indicating that while research volume is high, its impact varies.

Previous studies emphasize the importance of policies to develop scientific publications in Indonesia, highlighting the need for publishing in reputable media to enhance journal impacts, citations, and authors' H-Index (Madi, 2019). Indonesia's scientific publications underperform Southeast Asia in terms of citation indices, pointing out areas for improvement in quality and impact (Komala Putri et al., 2018).

Regarding citation market share within Asia, Indonesia ranges from 4-12%, showing substantial regional influence but still lagging Southeast Asian peers. Challenges include BRIN’s limited funding for open-access publication fees and a small research budget, considered as hindering the broader visibility and impact of Indonesian research globally.

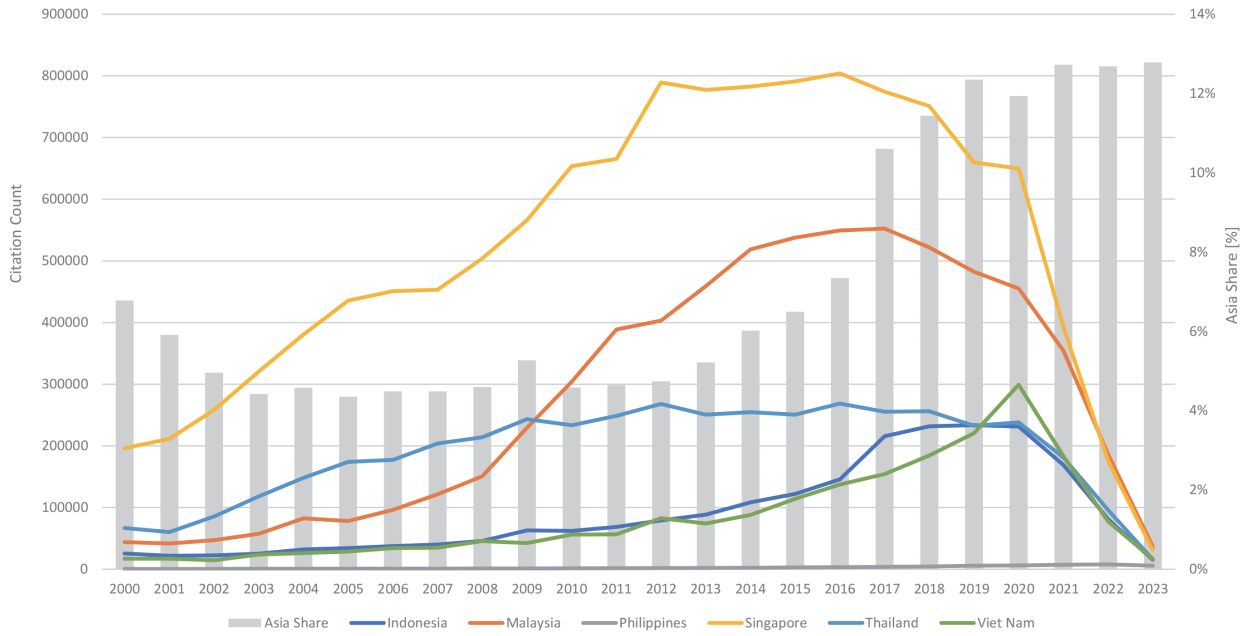


Figure 9 Comparison of the citation count of papers (all publication types) and Asia share (2000-2023)

Source: SciVal, based on Scopus Data

From 2000 to 2023, Indonesia's representation in the Top 10% Journal Percentiles by CiteScore fell from 23.3% to 8.5%, showing a decline despite early success, unlike Singapore's stable increase to 50.9% in 2023 (Figure 10). This fluctuation reflects periods of academic strength followed by significant decreases. Although Indonesia's research output and citations grew, its presence in high-impact journals lagged, contributing only 3-6% to Southeast Asia's top papers.

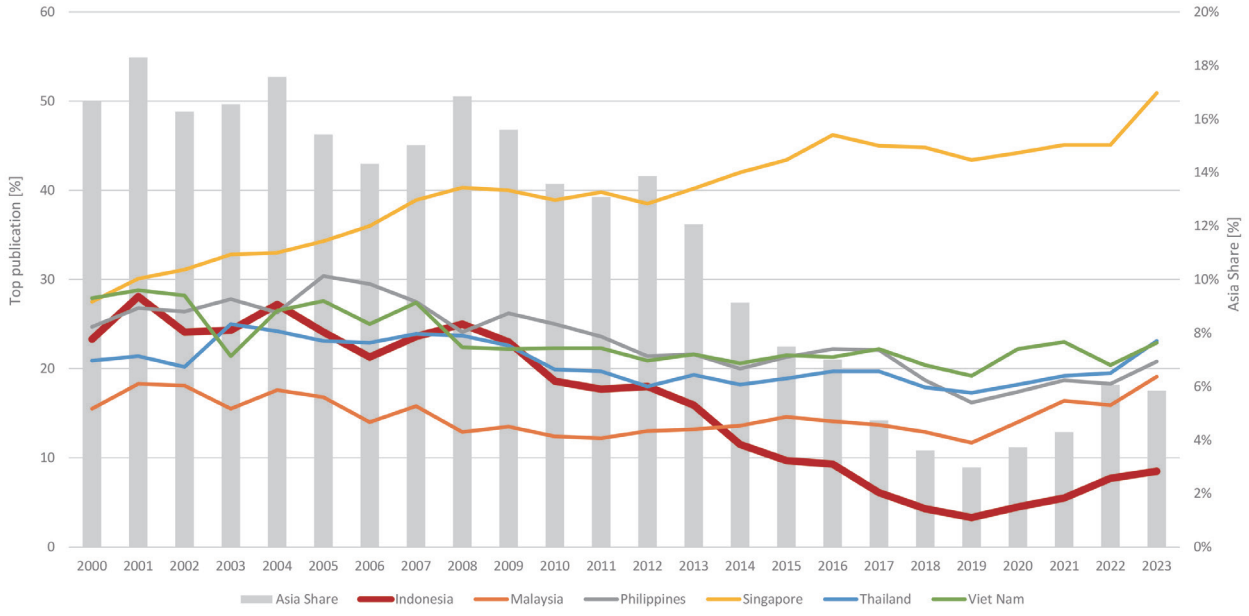


Figure 10 Comparison percentage of top papers (all publication types) in Top 10% Journal Percentiles by CiteScore Percentile (%) and Asia share (2000-2023)

Source: SciVal, based on Scopus Data

Indonesia's publications in the Q1 Journal Quartile by CiteScore fluctuated from 52.7% in 2000 to 22.9% in 2023, showing a decline after an initial improvement up to 2018 (Figure 11). This places Indonesia behind regional counterparts like Singapore, which maintained over 70% in high-quality journals.

The decline in top-quality journal publications correlates with the decrease in the top 10% of journal papers, suggesting a link between research quality and high-impact outputs. Indonesia's relative performance in Asia's Q1 publications has been decreasing, with the percentage share fluctuating from a high of 18% in 2000 to only 8% in 2023. Over the past five years, Indonesia's share ranged from 4-8%, indicating a lower performance than Singapore and the Philippines, which consistently scored higher (37-32% and 14-15%). This trend highlights the need for Indonesia to focus on enhancing the quality and impact of its research to improve its standing in the regional and global scientific community.

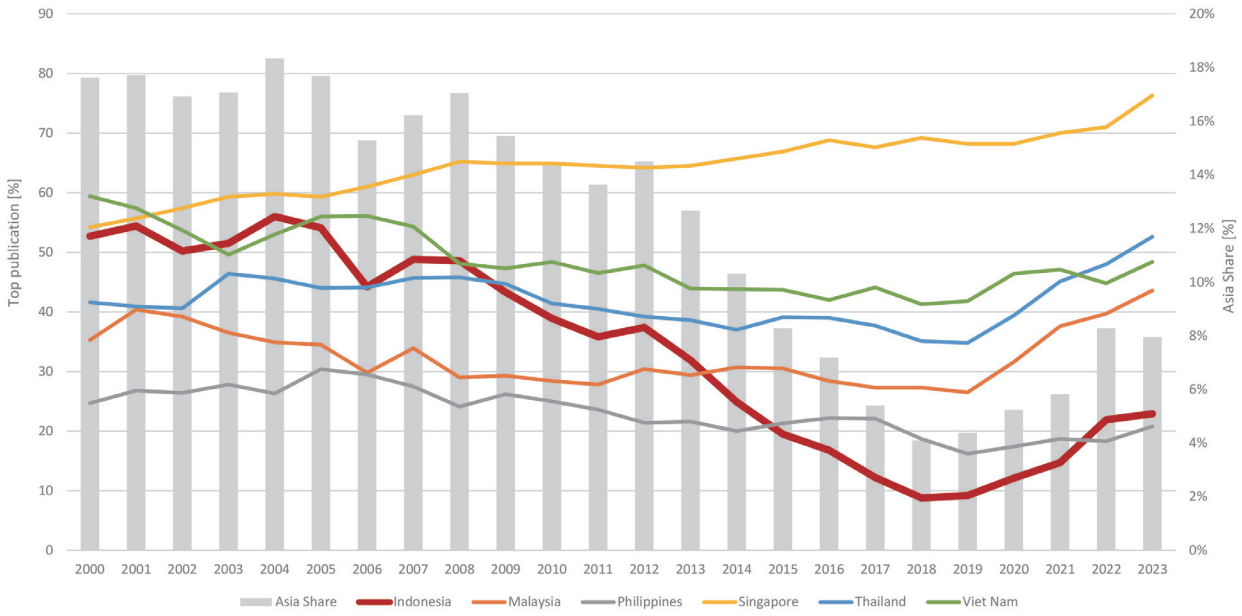


Figure 11 Comparison percentage of publications in Q1 Journal Quartile by CiteScore (%) and Asia share (2000-2023)

Source: SciVal, based on Scopus Data

The analysis of academic-corporate collaboration in publications from 2000 to 2023 shows varying trends across Asia, with a general increase indicating stronger academia-industry ties (Figure 12). Indonesia, however, exhibits a declining trend in such collaborations, contrasting with regional progress and highlighting a lag in effectively engaging with the industrial sector. While countries like Singapore demonstrate strong university-industry integration through high collaboration rates, Indonesia's lower percentage of joint publications suggests significant potential for growth in enhancing knowledge transfer and fostering partnerships with the corporate sector.

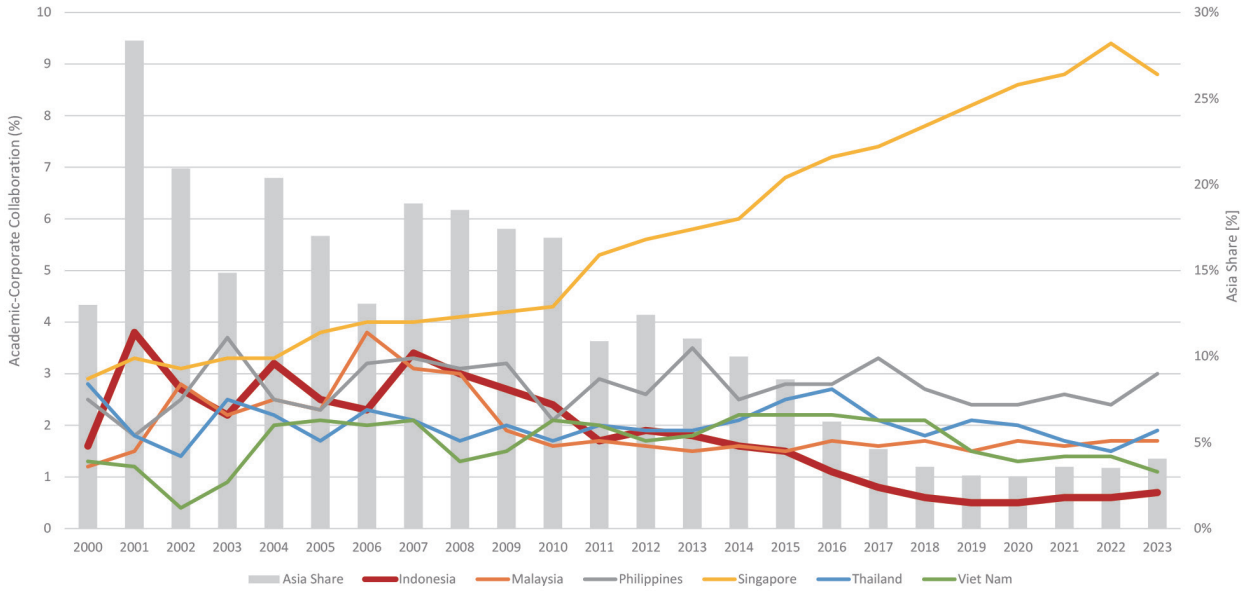


Figure 12 Academic-Corporate Collaboration (%) publication (all types) and Asia share (2000-2023)

Source: SciVal, based on Scopus Data

2.2.2 Research Results and SDGs: University Contributions

Regarding the 2030 Agenda for Sustainable Development (Sustainable Development Goals, hereafter "SDGs"), Figure 13 shows that, SDG 3 (Good Health and Well-being) leads with 33,751 publications and 466,459 citations, underscoring its pivotal role in sustainable development and its significant academic influence (Figure 14). While SDG 3 and SDG 7 garner substantial attention and citations, SDG 1 (No Poverty) and SDG 5 (Gender Equality) show lower outputs but still have considerable citation impacts of 18,625 and 20,675, respectively. SDG 16 (Promote just, peaceful and inclusive societies) exhibits the highest citation per publication ratio.

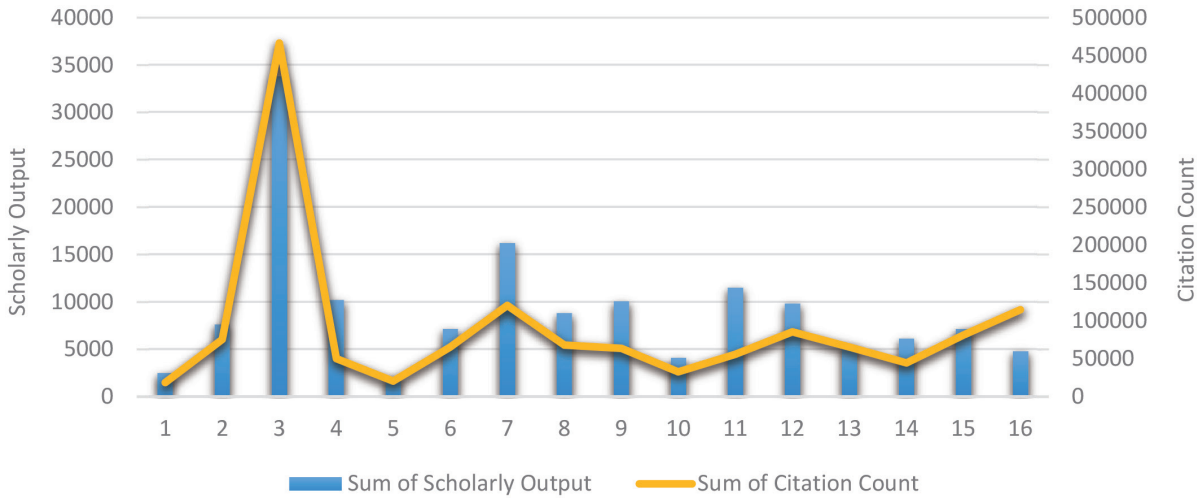


Figure 13 Total scholarly output and citation count of 16 SDGs collected from 100 institutions in Indonesia from 2013-2022

Scholarly output data from 2013 to 2022 for the top 20 institutions highlights significant contributions to SDGs (Figure 14). The University of Indonesia leads with 14,542 publications, followed by Gadjah Mada University and Bandung Institute of Technology, with 9,597 and 7,384 publications, respectively, illustrating their robust research commitments across all SDGs.

Institutional emphasis on SDGs varies, with each showcasing distinct strength. The Centre for International Forestry Research excels in forestry-related SDGs, while the BRIN predominantly addresses government-related SDGs, significantly impacting policy and governance aspects of sustainable development.

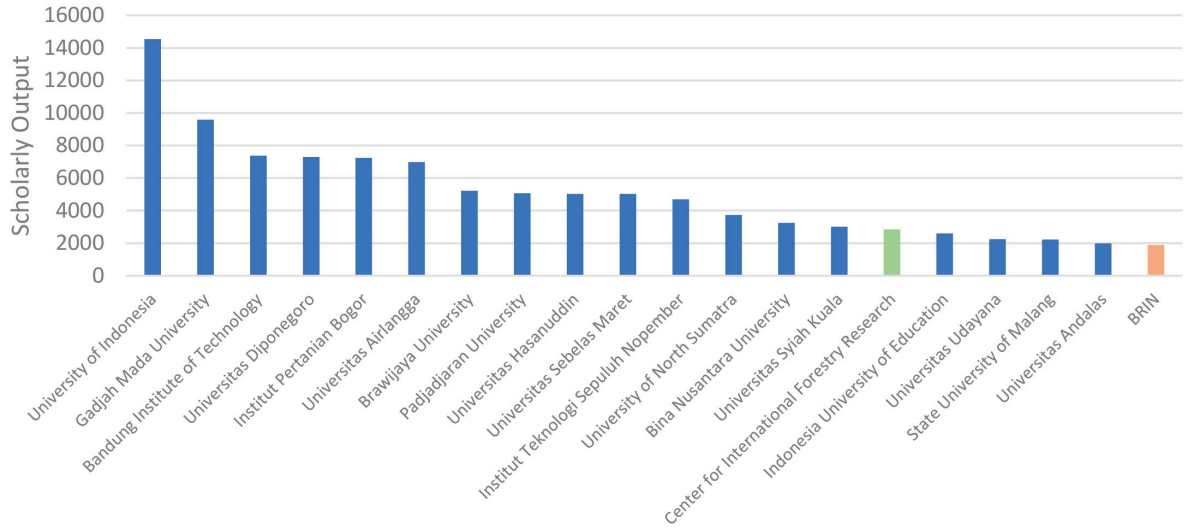


Figure 14 Scholarly output of TOP20 institution for all SDGs from 2013-2022. Blue indicates the academia sector, green is the research centre (NGO), and red is the government sector

The analysis from 2013 to 2022 shows collaborative solid efforts among Indonesian institutions towards the SDGs, illustrated in Table 1, particularly in SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), and SDG 7 (Affordable and Clean Energy), demonstrating a national commitment to health and environmental sustainability. This trend highlights the collective focus on addressing significant societal challenges.

Notably, Universitas Indonesia leads in SDG 3 contributions with 5104 publications, reflecting its pivotal role in advancing national health priorities and global healthcare improvements. Airlangga University and Universitas Gajah Mada also show firm commitments, underlining a nationwide dedication to improving health outcomes.

Furthermore, Institut Teknologi Bandung excels in SDG 7 research, with 1842 publications, driven by Indonesia's growing energy needs and its role in climate change mitigation (Jaenudin et al., 2023). It also shows significant involvement in SDG 11. At the same time, Universitas Gajah Mada presents a balanced approach to SDGs, particularly in clean energy.

Bogor Agricultural University (IPB) and the Centre for International Forestry Research (CIFOR) emphasize environmental sustainability through SDGs 14 (Life Below Water) and 15 (Life on Land), with focused efforts on natural resource management. This specialized focus across institutions supports Indonesia's strategy to meet the SDGs, showing a strategic alignment with national and global sustainability targets.

Table 1 List of Institutions and Scholarly Output on Each SDG

Institutions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Bina Nusantara University				416				332	588	131						183
Brawijaya University	82	405	1369		42	308	477	339	302	116	369	337	136	337	299	173
BRIN														199	202	
CIFOR	103	385											406		880	
Indonesia University of Education				1049	51											
Institut Teknologi Sepuluh Nopember						372	1252		457		581	361	205			
IPB	103	910				406	440	536	365	102	407	689	441	805	1109	
ITB			939			457	1842	307	725		1214	474	348	259		127
Padjadjaran University	112	330	2002		94			376		158					201	189
Semarang State University				302												
State University of Jakarta				498												
State University of Malang				711												
State University of Padang				377												
UGM	160	658	2778		127	508	1054	482	456	272	805	516	408	310	579	273
UI	268	408	5104	413	319	531	1683	773	941	484	1173	774	502	285	319	565
Universitas Airlangga	153		3789		185	294		324	316	229				335		181
Universitas Diponegoro	120	230	1203		91	637	728	480	558	198	785	708	322	598	246	236
Universitas Hasanuddin	83	463	1469		64	232				109	369	318	168	440	299	135
Universitas Negeri Surabaya				362												
Universitas Sebelas Maret	85	327		532	65	220	798	326	324	192		392	302			170
Universitas Syiah Kuala							381				385			213		
Universitas Udayana			935		85											
University of North Sumatra		233	1090				419				333	284			250	
Yogyakarta State University				662												

In summary, Indonesia's scholarly output highlights its dedication to the SDGs, emphasizing education, poverty reduction, regional development, environmental sustainability, and health. This research effort reflects Indonesia's comprehensive approach to sustainable development, aligning with the 17 SDGs and 169 targets (Afandi et al., 2021).

An important aspect of this analysis is the role of institutions in different sectors, such as academic, corporate, government, and others, as shown in Figure 15. Analysis reveals that academic institutions contribute significantly to SDG research, accounting for 95% of publications (140,215). At the same time, corporate involvement is minimal, representing less than 1%. Government and other sectors contribute 2.6% (3,779 publications) and 2% (2,885 publications), respectively, suggesting that more cross-sector collaboration could enhance research impact and policy development. This highlights the need for an interdisciplinary approach to address sustainable development challenges effectively.

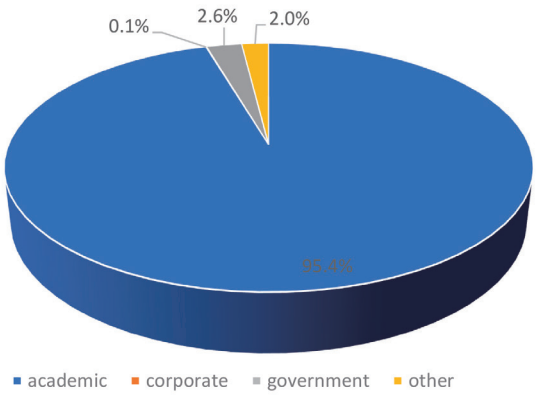


Figure 15 Scholarly output of 100 institutions from 2013-2022 on all SDGs across institutions in different sectors

2.2.3 Number of Patent Applications and Registrations

The comparison of patent numbers between Indonesia and other Asian countries from 2000 to 2020 reveals interesting insights (Figure 16). Indonesia's patent activity from 2000 to 2020, gathered from SciVal (based on Scopus Data), exhibited significant fluctuations. The overall pattern indicates inconsistencies, with peaks and troughs repeatedly over the years suggesting instability in Indonesia's innovation efforts.

Compared to Asian peers, Indonesia's patent numbers are lower, especially against Singapore, as shown in Figure 16, which reported up to 7,000 patents annually, highlighting a more vibrant innovation environment. Malaysia also consistently surpasses Indonesia in patent counts, underscoring the urgent need for Indonesia to enhance its innovation ecosystem to boost competitiveness in Asia.

Indonesia's regional patent share has been modest, ranging from 1-8%, significantly trailing Singapore's average of 62%. However, occasional spikes, such as in 2000 and 2008, demonstrate the potential for Indonesia to make a significant impact. This suggests that while Indonesia is active in patenting, it has the capacity to increase its contribution and compete with its neighbours.

To improve, Indonesia should focus on strengthening its research and development, enhancing academia-industry collaboration, and offering innovation incentives. These strategies could increase the number of patents and Indonesia's prominence in the Asian patent landscape.

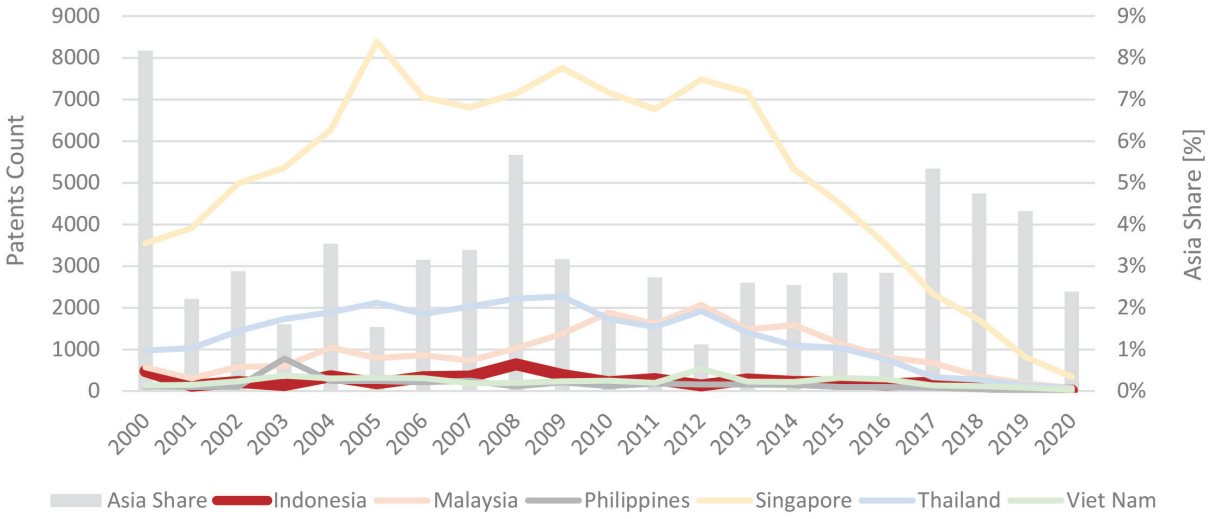


Figure 16 Comparison count of patents citing the scholarly output published by the entity in Indonesia and ASEAN 6 countries and share of Indonesia to Asia (2000-2020)

Source: SciVal, based on Scopus Data

The WIPO provides data on direct patent applications filed with national or regional patent offices by resident applicants, including individuals or entities domiciled in the country seeking intellectual property protection. From 2014 to 2022, Indonesia's patent application trends, illustrated in Figure 17, is fluctuated. A significant peak in 2017 was attributed to easing regulations through Patent Law No. 13 of 2016. Declines and another peak in 2019 followed this. A drop in 2020 was countered by recoveries in 2021 and 2022, indicating variable innovation activity influenced

by regulatory changes.

Additionally, in 2016, Indonesia simplified patent registration to streamline assessments and enhance sector insights, including 21 main changes spread across various articles. Amendment details are expansion of patent eligibility to include computer-related inventions, extension of the protection scope for simple patents to cover processes as well as products, and changes to the rules regarding compensation for employee inventions. The target of the amendment is to improve the implementation of patent protection and services that are innovative, responsive to the needs of the community, and in line with international developments. So far, many regions have complained that obtaining a patent requires a very long time and a complicated process so people are reluctant to register their work to obtain a patent. Thus, simplifying patent administration requirements and accelerating the registration process are the goals of this Law.

In 2017, the LPDP (*Lembaga Dana Pengelola Pendidikan*/ Indonesia Endowment Fund for Education) shifted its strategy, redirecting funds to strengthen the research-industry link, reducing scholarships but boosting research funding. Additionally, the economic growth in 2019 spurred increased investments in patent development, focusing on innovation and IP creation to support Indonesia's sustainable development and financial goals.

When comparing Indonesia's patent applications to other ASEAN 6 countries, Indonesia's patent applications from 2014 to 2022 were generally competitive compared to Singapore, which consistently recorded higher numbers. This comparison highlights the need for Indonesia to maintain and enhance its innovation ecosystem to compete regionally better.

Despite fluctuations, Indonesia's share of total patent applications in ASEAN 6 ranged from 14% to 40%. It peaked at 40% in 2019, showcasing its competitive potential against countries like Singapore, which ranged from 18% to 28%. However, a decline in 2020 underscores the need for ongoing innovation efforts to improve Indonesia's regional innovation standing.

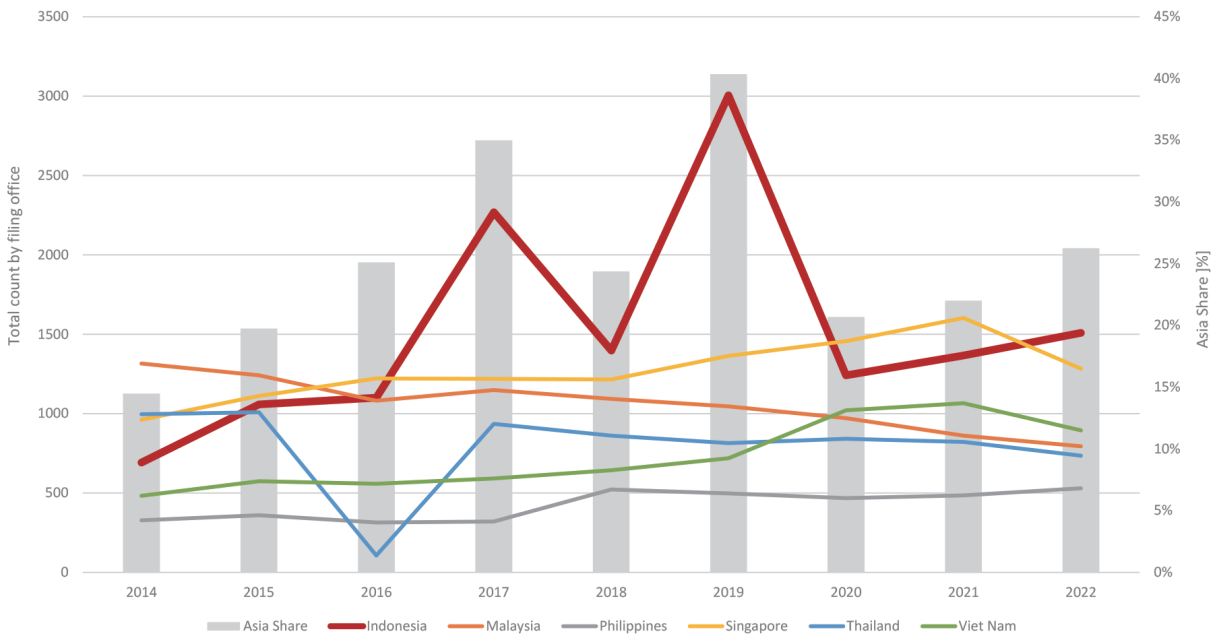


Figure 17 Comparison of residents' total patent applications (direct) by the respective filing office

Source: (WIPO, 2023b)

2.3 Outcomes from Research and Development

This assessment gauges innovation strength using global benchmarks like awards, technological intensity, innovation power, industry-academia connections, trade balance, and university rankings. It reflects on national awards like the Habibie Award, and international indices such as the Global Innovation Index (GII) and the Global Competitiveness Index (GCI), to provide a comprehensive view of Indonesia's innovation capabilities and global competitiveness. Additionally, the study examines technical trade flows to understand Indonesia's position in the global knowledge economy. It assesses academic influence through QS (Quacquarelli Symonds Ranking) and THE (Times Higher Education) university rankings, offering insights into the alignment of Indonesia's R&D with its educational institutions' international standing.

2.3.1 Scientific and Technological Award

The Habibie Award, named after former Indonesian president Bacharuddin Jusuf Habibie, is one of Indonesia's most prestigious scientific and technological awards. It honours exceptional achievements in science, technology, and innovation and symbolizes excellence and innovation in the Indonesian scientific community.

Since 1999, the Habibie Award has been presented annually to notable achievements across various disciplines (Figure 18). It acts as a platform for authoritative scientific publications, enhances the discourse in the scientific community, and serves as a prestigious recognition of individual contributions to advancing science and technology in Indonesia.

Analysing the data presented for 1999-2023, the Habibie Award has recognized significant achievements in various STEM fields, especially Medical Science. Notable recipients include Assoc. Prof. Dr Nicolaas C. Budhiparama from Universitas Airlangga for Orthopaedic Surgery in 2021 and Drg. Ika Dewi Ana from UGM for Dentistry in 2022. These recipients highlight the role of medical sciences in advancing healthcare technologies and life sciences. Biotechnology's focus on developing healthcare technologies such as pharmaceuticals and vaccines underscores its importance alongside traditional medical disciplines.

Engineering Science, a pillar of Indonesia's technological and infrastructure advancement, is also prominently featured among the award categories. Frequent recipients like ITB and UI, leaders in Indonesia's engineering sector, have been recognized for their transformative work—awards to individuals like Prof. Dr Ir. Subagjo from ITB for his groundbreaking contributions to Mechanical Engineering, and Prof. Dr Riri Fitri Sari from UI for her innovative work in Electrical Engineering in recent years, highlighting the strategic role of engineering in national development and inspiring future generations of STEM professionals.

Basic Science receives considerable attention, with ITB leading with 12 awards. These awards showcase significant contributions to fundamental research, like Dr. Eng. Ferry Iskandar's discovery in materials science and Dr. Anton Sulaksono's theoretical nuclear physics research at UI. These awards underscore the critical role of basic science in supporting broader STEM advancements, emphasizing the importance of foundational research in fostering scientific progress and innovation in Indonesia.

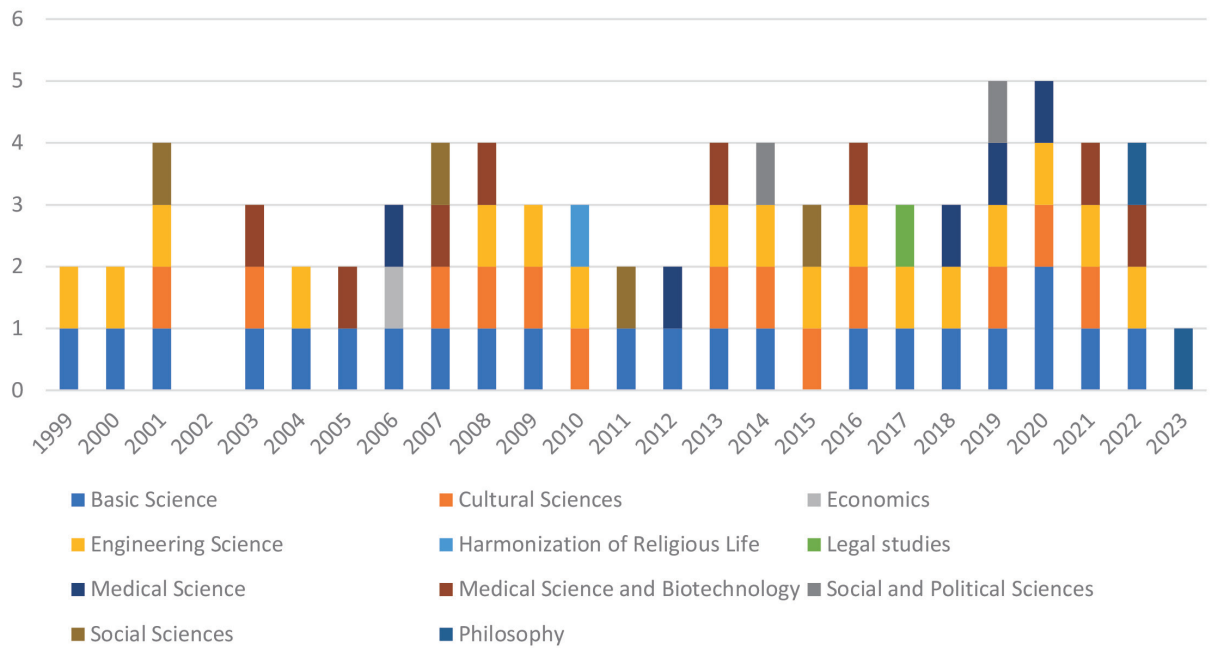


Figure 18 Number of Habibie Award recipients by field for 1999-2023

Source: www.habibiecentre.or.id

2.3.2 Global Innovation Index (GII)

Technology intensity and innovation are pivotal for economic growth, particularly in high-tech and low-tech industries in Indonesia. Utilizing The GII, a tool measuring innovation performance reveals Indonesia's strengths and weaknesses in tech intensity and innovation (Figure 19). While Indonesia performs above lower-middle-income countries in areas like institutions, human capital, and infrastructure, it lags behind Southeast, East, and Oceania averages (WIPO, 2023). This discrepancy highlights the need for targeted improvements to elevate Indonesia's innovation capabilities within a competitive regional landscape, aiding policymakers in focusing development efforts.

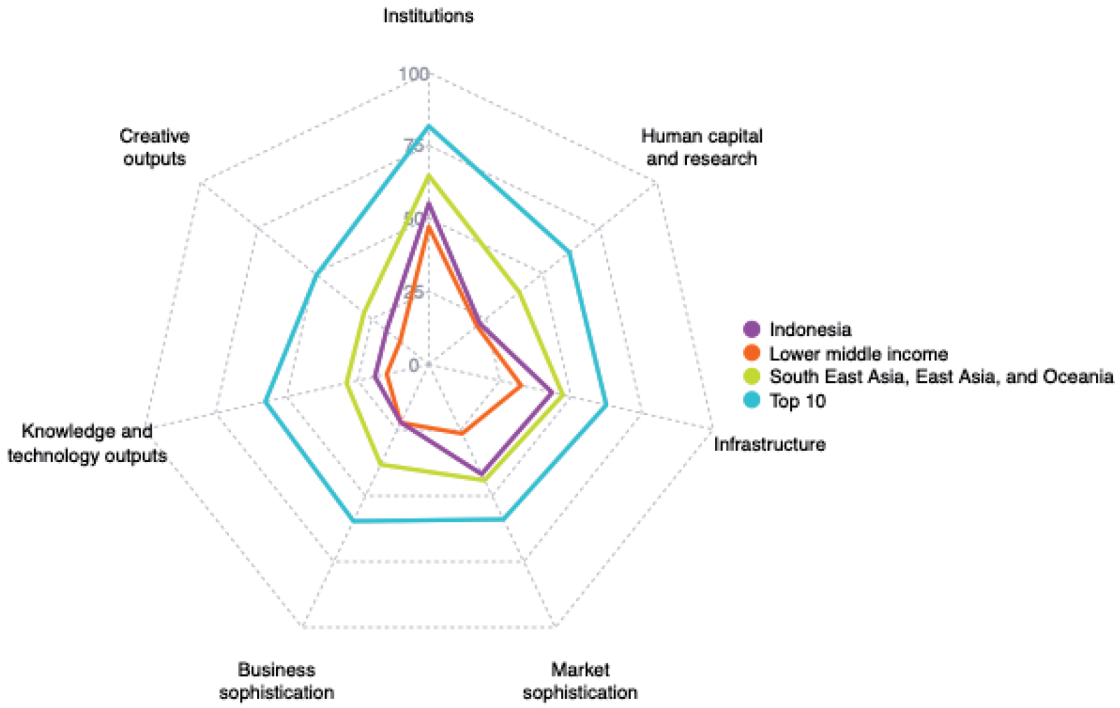


Figure 19 Comparison of Indonesia and Global in Tech Intensity and Innovation

Source: WIPO (2023)

Further analysis relies on the GII score from 2015 to 2022, as shown in Figure 20. From 2015 to 2022, Indonesia's GII scores fluctuated, averaging 29.14 points, with a high of 30.10 in 2017 and a low of 26.5 in 2020, culminating in 27.9 points in 2022. Compared to a global average of 32.09 points in 2022, Indonesia ranks 75th among 132 countries, climbing 12 from the previous year, illustrating noticeable progress in its innovation capabilities (Valev, 2023).

Indonesia's recent achievements include entering the top 80 most innovative countries and being named an "Innovation Achiever" by WIPO for the first time, indicating significant advancement for a lower-middle-income country. (with rank 13 out of 132 countries) (WIPO, 2023). Moreover, this recognition is due to its strong performance in areas like startup financing, which ranks 4th globally, and support for entrepreneurship, which ranked 2nd. out of 132 countries (WIPO, 2023). These strengths, effective university-industry collaborations and a focus on intangible assets position Indonesia well within the global innovation landscape, although continuous improvement is needed to enhance its overall innovation standing.

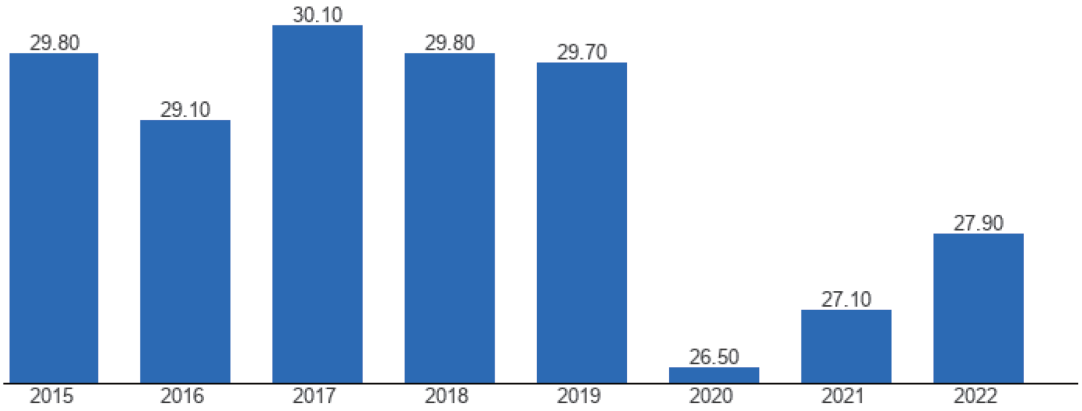


Figure 20 Global Innovation Index for Indonesia for the period 2015-2022

In the public sector, the connection between R&D budgets and the progress of startups is crucial for Indonesia's innovation ecosystem. Over the past five years, the country has developed a supportive environment for technology-based startups through various initiatives (Bachtiar et al., 2023). The government plays a significant role in funding R&D activities, influencing the growth and performance of startups (Harymawan et al., 2020).

Following the third digitalization wave, deep tech startups are seen as the new frontier of innovation. Indonesia, home to 1,190 startups in 2022, anticipates significant growth in startup development by 2025, potentially doubling its current economic impact. The ecosystem's expansion is supported by approximately 120 incubators and accelerators, along with 200 financing institutions catering to startups, fostering their growth (Bachtiar et al., 2023; BIMP-EAGA, 2023).

The landscape of Indonesian startups leans heavily towards non-technological sectors, advancing STI. Data reveal that 32% of startups operate within the general business sector, while only 6.39% are involved in Edutech, indicating a disparity in the development of educational technology ventures as shown in Figure 21. The dominance of e-commerce and fintech startups, making up 14.59% and 8.52% respectively. The improvement in digital payment systems, especially the Quick Response Code Indonesian Standard (QRIS), contributes as an important driver for digitisations in e-commerce. Additionally, most startups are structured as limited liability companies (Perusahaan Terbatas - PT), comprising 51.39% of the startup forms, which supports their operations and employee performance (MIKTI, 2022).

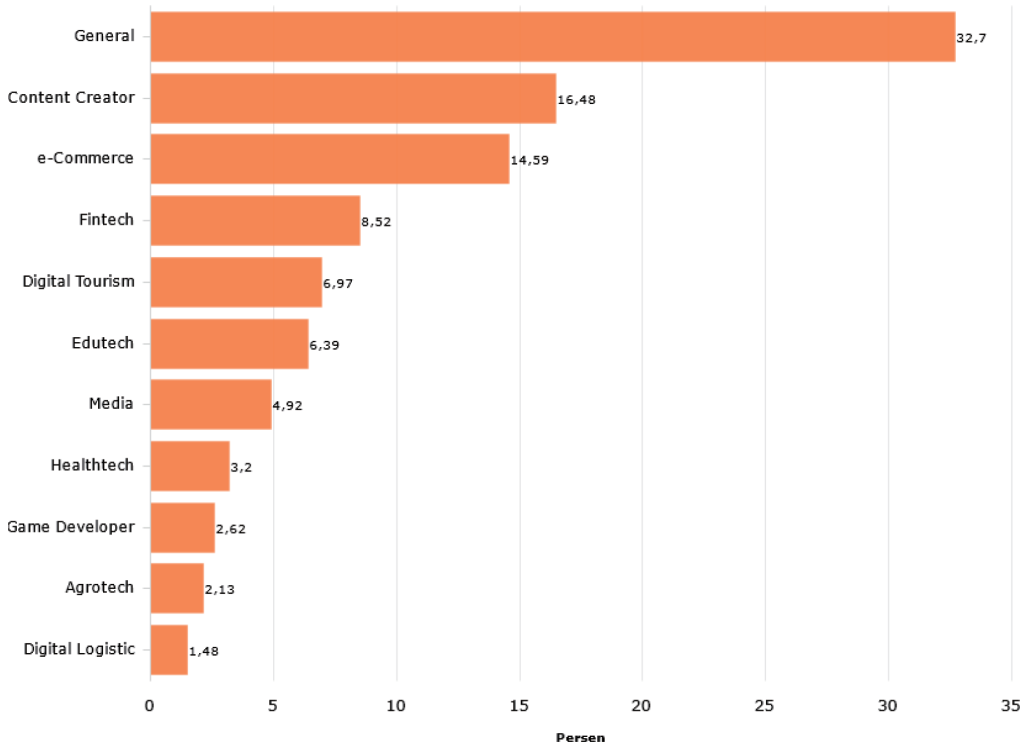


Figure 21 List of startups in Indonesia based on business field

Indonesia recognizes the potential of deep-tech startup unicorns and new applications that address community needs through online solutions, evidencing the growth of its startup ecosystem. The government has supported this development through grants from the CPPBT (*Calon Perusahaan Pemula Berbasis Teknologi*/Prospective Technology-Based Start-up Company) and PPBT (*Perusahaan Pemula Berbasis Teknologi*/ Technology-Based Start-up Company) programs until 2020. In December 2020, the Ministry of Education and Culture introduced the Kedaireka (*Kerja Sama Dunia Usaha dan Kreasi Reka*/Business Cooperation and Mutual Creation) matching fund program to boost innovation collaboration between universities and industries within STI fields (Bachtiar et al., 2023). The program, which began with a fund of Rp250 billion in 2021 and increased to Rp1 trillion in 2022, aims to strengthen partnerships across academic and industrial sectors (Hendayana, 2021). In late 2022, the Kedaireka programme expanded its initiatives with seven additional components.

The Kedaireka program facilitates collaboration on a single platform where university lecturers and students' team up with industry entities to create funding proposals. The allocated funds support the commercialization of technological products, enhance technology centers, and foster the development of the Centre for Technology Excellence, Teaching Industry, and Teaching Factory. The funds also support training and coaching for industry partners, help execute business plans and prototypes, and establish Centres of Excellence to tackle industry challenges and promote growth (Hendayana, 2021).

2.3.3 Global Competitiveness Index (GCI)

The GCI measures a country's ability to innovate and compete in the global market (Kordalska & Olczyk, 2016). Over seven years, from 2012 to 2019, Indonesia's GCI ranking showed significant fluctuations., as shown in Figure

23 (Kordalska & Olczyk, 2016). Starting at the 50th position among 144 countries in 2012-13, Indonesia improved notably, reaching the 38th spot in 2013-14 and peaking at 34th in 2014-15. However, subsequent years saw a decline, dropping to 37th in 2015-16 which implicated by the low technology readiness, 47th in 2016-17, and stabilizing briefly at 45th in 2017-18, before falling back to 50th in 2018-19 (Schwab, 2017). These shifts highlight Indonesia's variable performance on the global stage, indicating both progress and areas for improvement in maintaining and enhancing its competitiveness.

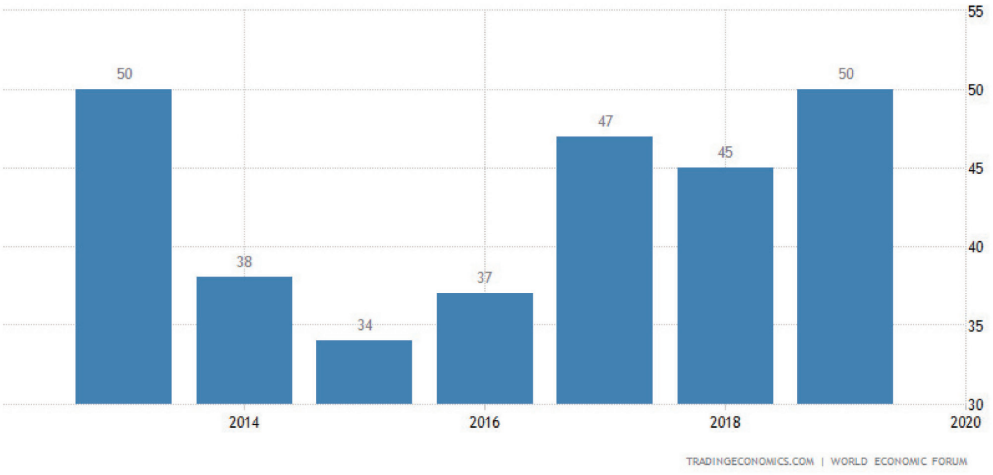
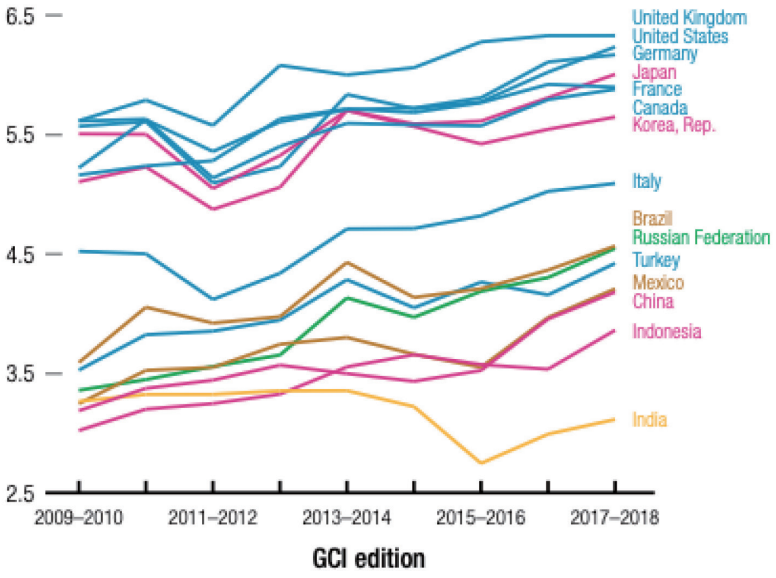


Figure 22 Indonesia Competitiveness Rank based on World Economic Forum 2012-2019

The GCI is integral to evaluating economic competitiveness and growth potential. (Kordalska & Olczyk, 2016). The GCI is a widely recognised tool for assessing a country's competitiveness and potential for economic growth. I Indonesia focuses on human resource competitiveness through initiatives like the Centre for Excellence Vocational School. This program prepares graduates for digital economy challenges, reinforcing the importance of creativity and innovation in sustaining competitiveness (Churiyah et al., 2022).

As an emerging market, Indonesia ranks second lowest in overall competitiveness among large economies (Figure 24), indicating a gap in readiness for new technologies among its population and businesses (Schwab, 2017). This gap highlights that while innovation breakthroughs exist, their societal benefits are limited to a few, suggesting a need for broader access to and adoption of new technologies to fully leverage economic and societal gains (Schwab, 2017).

In the ASEAN-6 context, based on WEF (World Economic Forum), Indonesia's 2017-2018 GCI ranking is 36th with a score of 4.68. (Schwab, 2017). This condition contrasts with leaders like Singapore, which ranked 3 with a score of 5.71, and Malaysia, which ranked 23rd with a score of 5.17. The rankings reveal varied regional competitiveness, spotlighting opportunities for Indonesia to boost its economic performance (Schwab, 2017).



Source: Calculations based on the results of the Global Competitiveness Index 2009–2010 through 2017–2018.
Note: Colors correspond to regional classifications: ■ Europe and North America; ■ East Asia and Pacific; ■ Latin American and the Caribbean; ■ Eurasia; and ■ South Asia.

Figure 23 Comparison of overall score of the competitiveness between Indonesia and large advanced economies countries, 2009-2018

Source: Schwab (2017)

A 2017 comparison of competitiveness pillars for Indonesia against East Asia and Pacific nations (Figure 23) shows Indonesia's relative strength in innovation and business sophistication, ranking 31st and 32nd with scores of 4/7 and excelling in market size with the top 6/7 among its pillars (Figure 24) (International Monetary Fund & World Economic Outlook Database, 2017). However, its performance in technological readiness and labour market efficiency lags, with rankings of 80th and 96th, respectively. Technological readiness scores particularly low at 3/7, reflecting ongoing challenges despite progress. High redundancy costs, limited wage flexibility, and low female workforce participation contribute to its lower labour market efficiency score (International Monetary Fund & World (International Monetary Fund & World Economic Outlook Database, 2017).

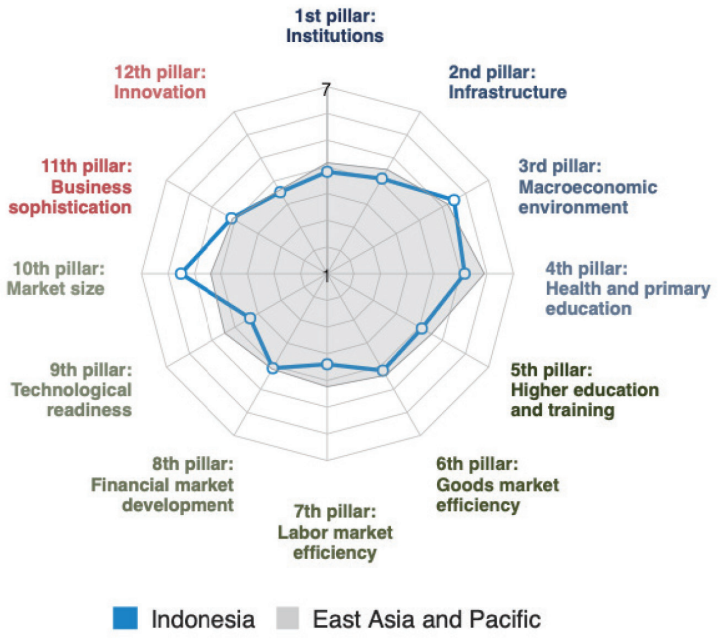


Figure 24 Comparison of the scores (1-7) on 12 competitiveness pillars between Indonesia and East Asia and Pacific (Data on 2017)

2.3.4 Research-Industry Connection and Export of High-Tech Products

The impact of research and education on industrial innovation can be analyzed through various methods, such as examining existing collaborations between academia and industry, the technological trade balance, trends in deep tech startups, and Technology Readiness Levels (TRL). These methods help assess how effectively research is translated into commercial ventures and gauge the educational support for transitioning from theoretical knowledge to practical application.

The linkage between education and industry is evident in Indonesia, as seen in collaboration between vocational schools and the industrial sector. By early 2019, 4,279 agreements between 2,329 vocational schools and 860 industries had been established, (KOMINFO, 2019) driven by Presidential Instruction No. 9 of 2016 on the revitalization of vocational education to improve the competitiveness and quality of workforce. For example, in Central Java, PT Sarana Utama Adimandiri collaborates with public vocational high schools to offer industry-specific classes, ensuring that students receive practical, industry-aligned education and opportunities for immediate employment upon graduation.

In the Presidential Instruction, President Jokowi instructs ministers, governors, and the Head of the National Professional Certification Agency to take necessary measures in accordance with their respective duties, functions, and authorities to revitalize vocational schools in order to improve the quality and competitiveness of Indonesian human resources. The President also instructed that a map of labor needs for SMK graduates be prepared in accordance with their respective duties, functions, and authorities by referring to the road map for SMK development.

Specifically for the Minister of Education and Culture, President Jokowi gave six instructions. The six instructions are: Create a road map for vocational schools; improve and harmonize the vocational school curriculum with competencies according to the needs of graduate users (link and match); increase the number and competence

of vocational school educators and education personnel; increase cooperation with ministries/institutions, local governments, and business/industry; increase access to certification of vocational school graduates and vocational school accreditation; and form a Vocational School Development Working Group.

To the Head of the National Professional Certification Agency, President Jokowi instructed to accelerate competency certification for SMK graduates, educators, and teaching staff, as well as accelerate the licensing of SMKs as first-party professional certification institutions. Furthermore, 34 governors are instructed to make it easy for the community to obtain quality vocational education services in accordance with the potential of their respective regions; provide adequate and quality vocational educators, education personnel, facilities, and infrastructure; carry out institutional arrangements for vocational schools which include vocational programs opened and the location of vocational schools; and develop superior vocational schools in accordance with the potential of their respective regions.

In Indonesia, while university-level industry engagement aims to transfer knowledge to industry, substantial collaboration is often lacking, as discussed in section 3.2.2, with limited ties between research, education, and the job market, unlike Malaysia's integrated approach (Suyantiningsih et al., 2023). Top Indonesian universities score low in fostering industry connections, indicating a need for more effective collaborations focusing on applied outputs and preparing students for industry roles. Later in the report, section 3.3.5 will elaborate on this issue in detail. High-technology exports, such as aerospace and pharmaceutical products, serve as not just indicators, but crucial benchmarks of a country's ability to translate R&D into commercially valuable products. A positive trend in these exports not only reflects effective research-to-industry transfer, but also underscores the paramount importance of such metrics in evaluating the success of technological advancements and a country's global market competitiveness (*High Tech Exports by Country, around the World,* n.d.).

Moreover, Figure 25 shows high-tech exports for ASEAN countries and Japan as a percentage of total manufacturing exports from 2007 to 2022. Indonesia displays minor fluctuations but generally maintains a steady share, lagging leaders like Singapore and Malaysia, who show pronounced and consistent high-tech sector dominance.

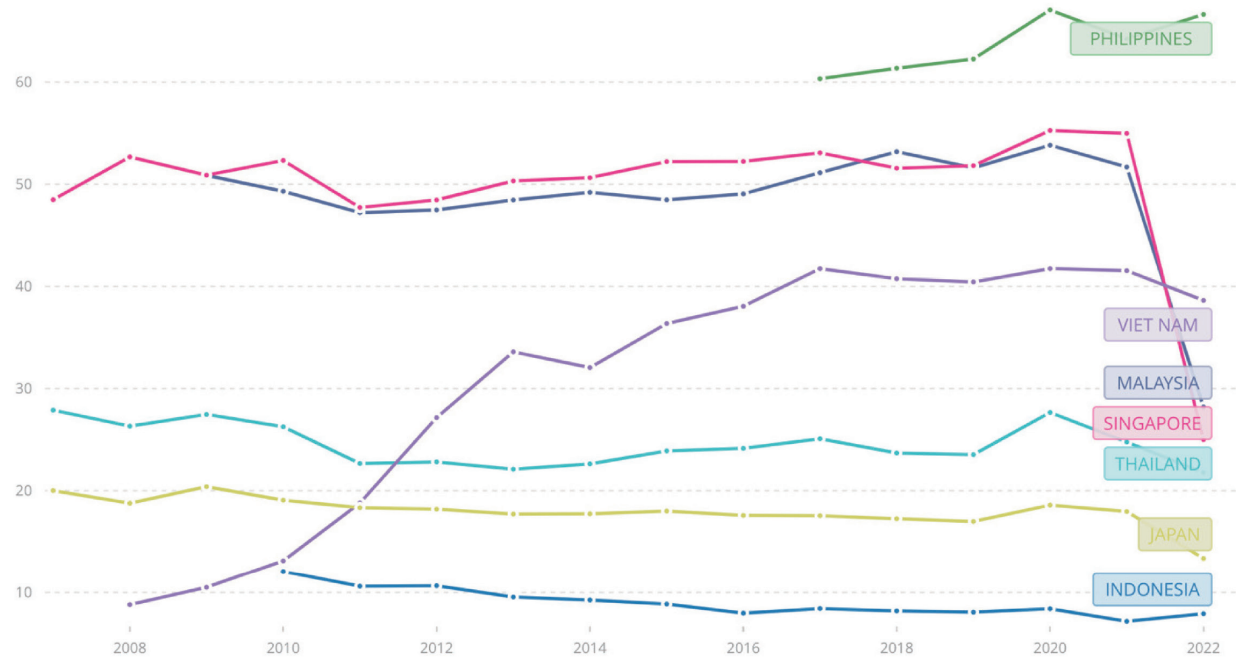


Figure 25 High-tech exports as a percentage of manufactured exports for Japan and ASEAN countries from 2007 to 2022

Meanwhile, Figure 26 details high-tech export values for ASEAN 6 countries and Japan from 2007 to 2022. While the Philippines has a high percentage relative to its manufacturing, Singapore's high-tech sector shows significant growth, far outpacing others. Japan maintains stable exports, indicating a robust industry. In contrast, Indonesia, Thailand, and Laos show modest figures, highlighting disparities in regional high-tech capabilities.

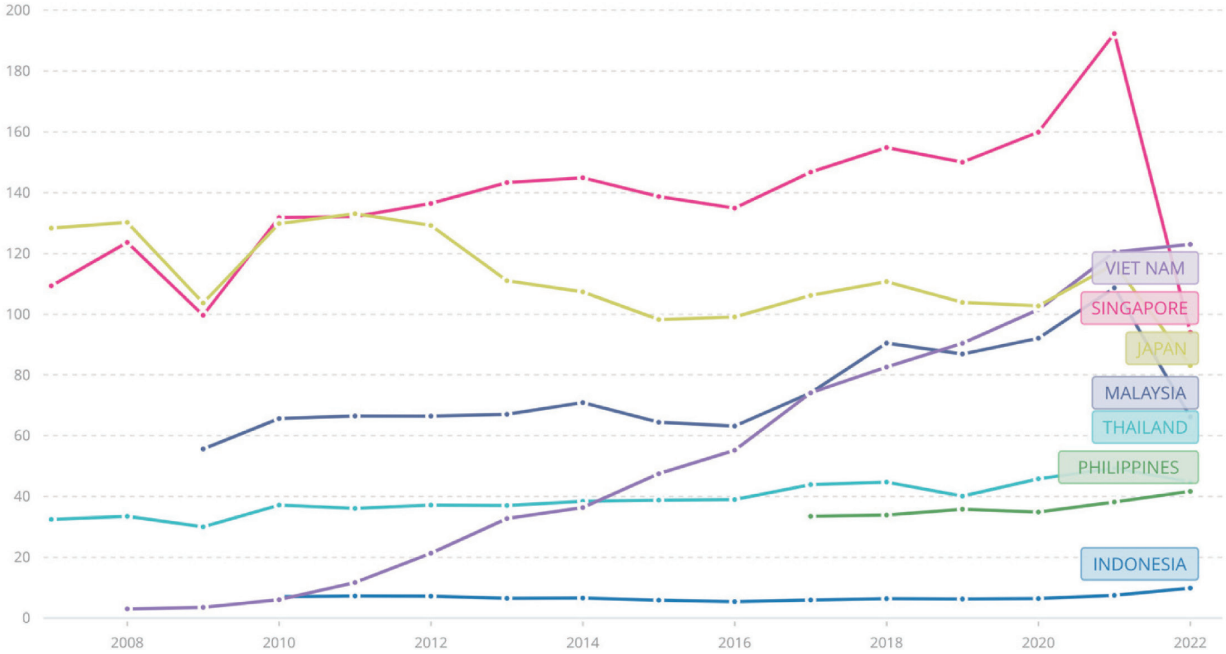


Figure 26 High-tech exports (Billion USD) for Japan and ASEAN countries from 2007 to 2022

Despite modest high-tech exports, Indonesia sees growth in deep-tech startups, such as PT Prosa Solusi Cerdas in natural language processing and AI Senyum in analytics (Mutia, 2023). Predominantly, these startups focus on AI, blockchain agritech, and cryptocurrencies, indicating evolving technological capabilities and potential future growth in Indonesia's high-tech sector (Mutia, 2023). However, according to Tracxn (2023), these startups primarily focus on AI, blockchain, agritech, and cryptocurrencies, indicating evolving technological capabilities and potential future growth in Indonesia's high-tech sector.

2.3.5 Overview of Top-ranked Universities and Achievements

Indonesia aims to elevate its universities into the world's top 500, focusing on internationalization, competitive advantage, and producing globally competitive human capital. These efforts are measured by QS World University Rankings and THE World University Rankings (Kusumawati et al., 2020). However, achieving world-class university status is challenging due to bureaucratic governance, reliance on government subsidies, and the need for more professional management, which inhibits progress (Murdowo, 2018).

Indonesia's top universities, as shown in Table 2, including UI, UGM, ITB, and IPB, are benchmarked in the QS World University Rankings 2023 (QS World University Rankings, 2023). UI, ranking 237th globally, excels in employer reputation and international faculty presence but lags in faculty-student ratio (50.4). UGM, though globally lower than UI, leads to academic reputation (51.7) and sustainability (47.2). ITB is noted for its citations per faculty (2.5). IPB offers the best faculty-student ratio (66.1), suggesting a more personalized education. All four universities score low in citations and international research networks (701+), underscoring a need to enhance research visibility and international collaborations.

Table 2 Top-ranked Universities in Indonesia Based on QS World University Rankings 2023

Indicator	Score and Rank	University Name			
		University of Indonesia (UI)	Gadjah Mada University (UGM)	Bandung Institute of Technology (ITB)	Bogor Agricultural University (IPB)
Overall	Score	40,9	38	36,6	23,6
	Rank	=237	263	=281	=489
Academic Reputation	Score	50,5	51,7	41	21,6
	Rank	161	152	203	399
Employer Reputation	Score	73	66,5	65,6	39
	Rank	91	118	122	244
Faculty Student	Score	50,4	54,4	65,6	66,1
	Rank	309	282	208	203
Citations per Faculty	Score	2	1,7	2,5	1,7
	Rank	701+	701+	701+	701+

International Faculty	Score	75,8	38,5	84,4	54,6
	Rank	249	419	213	339
International Students	Score	4,8	1,6	2,3	3,8
	Rank	701+	701+	701+	701+
International Research Network	Score	2	2,1	1,2	1,2
	Rank	701+	701+	701+	701+
Employment Outcomes	Score	58,7	42,6	35,7	24,1
	Rank	103	169	209	347
Sustainability	Score	42,3	47,2	21,2	3,4
	Rank	351=	323=	533=	701+

Globally, European and North American universities dominate the top 500 rankings. Still, Asian universities, including those in Indonesia, excel in environmental sustainability, notably in the UI GreenMetric ranking (Muñoz-Suárez et al., 2020), reflecting their focus on sustainable practices, which may enhance their international standings.

The UI GreenMetric World University Ranking, initiated by Universitas Indonesia in 2010, evaluates universities globally on their environmental sustainability across six criteria: Setting and Infrastructure, Energy and Climate Change, Waste, Water, Transportation, and Education and Research, using 39 indicators. In 2023, 1183 universities from 84 countries participated, with 26 Indonesian universities making the top 200 as shown in Table 3, highlighting the significant role of UI GreenMetric in promoting environmental responsibility in higher education.

Table 3 Top 100 Universities in Indonesia Based on UI GreenMetric 2023

Rank 2023	University	Setting & Infrastructure	Energy & Climate Change	Waste	Water	Trans-portation	Education & Research
24	UI	1325	1850	1575	950	1425	1800
27	Universitas Diponegoro	1250	1750	1500	900	1675	1800
30	UGM	1350	1725	1425	900	1650	1800
34	IPB	1375	1475	1575	950	1650	1800
37	Universitas Negeri Semarang	1275	1775	1575	900	1550	1700
43	Universitas Sebelas Maret	1225	1725	1575	900	1425	1800
44	Institut Teknologi Sepuluh Nopember	1350	1725	1500	900	1375	1800
57	Airlangga University	1350	1600	1425	850	1625	1750

71	Universitas Islam Negeri Raden Intan Lampung	1100	1875	1425	900	1550	1700
81	Universitas Padjadjaran	1175	1650	1575	850	1575	1675
95	Telkom University	1050	1625	1425	900	1600	1800
99	Lampung University	1075	1800	1500	800	1375	1800

In THE World University Rankings 2023, Indonesian universities like UI, UGM, ITB, and IPB show distinct positions compared to QS rankings, with UI ranked in the 801-1000 range and the others in the 1201-1500 range. This highlights differences in evaluation criteria, which include Teaching, Research, International Outlook, and Industry Engagement (THE, 2023). The detail can be seen in Table 4.

Regarding performance, UI scores are between 32.7 and 36.9 overall, with a teaching score of 45.5 indicating a robust educational impact. UGM, ITB, and IPB score 22.8-28.2 overall, with varied Teaching scores from 23.7 to 30.9. Industry Engagement scores reflect direct industry links, with UI scoring 51.9 in THE and International Outlook scores like UI's 60.3, illustrating the extent of global engagement.

Table 4 Top-ranked Universities in Indonesia Based on THE World University Rankings 2023

Indicator	University Name			
	UI	UGM	ITB	IPB
2024 Rank	801–1000	1201–1500	1201–1500	1201–1500
Overall Score	32.7–36.9	22.8–28.2	22.8–28.2	22.8–28.2
Teaching	45,5	30,9	23,7	30,9
Research Environment	23,1	19,8	17,1	9,8
Research Quality	29,2	21,7	29,2	24,2
Industry Engagement	51,9	52,8	29,4	39,2
International Outlook	60,3	45,8	38,5	45

The 2020 world university rankings reveal new entrants, highlighting their recognition within the academic community (Bothwell, 2019). This edition shows that Asian universities, including those from Indonesia, typically score lower than other regions. This data is crucial for Indonesian higher education to recognize areas for improvement and formulate strategies to enhance university quality.

Looking into details on the STI field contribution to the THE World University Rankings 2023 (Table 5) on selected institutions, it provides an intricate view of the subjects ranking results for various fields of study (THE, 2023).

ITB consistently performs well in computer science with a Research Quality score of 36.4. However, there is a need for improvement in teaching and physical sciences. IPB excels in life sciences, benefiting from strong industry and

international outlook scores and suggesting effective industry partnerships. UGM is noted for its International Outlook in social sciences, indicating global relevance, though it needs enhancement in physical sciences. UI stands out in computer science and shows vital Industry Engagement in engineering and social sciences, pointing to successful knowledge transfer. However, UI's lower teaching scores in physical sciences highlight areas needing strategic improvement.

Table 5 The selected field of top-ranked Universities in Indonesia Based on THE World University Rankings 2023

Field	Teaching	Research Environment	Research Quality	Industry	International Outlook
ITB					
computer science	16,9	26,3	36,4	44,8	34,1
engineering	22,3	16,7	31,3	26,2	38,7
life sciences	16,2	12,1	20,7	22,7	44,6
physical sciences	14,2	9	31,1	20,2	27,9
IPB					
life sciences	25	13,1	17,8	35,3	48
UGM					
engineering	20,2	15,6	25	51,7	38
life sciences	21,6	14,9	18,3	43,6	51,8
physical sciences	12,9	11,2	31,3	52	35,6
social sciences	32,2	21	33,5	67,3	58,1
UI					
computer science	32,7	18,6	29	52,3	40,8
engineering	28,3	17,3	27,9	50,8	56,3
life sciences	28,8	12,8	31	42,2	53
physical sciences	13,5	14,4	36,7	51,2	43,5
social sciences	33,9	19,5	30,4	50	67

3 Science and Technology Policy and Organization in Indonesia

This chapter chrolonogically reviews essential legislation and documents shaping the nation's S&T advancement and considers policy implementation and patent policies affecting researchers. Indonesia's STI strategy is guided by critical legislations like the RIRN Presidential Decree and the Sisnas (National System of Science and Technology Law) Iptek Law, setting national research priorities to foster a knowledge-driven economy. Subsequently, it evaluates the institutions responsible for implementing science and technology policies and their roles in governance. The establishment of BRIN and the merger of educational and research ministries into KEMENDIKBUDRISTEK and the Ministry of Finance's role in R&D budgeting through the LPDP are pivotal in enhancing the national STI. This chapter explains the structure and function of these institutions and considers their roles in Indonesia's STI governance.

3.1 Science and Technology Policy Framework and Strategy

This section highlights the government's efforts to create a conducive environment for research and innovation. More concretely, it reviews the legal frameworks guiding Indonesia's science and technology development, starting with Presidential Decrees, such as the National Research Master Plan, and subsequent legislative actions driving the nation towards a knowledge-based economy.

Indonesia's R&D institutions and relevant activities are guided by a structured framework of laws, regulations, and strategic documents, outlined in Table 6.

Table 6 Laws, regulations, and strategic documents that direct, fund, and implement R&D activities

Policy Format	Implementation	Main Actor
Presidential Regulation No. 38 of 2018 about RIRN 2017-2045	RIRN 2017-2045 in Indonesia establishes a framework for national research priorities focusing on critical areas to enhance the nation's competitiveness.	KEMENDIKBUDRISTEK, BRIN, and Universities (Higher Education)
Presidential Decree No. 78 of 2021 on the management of BRIN and BRIDA	regulates the responsibilities of BRIN and how research and innovation of science and technology are implemented at the regional level by BRIDA.	BRIN & BRIDA
Permenristekdikti No. 38 of 2019 about PRN (National Research Priority) 2020-2024	PRN 2020-2024 aims to derivate the above RIRN fields into five (5) years of research focus. The Government of Indonesia then streams the research focus into nine (9) research focuses.	KEMENDIKBUDRISTEK and Universities (Higher Education)
Law No. 11 of 2019 about *Sisnas Iptek law*	The Sisnas Iptek Law reflects Indonesia's aspiration to transform into a 'knowledge economy', with the ultimate objective of being one of the world's foremost economies by 2045, with R&D as a national asset.	KEMENDIKBUDRISTEK, BRIN, and Universities (Higher Education)

Permendikbudristek No. 5 of 2022 and No. 7 of 2022 about Merdeka Belajar	Merdeka Belajar program (Freedom to Learn) aims to empower students, teachers, and educational institutions.	KEMENDIKBUDRISTEK and Universities (Higher Education)
SAINS45 research agenda	Indonesia's Science Agenda Towards a Century of Independence. SAINS45 encompasses eight fundamental areas of scientific research.	AIMI, DIPI, ALMI
Law No. 13 of 2016, Government Regulation No. 34 of 2020 and Government Regulation No. 46 of 2020 about patent	The fundamental patent regulation in Indonesia Procedures for Implementing Patents by the Government and procedure of patent transfer	Minister of Law and Human Rights Regulation (Permenkumham) and Dir. General of Intellectual Property (DJKI)
Government Regulation No. 41 of 2006 about foreign researcher permit **Presidential Regulation No. 33 of 2020** about guidelines on foreign research implementation	Procedures for Granting of Research and Development Permits for Foreign Universities, Foreign Research and Development Institutions, Foreign Business Entities, and Foreigners Regulates how researchers need to follow the guidelines and procedures for implementing and coordinating national research activities.	BRIN Foreign Universities, Foreign Research and Development Institutions, Foreign Business Entities, and Foreigners

The whole science and technology policy is placed in national mid-term and-long-term strategy.

Presidential Decree No. 38 of 2018 outlines Indonesia's National Research Priorities (RIRN), aligning research with national development goals. The RIRN coordinates sectoral efforts, enhancing socio-economic and technological progress, and integrates with the Long-Term Development Plan managed by BAPPENAS to bolster Indonesia's innovation landscape.

Under President Joko Widodo's second term in 2020, Indonesia shifted focus from infrastructure to enhancing human capital and STI, marked by the Sisnas Iptek Law No. 11 of 2019. This law aims to make Indonesia a leading knowledge economy by 2045, with R&D as a critical component. It mandates the creation of the RIPIPTEK, a master plan that provides guidelines for STI management, aligning with national development plans. RIPIPTEK addresses governance and funding, while RIRN focuses on operational research and innovation details.

KEMENDIKBUDRISTEK issued Permenristekdikti No. 38 of 2019, detailing PRN for 2020-2024 based on the RPJPN/The country's Long-Term Development Plan 2005-2025 and PUNAS. The PRN targets strategic national issues across nine research themes.

BRIN was established via Presidential Decree No. 74 of 2019 to implement Sisnas Iptek, integrating with regional efforts through BRIDA as per Presidential Decree No. 78 of 2021, with additional responsibilities described in Section 4.2. This integration also saw the Ministry of Education and Culture merging with the Ministry of Research and Technology into KEMENDIKBUDRISTEK to streamline education, culture, research, and technology policies. KEMENDIKBUDRISTEK introduced initiatives like "Merdeka Belajar" and established SINAS and DRIN to support research and innovation. However, DRIN has sparked concerns about funding overlaps with BRIN.

They support regulations like Law No. 12 of 2012 and Government Regulations Nos. 41 of 2006 and 48 of 2009 also play critical roles in regulating research activities and status. They aim to build a comprehensive framework to boost Indonesia's research and innovation ecosystem and achieve its vision as a knowledge economy by 2045.

Additionally, the patent system, legal approvals of foreign researchers, and relevant provisions on research ethics are

established to enhance the commercial availability of research output and promote international cooperation through human exchanges. Firstly, we would like to introduce the policies on intellectual rights protection and legislation on managing patents.

Indonesia is enhancing the commercial viability of research outputs through updated patent laws to foster a knowledge-based economy. Replacing Law No. 13 of 2016, Government Regulation– (Perpu) No. 2 of 2022 and Minister of Law and Human Rights Regulation (Permenkumham) No. 13 of 2021, streamlines patent applications and modifications, facilitating quicker processes for simple patents and improving the investment environment.

The patenting process, managed by the Directorate General of Intellectual Property (DJKI) and detailed in Figure 27, spans several stages. It starts with filing within 12 months of the priority date (step 1), followed by an 18-month public review phase and a mandatory substantive examination within 36 months (step 4). Simple patents focus on novelty checks and take 36 months to process, resulting in a grant or rejection. Standard patents last 20 years, and simple patents last 10 years.

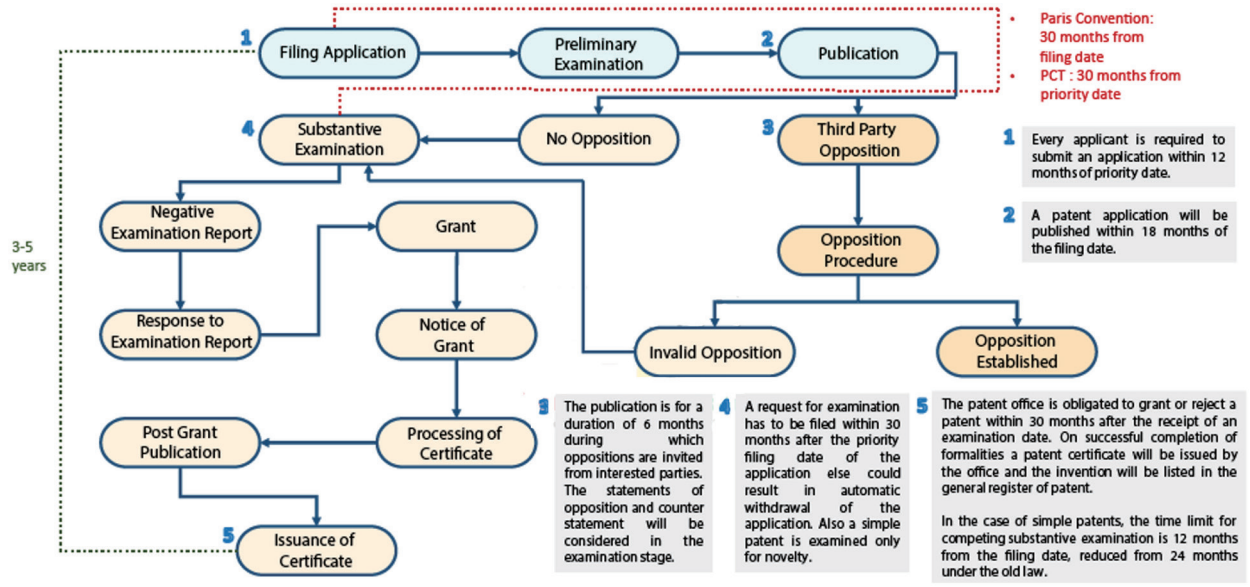


Figure 27 Patent application processes in Indonesia

Source: Pintas (2023)

Government Regulation No. 34 of 2020 superseding Government Regulation No. 27 of 2004, , outlines the conditions under which the government can utilize patents without the holder's consent for public interest or national security. Additionally, Government Regulation No. 46 of 2020 which supersedes Presidential Regulation No. 37 of 2010, revises patent transfer guidelines, detailing documentation, fees, validity, transfer enforceability, and registration implications.

Indonesia has made significant revisions to its patent policy with Perpu No. 2 of 2022 on Cipta Kerja – also known as the Job Creation Law, aimed at revitalizing the economy, simplifying business processes, and stimulating investment. This law introduces pivotal changes to research, innovation, and patent regulations, including a new category for simple patents and streamlined examination and application processes. It also ensures ongoing

applications are processed under old regulations, promoting a research-friendly environment conducive to startups and economic growth. An IPR (Intellectual Property Right) centre is a work unit that functions to manage and utilize intellectual property, as well as a centre for IPR information and services. With this obligation, universities and R&D institutions can be encouraged to develop organizational units and procedures to manage all intellectual property and information on science and technology.

Indonesia's patent system, distinct from those in other regions, faces challenges from the diverse patent regimes and languages within ASEAN. (John Walker, 2017). Despite being the largest ASEAN market, Indonesia's average patent pendency is 2 to 5 years, better than the regional average. The system expedites patents if claims match those approved in major jurisdictions like the EPO (European Patent Office), China, USA, Japan, Korea, or Australia (Chow, 2020).

Challenges include mandatory translations into local languages and the need for robust IP rights to attract FDI (Foreign Direct Investment). The Job Creation Law of 2020 strengthens IP rights., including patents (Geneva Network & Paramadina Public Policy Institute, 2022). However, the industry application for patents remains limited (Wongrat Ratanaprayul & Melinda Ambrisal, 2019). Despite efforts to enhance the system, Indonesia still grapples with issues like long pendency periods and the need for further reforms to improve its position in the global patent arena.

International collaboration is critical to advancing Indonesian research and innovation. Foreign researchers must secure a research permit and visa under Government Regulation No. 41 of 2006, which outlines the process for foreign universities, institutions, and business entities. They must also adhere to BRIN's guidelines for national research coordination, per Presidential Regulation No. 33 of 2020. Additionally, compliance with Law No. 13 of 2016 on Patents and the Science and Technology System Law No. 18 of 2002 on data protection and specimen transfer is mandatory.

For foreign researchers interested in conducting studies in Indonesia, securing a research permit based on Government Regulation No. 41 of 2006, involves using BRIN's comprehensive online platform, the Foreign Research Permit - Indonesia (https://klirensetik.brin.go.id). This portal facilitates the entire process, from account registration and application form completion to document submission and report filing. The Secretariat of Foreign Research Permit oversees these procedures, ensuring smooth communication and management of permit-related issues.

The application for a research permit is simultaneously submitted with the research ethics clearance. If the ethics clearance is approved and the foreign entity is not on the blocklist, the research permit and the ethics clearance decision letter will be issued together. Researchers must verify the need for ethical clearance via the BRIN portal and complete the necessary queries. The permit assessment is conducted based on the responses provided.

3.2 Institutions and Roles in Implementing Science and Technology Policy

3.2.1 Hierarchical Structure Related to Government Policy Implementation

The passage of Law No. 11 of 2019 was a turning point in Indonesia's science and technology governance, shifting from the New Order Era to the establishment of BRIN and the dissolution of Kemenristek. This move streamlined research policies and saw four Non-Ministerial Government Institutions, including LIPI (Lembaga Ilmu Pengetahuan Indonesia/Indonesian Institue of Science), being reorganized as implementing organizations under BRIN. LIPI, for

instance, now focuses on research, development, and assessment, signifying a new phase in the institutionalization of science and technology. The restructuring is visually depicted in Figure 28.

Key government bodies implementing national science and technology policy include KEMENDIKBUDRISTEK, BAPPENAS, BRIN, ministerial and local government R&D agencies, and state-owned enterprise research entities. The Ministry of Finance (MoF) is crucial in advancing Indonesia's STI by funding, incentivizing, and fostering research partnerships, as outlined in the National Medium-term Development Plan for 2020-2024 by BAPPENAS. Governed by Law No. 17 of 2003, the MoF's responsibilities include managing state finances and distributing funds for R&D, positioning it as a central figure in Indonesia's STI advancement.

The Directorate of Budget within the MoF plays a pivotal role in managing funds for education through different financial sources, such as the National Education Development Fund. According to MoF Regulation No. 47/PMK.01 of 2020, the Education Fund Management Institution, supervised by the MoF, is responsible for planning and implementing investments, scholarships, and research funding, ensuring transparent resource management for educational improvement. Additionally, education funds are allocated in various forms, such as regional transfers and supporting expenditures for ministries like KEMENDIKBUDRISTEK, the Ministry of Religious Affairs (Kemenag), and BRIN, with the MoF's LPDP also investing in education through endowment funds.

Apart from government sources, DIPI, an independent body, offers competitive grants for scientific research with significant merit, aiming to promote a culture of excellence in Indonesian research. The private sector also supports research by partnering with universities and research institutes to address economic and social challenges (Dzulfikar, 2019). More details on research funding will be explored.

Beyond government bodies, public and private universities contribute to the National Research Master Plan through their research activities, which are historically overseen by KEMENDIKBUDRISTEK's Directorate General of Higher Education. Research also extends to corporate and non-government sectors, tackling practical societal challenges. Social research institutions like CSIS and SMERU Research Institute are vital in quickly responding to social phenomena and shaping policy recommendations, often collaborating with international donors for more flexible funding solutions.

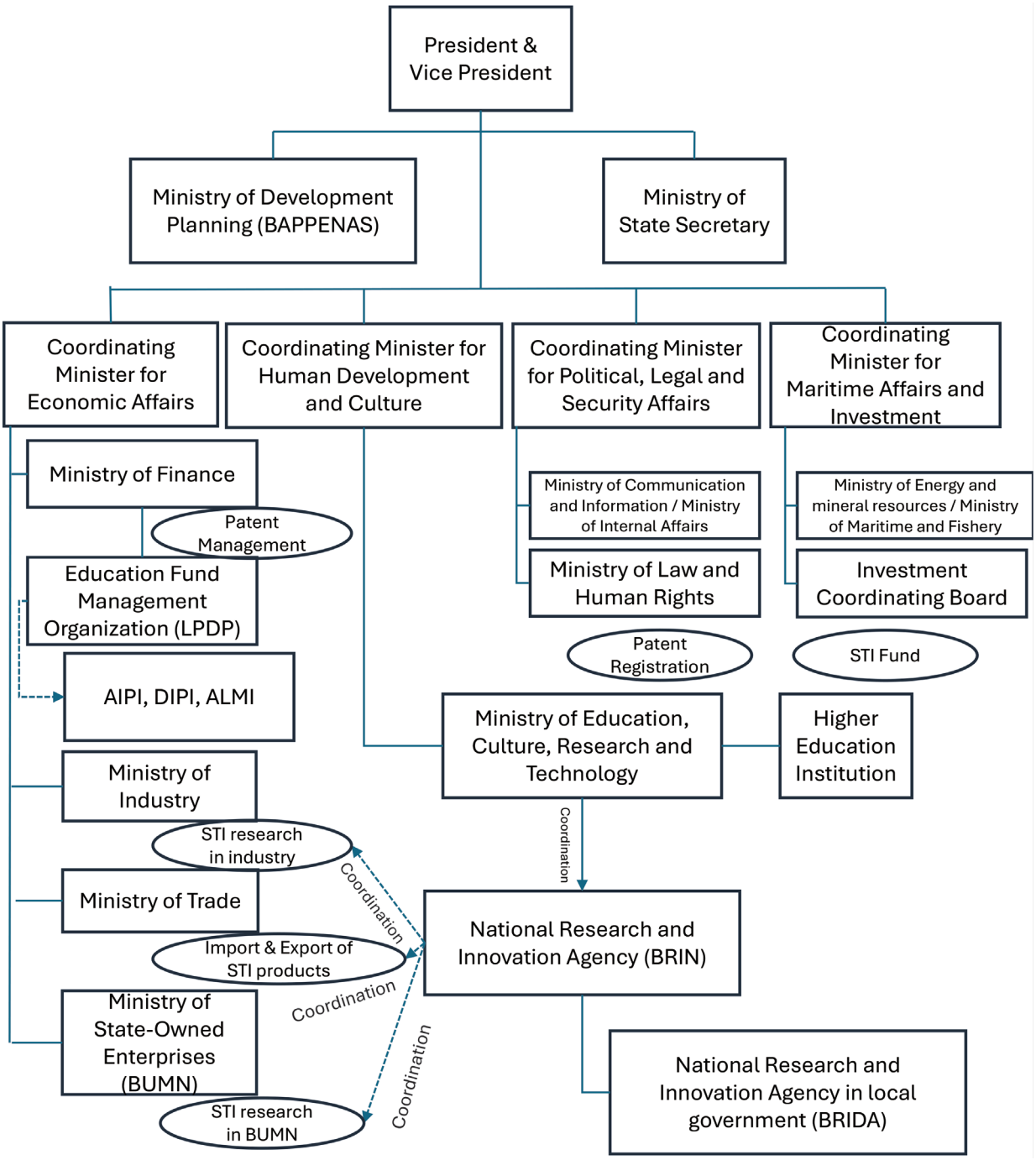


Figure 28 Institutions in implementing Science and Technology Policy in Indonesia

Source: adapted from JST (2015)

BRIN, the Ministry of National Development Planning (BAPPENAS), KEMENDIKBUDRISTEK, LPDP, the Indonesian Academy of Sciences/*Akademi Ilmu Pengetahuan Indonesia* (AIPI), the Indonesian Young Academy of Sciences/ *Akademi Ilmuan Muda Indonesia* (ALMI), and the Indonesian Science Fund (DIPI) play vital roles in Indonesia's R&D landscape, shaping technological advancements and fostering innovation (See Table 7).

Table 7 Roles of Indonesian R&D Organizations

Organization	Roles in Indonesian R&D
BRIN	· Supporters of evidence/science-based development policies: National Ministries/ Institutions and Regional Governments in the regions (with support from BRIDA (Regional Research and Innovation Agency). · Strengthening the national research and innovation ecosystem as a funding agency. · As an executing agency for research and innovation activities.
BAPPENAS	· Coordinate and formulate policies for national development planning in higher education and science and tech. · Monitors, evaluates, and controls initiatives across various national development planning sectors. · Focuses on areas such as higher education learning, technology diffusion, innovation, and research and development
KEMENDIKBUDRISTEK	· Manages education, cultural, research, and technology affairs in Indonesia. · Improves the quality of education at all levels, from early childhood to higher education. · Promotes innovation and technology integration in educational processes. · Formulates policies related to academic higher education and implements them comprehensively. · Focuses on enhancing the higher education system through strategic priorities, independent campus activities, key performance indicators, and funding mechanisms.
LPDP- (under MoF: Ministry of Finance**)**	· It provides scholarships and research funding and supports human resources development in various fields, including STI. · Manages the state's education endowment fund, aimed at developing highly skilled professionals and academics. · Allocates funds and sets financial policies supporting STI initiatives in collaboration with the MoF. · Develop the National Education Development Fund (DPPN) through strategic investments in various instruments. · Administers two funding schemes, Fund Development Services and Fund Disbursement Service, aimed at supporting scholarships, research funding, cultural activities, and higher education initiatives.
AIPI	· Unites leading scientists to contribute to scientific development actively. · Organizes scientific meetings, supports research grants, and empowers young scientists. · Provides science-based policy advice to the government and promotes science development through various initiatives. · Focuses on seven key policy directions to strengthen scientific excellence and management.
ALMI	· Empower young scientists to advance science and nurture a superior scientific culture. · Propels frontier science through cross-disciplinary collaboration. · Cultivates scientific temperament and integrates science into public policy formulation. · Engages in global young scientist academy movements to address international challenges. · Conducts activities across four main pillars: frontier science, science and society, science and policy, and science and education.
DIPI	· Provides funding support for researchers with scientific merit and potential by collaborating with some primary research funding. It employs a merit-based open competition for research grants with international standards. · Operates autonomously outside the state budgeting cycle to enhance research quality and global competitiveness. · Fosters scientific excellence by granting rewards and incentives for quality research. · Seeks financial sustainability through diversified funding sources and collaborative efforts.

3.2.2 Overview of BRIN: Enhancing core research function and comprehensive coordination

President Joko Widodo established the BRIN through Presidential Regulation No. 74 of 2019, the process leading to BRIN's creation is illustrated in Figure 29; positioning it as the primary national research organization by consolidating all major research bodies including LIPI, BPPT (Agency for the Assessment and Application of Technology/*Badan Pengkajian dan Penerapan Teknologi*), BATAN (National Nuclear Energy Agency/*Badan Tenaga Nuklir Nasional*), and LAPAN (National Institute of Aeronautics and Space/*Lembaga Penerbangan dan Antariksa Nasiona*) under Presidential Regulation No. 33 of 2021. This merger addressed institutional fragmentation, limited innovation, and poor collaboration among existing science and technology entities.

BRIN's centralization of research is not just about reducing duplication and providing strategic direction. It's a significant shift in the agency's role, moving away from its regulatory functions to become an autonomous entity solely dedicated to fostering impactful research and innovation. This new structure is designed to strengthen coordination, improve project outcomes, and optimize resource allocation across the national research and innovation system.

The integration of science and technology entities under BRIN streamlines research processes and aims to drive economic growth by translating research outcomes into marketable innovations that enhance Indonesia's competitiveness in the global market. Additionally, BRIN enhances collaboration with government, researchers, and businesses to tackle national challenges and seize opportunities effectively.

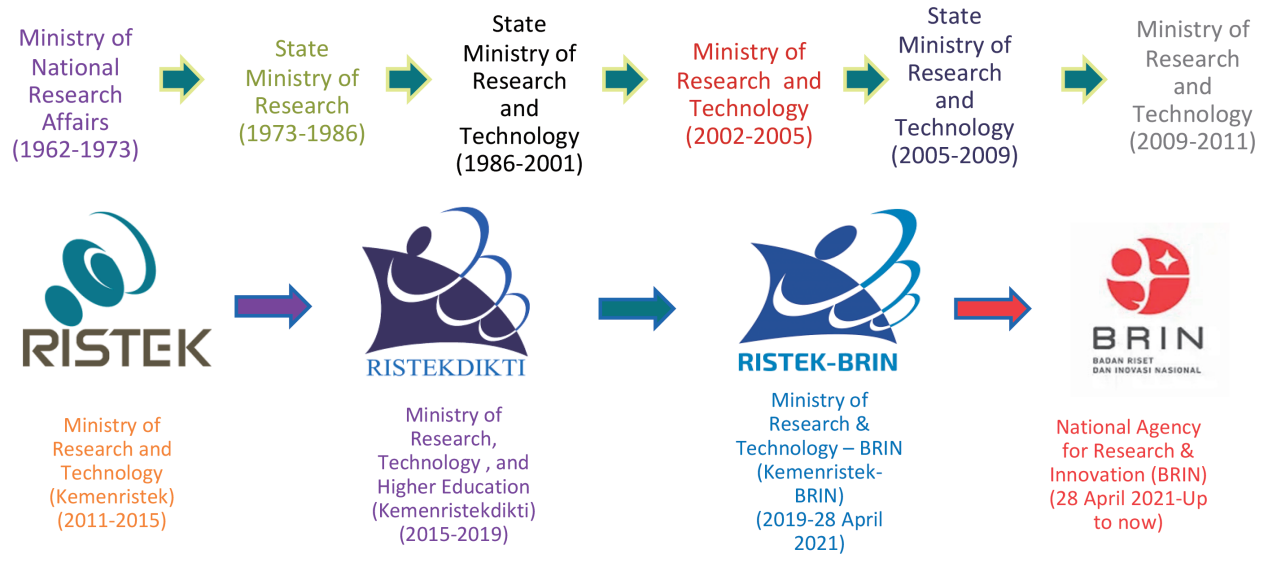


Figure 29 Background to the establishment of BRIN

Source: Dudi (2024)

In 2019, Indonesia allocated IDR 26 trillion (US$69 million) annually to research and innovation (Burhani et al., 2021). this funding was often inefficiently dispersed across various ministries and research bodies, leading to potential research duplication and suboptimal innovation results. To address these issues, President Joko Widodo enacted Presidential Decree No. 33 of 2021 on April 28, 2021, and subsequently amended it with Presidential Decree

No. 78 of 2021 on 24 August 2021, reinforcing BRIN's central role in Indonesia's science and technology (STI) policy.

Presidential Decree No. 78 of 2021, establishes BRIN as the key institution for overseeing research and innovation across diverse sectors, including science, technology, nuclear energy, and space – see 4.2.3. BRIN is charged with formulating and executing policies, plans, and programs in research and innovation while also providing support, training, and evaluations for other STI institutions. BRIN's responsibilities include producing scientific studies and innovations that contribute to national development, embracing diversity, and upholding the nation's identity. Additionally, BRIN evaluates the performance of BRIDA, with ongoing adjustments to governance at regional research centres and redistribution of responsibilities still in progress.

BRIN has seven key objectives: (i) unify management of research institutions, (ii) derive economic benefits from strategic research and innovation, (iii) establish a "research powerhouse," (iv) enhance scientific human resources, (v) advance life science and intellectual property management, (vi) create a collaborative research and innovation ecosystem, and (vii) strengthen partnerships between government, researchers, and the business and industrial sectors (DUDI/ (*Dunia Usaha dan Dunia Industri*). This integration involves transferring all research functions from state ministries and other central agencies to BRIN, addressing past issues where several research units were rebranded to "Policy Assessment Centres" due to historical mismanagement (Burhani et al., 2021). Another critical goal of BRIN is to enhance life sciences and intellectual property management, positioning it as a leading authority in implementing scientific research.

BRIN is also tasked with establishing a robust research and innovation ecosystem through collaborations with government, academia, and industry, which is crucial for the future national research agenda (See Figure 30). The focus is making research results commercially viable, potentially impacting societal and environmental benefits. A significant reform in the funding system has been introduced with the creation of the Indonesian Research and Innovation Fund (IRIF), which supports various research grants, infrastructure, and researcher mobility initiatives, as mandated by Presidential Decree No. 33 of 2021 (Antara News, 2023).

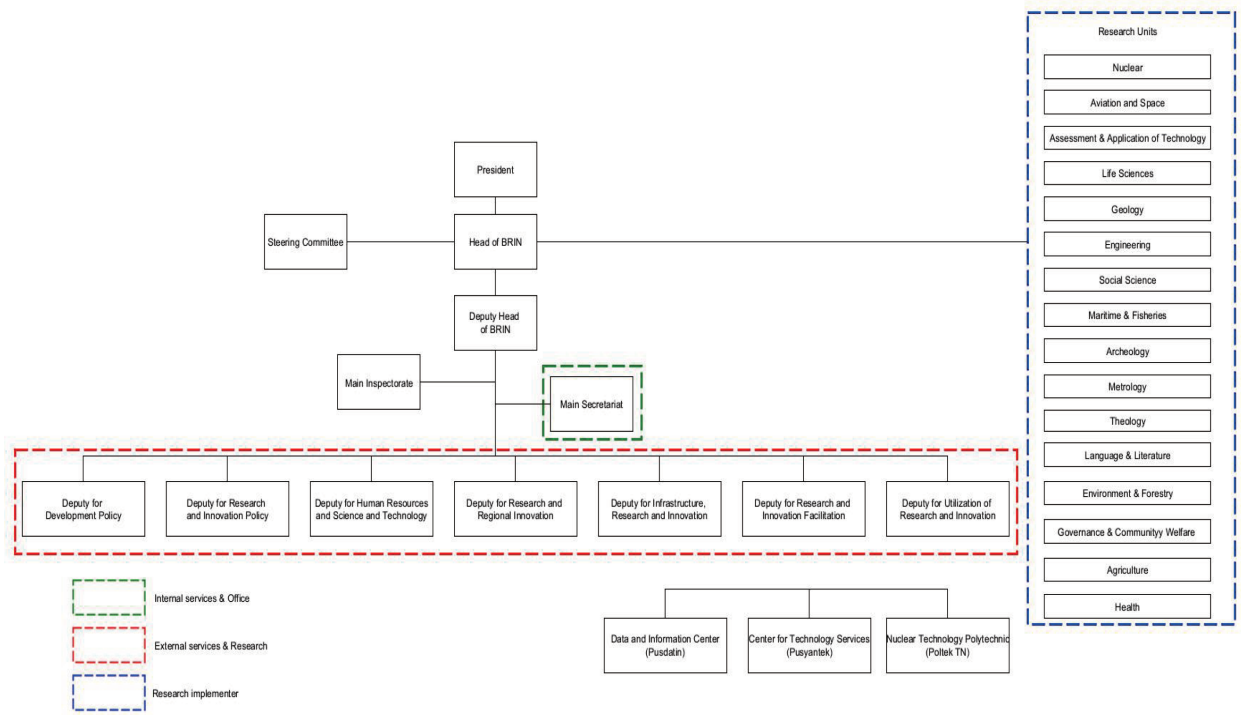


Figure 30 BRIN Structure

Source: Handoko (2021)

3.2.3 Overview of BAPPENAS: Supervising national development plans

The sub-directorate of higher education and science and technology, under BAPPENAS's Deputy for Human Development, Society, and Culture (Figure 31), is essential for coordinating and developing policies in national development planning within higher education and science and technology. This Directorate ensures policy implementation alignment, and monitors and controls various initiatives. As outlined in Article 119, its responsibilities include coordinating and formulating policies, synchronizing planning and budgeting, and developing strategic cross-sector initiatives. These tasks span regulatory to international cooperation efforts, highlighting the holistic approach needed for effective development in these sectors.

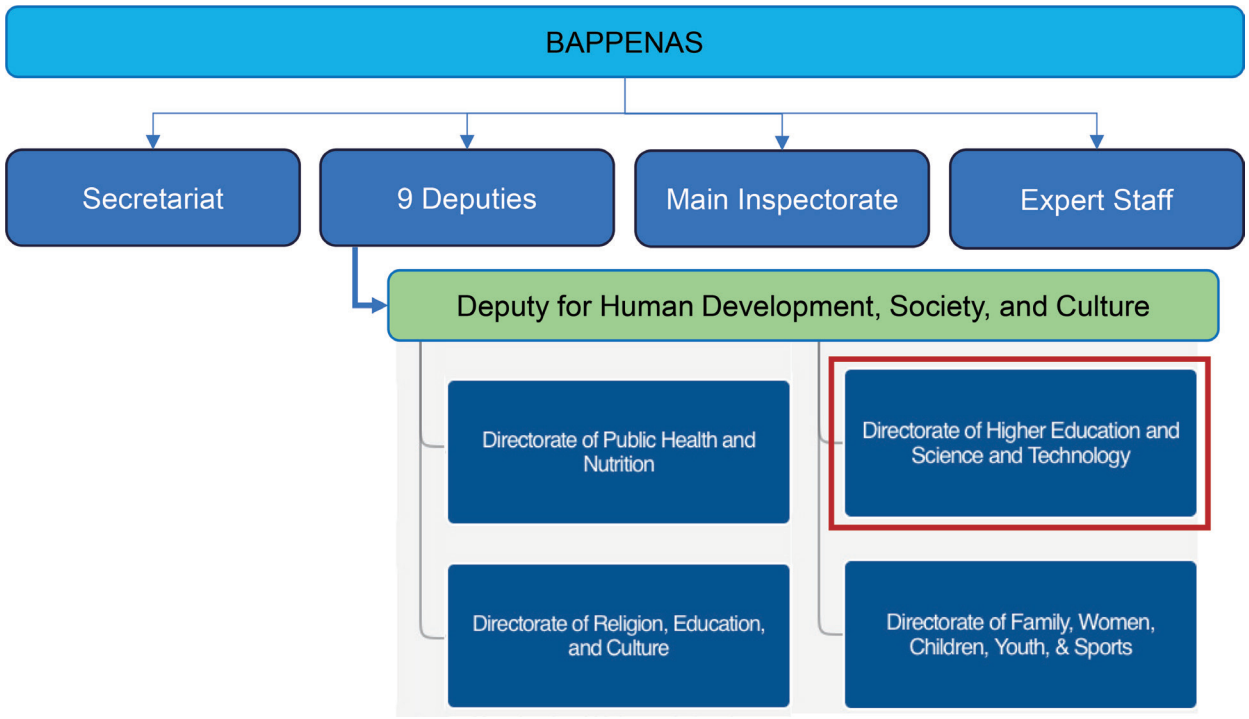


Figure 31 Organization structure chart of BAPPENAS and Deputy for Human Development, Society, and Culture

The Directorate prioritizes critical areas such as higher education, resource management, technology diffusion, and science and technology R&D, emphasizing coordination, integration, and acceleration to ensure a cohesive approach to national development. It also handles crucial tasks like monitoring and evaluating development programs and reporting outcomes. Article 120 details the Directorate's organizational structure, underscoring the importance of Functional Position Groups in managing its diverse functions effectively in higher education and science and technology planning.

The Directorate has developed a comprehensive strategy to promote sustainable development through science and technology (Bappenas, 2024). The first pillar emphasizes prioritizing science and technology in crucial sustainability areas, focusing on the National Research Priority Flagship, which includes technology for natural resource sustainability, disaster mitigation, and social innovation. The second pillar aims to create an innovation ecosystem, enhancing triple-helix collaborations, patent management, and functionalities of Science Techno Parks. This pillar includes the establishment of Technology Commercialisation and Transfer Offices at STPs and the promotion of technology-based startups to boost innovation. (Bappenas, 2024).

The third aspect of the policy strategy focuses on building a research powerhouse by enhancing the quantity and quality of science and technology human resources, developing strategic R&D infrastructure, and strengthening the Science and Technology Centres of Excellence. It includes accrediting R&D institutions, managing biodiversity and intellectual property data, and enhancing research networks (Bappenas, 2024). The fourth component aims to improve R&D spending through structural changes, such as establishing BRIN, optimizing Research Endowment Funds, seeking alternative funding sources, and enhancing collaborations with non-governmental entities for R&D funding (Bappenas, 2024). These initiatives highlight the Directorate's dedication to fostering scientific and technological innovation in line with national development objectives.

3.2.4 Overview of KEMENDIKBUDRISTEK

KEMENDIKBUDRISTEK, in collaboration with its five directorate generals, oversees Indonesia's education, culture, research, and technology sectors. The ministry's primary focus is on enhancing education quality from early childhood to higher education and integrating technology into educational processes. It also fosters research and development activities. While BAPPENAS takes the lead in planning and coordination, KEMENDIKBUDRISTEK is the key driver in implementing educational and research policies and practices.

Specifically, The Directorate General of Higher Education, Research, and Technology, indicated in Figure 32, is a crucial component of the Ministry of Education and Culture. Outlined in Ministerial Regulation Number 45 of 2019, it plays a central role in formulating policies for academic higher education. It is responsible for implementing these policies across learning, student affairs, institutions, and resources.

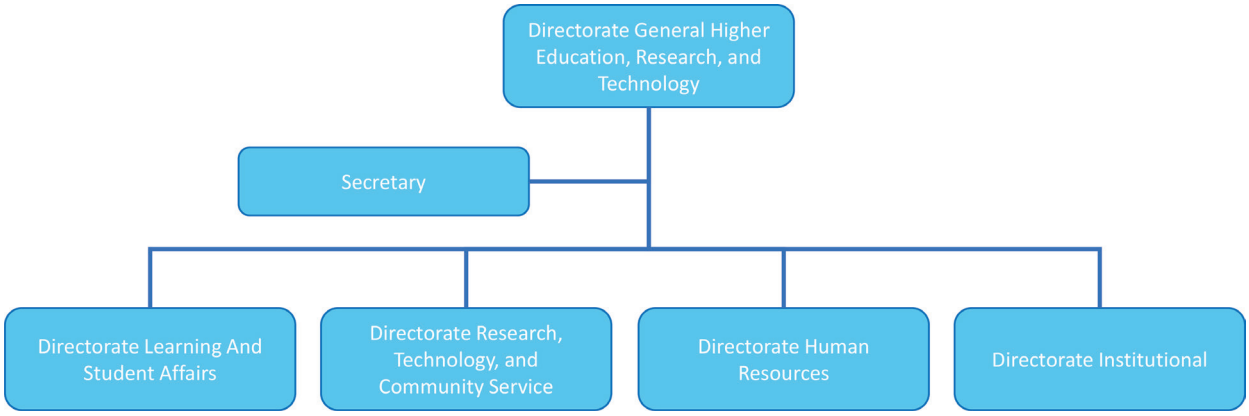


Figure 32 Organization structure chart of the Directorate General of Higher Education, Research, and Technology

Additionally, the directorate is responsible for developing licenses for community-run private universities, playing a pivotal role in evaluating and reporting on higher education. It performs various administrative duties and other tasks directed by the Minister, underscoring its broad scope of responsibilities. The directorate's activities are aligned with five strategic priorities, detailed through 9 campus activities, 8 Key Performance Indicators (KPIs), and three funding mechanisms, as illustrated in Figure 33 below.

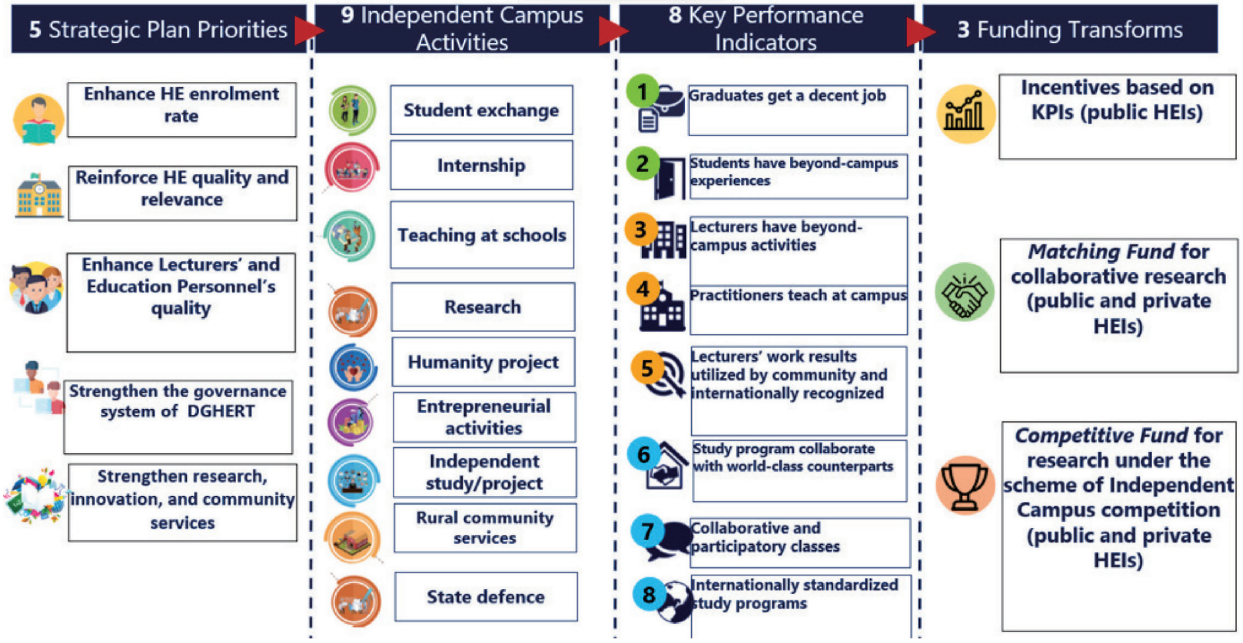


Figure 33 Higher education policies and strategies

Source: Kemendikbudristek (2024a)

The Directorate General of Higher Education in Indonesia has outlined a strategy to enhance the national higher education system, focused on five strategic priorities: increasing enrolment rates, improving program quality and relevance, enhancing lecturer and staff qualifications, strengthening governance, and advancing research, innovation, and community services (Kemendikbudristek, 2024a). Nine specific campus initiatives are implemented to realize these objectives. These include student exchanges for global exposure, internships linking studies with industry, and teaching programs bridging higher and secondary education. Additionally, initiatives like research, community-oriented projects, and entrepreneurship aim to foster knowledge and societal development. Other activities, such as rural outreach and state defence involvement, further integrate academic efforts with national challenges.

The effectiveness of the strategic activities is measured by eight key performance indicators (KPIs), which include graduate employment rates, quality of off-campus student experiences, lecturers' external involvement, and industry engagement in teaching. Other KPIs assess the global reach and community impact of lecturers' work, international collaboration in study programs, classroom practice effectiveness, and international standards compliance in programs (Kemendikbudristek, 2024a).

Three funding mechanisms are employed to support these initiatives: performance-based incentives for public institutions (Kemendikbudristek, 2024a), matching funds for collaborative research between public and private entities, and a competitive fund for the Independent Campus competition aimed at fostering research. The detailed funding program by KEMENDIKBUDRISTEK is explained in Section 5.1.2.

3.2.5 Overview of AIPI, ALMI, and DIPI

Three key institutions notably enhance Indonesian scientific advancement: ALMI, under AIPI, supports young scientists through initiatives in science, societal engagement, policy influence, and education. AIPI, established in

1990, unites top scientists to drive scientific progress aligned with seven strategic policy directions. DIPI boosts research quality and competitiveness by providing independent funding and promoting scientific excellence (AIPI & KSI, 2020). .

AIPI, founded formally in 1990, continues the legacy of a national science academy, tracing back to the Natuurwetenschappelijke Raad voor Nederlandsch-Indie in 1928. It contributes to scientific advancement by hosting significant scientific meetings, awarding research grants, and fostering young scientists' growth through collaborative efforts. It maintains its commitment to scientific excellence by establishing a research grant fund (AIPI & KSI, 2020).

AIPI's seven policy directions focus on enhancing its role in science-based policy advice, increasing visibility, integrating young scientists, addressing strategic scientific questions, establishing the Indonesian Science Fund, expanding reach through AIPI Press, and managing government and non-government funds.

ALMI, under AIPI's guidance and shown in Figure 34, was established to engage Indonesia's top young scientists in advancing scientific culture nationally. AIPI declared its establishment on May 20, 2015, but it was officially recognized after President Joko Widodo signed RI Presidential Decree No.9/2016 on February 29, 2016. ALMI originated from thirteen young scientists who authored the SAINS45 book, setting the groundwork for the academy's structure.

ALMI's mission is to drive interdisciplinary scientific advancement and instil a robust scientific culture among the youth. It promotes integrating science into public policy and actively participates in the global young scientist community. The academy's efforts are organized around four main pillars:

- Promoting frontier science through interdisciplinary work
- Fostering scientific temperament and culture
- Integrating science into public policy making
- Enhancing national character through science education

The AIPI, established under Law No.8/1990, functions independently with dual objectives: providing expert opinions on science and technology to the government and public and fostering scientific development through conferences, policy debates, publications, and national and international collaborations [61, I, 2]. It unites Indonesia's leading scientists to significantly advance the national scientific landscape, with details on high-technology research priorities discussed in Section 5.2.1.

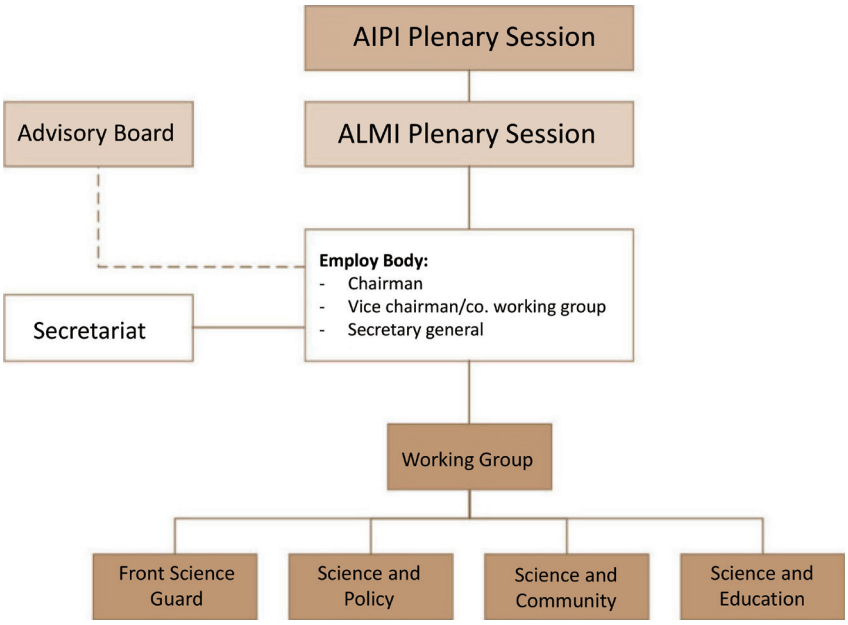


Figure 34 Organization structure chart of AIPI and ALMI

DIPI, an autonomous body under AIPI, provides independent funding for scientifically meritorious research. Officially launched on March 30, 2016, by the MoF following Presidential Decree No. 9 of 2016, DIPI aims to enhance Indonesia's research quality and global competitiveness through a sustainable financial framework based on the initial establishment of AIPI under Law No. 8 of 1990.

DIPI operates independently of the state budgeting cycle, with grants reviewed by external experts. Its mission focuses on boosting Indonesia's scientific capabilities and fostering a culture of excellence. DIPI supports impactful research, increases the pool of skilled scientists, and promotes rigorous scientific work through competitive rewards and incentives. The DIPI roles and descriptions can be seen in Figure 35.

DIPI is effectively guided by a management board and a science steering committee, the latter of which plays a pivotal role in setting scientific goals and strategic research directions. Comprised of eminent scientists and policymakers, the committee ensures that DIPI aligns with AIPI's broader objectives, with oversight from the AIPI General Assembly.

As a semi-independent entity, DIPI leverages funds from non-governmental sources, allowing for greater strategic flexibility beyond the State Budget's constraints. It conducts merit-based research grant competitions, proudly meeting and often exceeding international standards and engaging global experts [61, I, 2].

However, DIPI heavily relies on external support, including human resources, expertise, and funding from organizations such as LPDP, the MoF, and European partners for collaborative research [61, I, 2]. It actively seeks further collaborations to expand its network. It has established a science hub focusing on innovative science, resource mobilization, and carbon development initiatives. Additionally, DIPI is working to bridge funding gaps by creating trust funds, including endowment and sinking funds.

DIPI, in its strategic partnership with the Directorate of Higher Education within KEMENDIKBUDRISTEK, is actively working on developing an endowment fund from non-governmental sources, a testament to its unwavering commitment to long-term economic stability. Since 2018, DIPI has served as the secretariat for a joint funding scheme between Asia and the European Union, involving nine ASEAN countries. This role emphasizes DIPI's commitment to

international collaboration and active participation in initiatives like E-Asia, enhancing joint scientific research across borders.

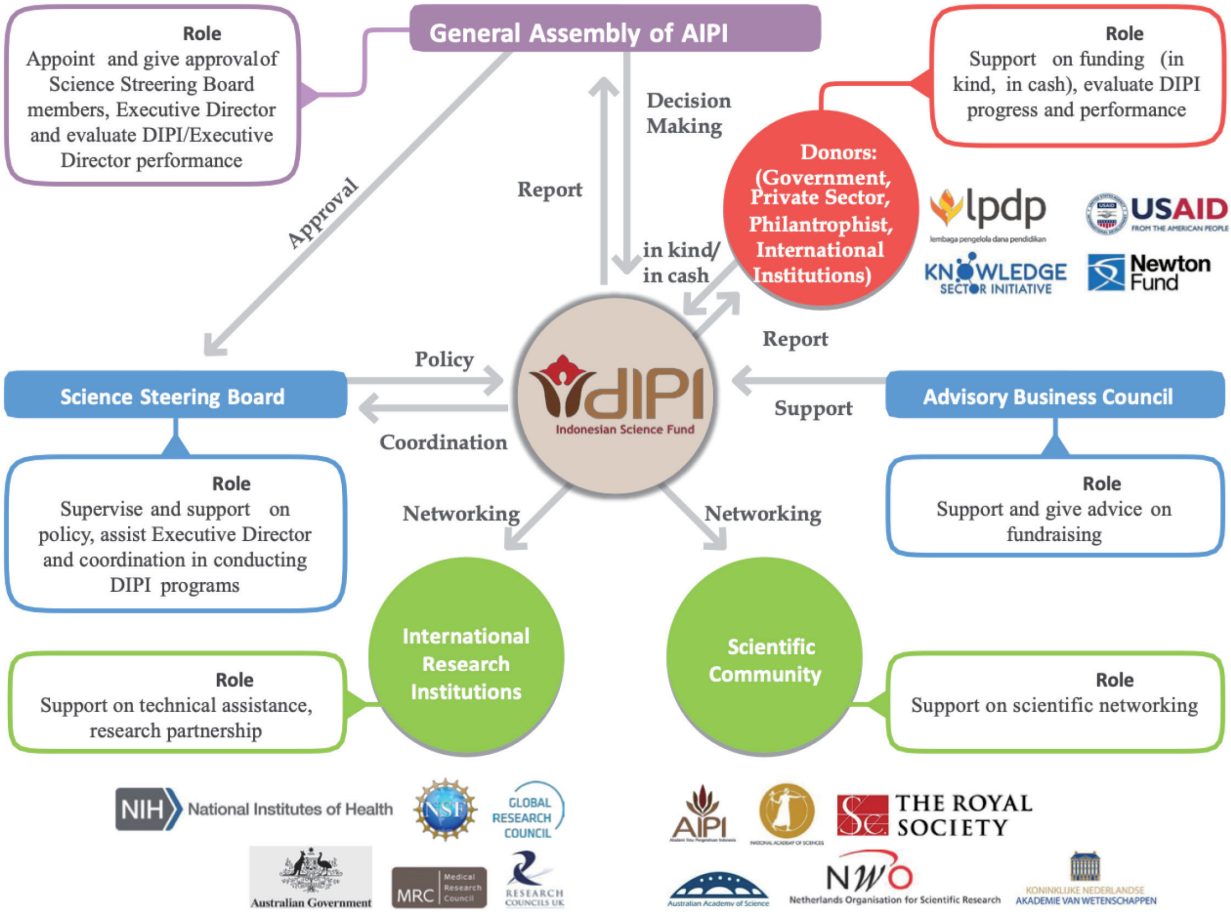


Figure 35 Organization structure chart of AIPI and DIPI

3.2.6 Overview of Ministry of Finance and LPDP

LPDP was established under Presidential Regulation No. 121 of 2012and organized as per the Minister of Finance No.47/PMK.01/2020. It manages Indonesia's education endowment fund with four directorates and 14 subdivisions, depicted in Figure 36.

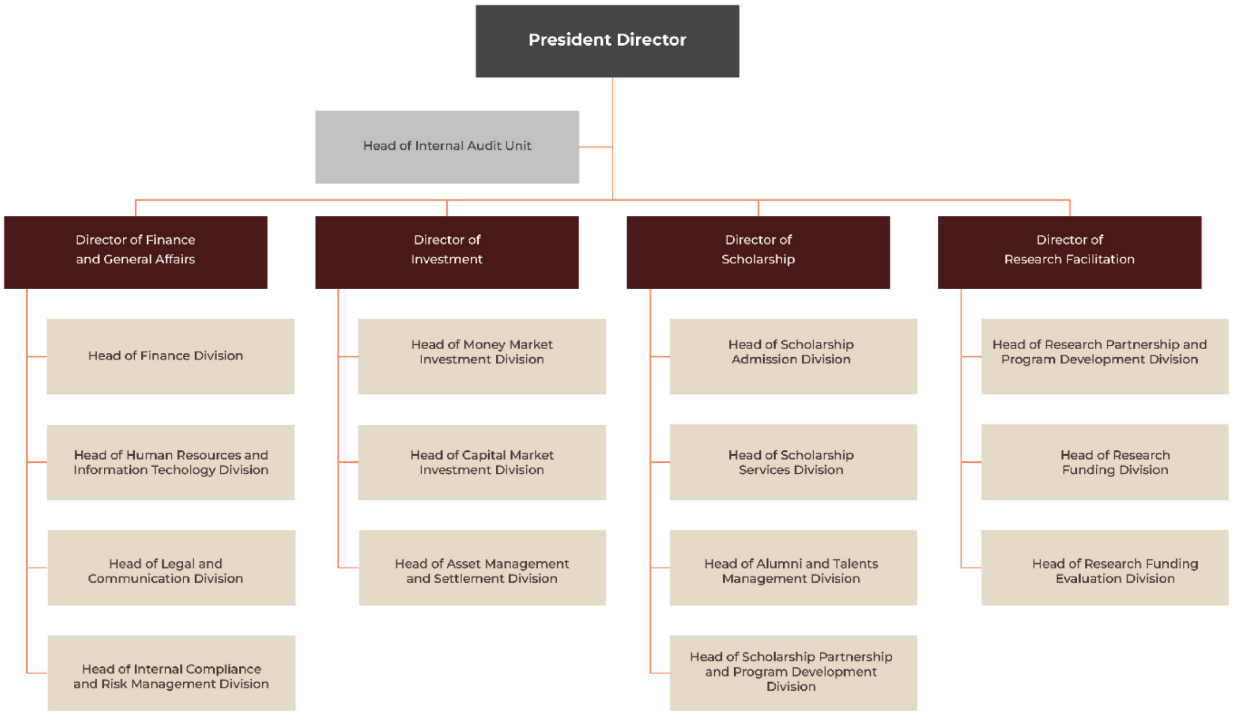


Figure 36 Organization structure of LPDP

Source: LPDP (2023a)

LPDP awards scholarships and research funding (The Jakarta Post, 2023), supporting the development of skilled professionals and academics crucial for national progress. The Ministry of Finance is pivotal in funding and policy setting for STI endeavours.

LPDP demonstrates its financial acumen and resourcefulness by enhancing the state's education endowment fund through strategic investments. It manages non-tax revenues for scholarships, research funding, and operational costs, utilizing a diverse range of investment instruments and non-state sources such as grants and commercial partnerships. This strategic approach helps to reduce dependency on state budgets (LPDP, 2023a).

The funding operations of LPDP include Fund Development Services, which involve diversifying investments to bolster the Education Endowment Fund, and Fund Disbursement Service, which allocates developed funds to scholarships, research, and cultural and educational programs. Collaborative efforts with Kemdikbudristek and other ministries enhance LPDP's scholarship offerings, with the RISPRO program targeting research commercialization to drive innovation (LPDP, 2023a).

As explained above, STI advancement in Indonesia faces hurdles such as limited funding at 0.08% of GDP, far below the ASEAN average, which impacts research quality and infrastructure. Regulatory complexities arise from decentralized governance, hindering policy coordination across levels and sectors (Nasution, 2016).

Collaboration issues between academia, industry, and government further impede the innovation ecosystem, alongside intellectual property challenges, such as those difficult administrative requirements to get patent for some provinces and TRL requirements to register the patent that affect research commercialization. Integrating research bodies into BRIN complicates matters, requiring careful management to avoid conflicts and maintain efficiency (Antara News, 2023).

A uniform salary structure for lecturers and researchers challenges STI strategies, which may affect motivation and talent retention. Resource distribution inefficiencies are evident in the varying quality across public universities. Additionally, there needs to be more clarity between research objectives and industry needs, emphasizing quantitative targets rather than effective collaborations. Low early-stage technological adoption and limited research funding at 0.28% of GDP suggest a need for more diversified financial sources to enhance the research landscape.

For advancing a more effective research ecosystem in Indonesia, a review to ensure a more accurate and impactful evaluation of research efforts is necessary.

3.3 Future Direction of Science and Technology Policy under New Presidency

Amid the 2024 presidential election, potential shifts in R&D policy may align with the goals of the Prabowo-Gibran administration. Their "*Together Indonesia Goes Forward Towards Golden Indonesia 2045*" plan aims to continue Joko Widodo's initiatives, focusing on human resources, education, and STI. Their campaign includes 17 priority programs and specific initiatives targeting human resource development and socio-economic advancement, promising to elevate education, science, and technology sectors.

- **Strengthening Education and Research:** Collaborate with Japanese institutions to improve education and research in renewable energy, agriculture, and digital technology.
- **Innovation and Technology Development:** E Develop innovation and technology, particularly in sectors such as food security, energy, and digital economy, by establishing innovation hubs and technology parks with Japanese expertise and investment.
- **Human Resource Development:** Enhance human resource capabilities in STEM fields through joint educational programs, scholarships, and training initiatives with Japanese universities.
- **Sustainable Development:** Work with Japan on sustainable projects in renewable energy, waste management, and climate change mitigation.
- **Economic Syariah and Green Economy:** Partner in the economic Sharia and green economy sectors, using Japanese expertise in halal industry standards and eco-friendly technologies.
- **Maritime Cooperation:** Engage in maritime research and industry development, including fisheries and marine conservation.
- **Healthcare and Biotechnology:** Collaborate in healthcare and biotechnology to improve healthcare services and pharmaceutical industries.
- **Infrastructure Development:** Partner with Japan on infrastructure projects critical for water management, transportation, and urban development.
- **Digital Transformation:** Utilize Japanese digital technology expertise to enhance Indonesia's digital infrastructure and economy.
- **Disaster Management and Resilience:** Jointly develop disaster management technologies, focusing on Indonesia's need for resilience against natural disasters.

The HR quality improvement system employs digital technology to strengthen ties between education, government,

and industry. It enhances scholarship and skill development initiatives across sectors, including Islamic boarding schools, supported by Law No. 18 2019. Furthermore, a new management body will oversee NGO (Non Government Organization) funds to elevate democratic quality.

Exciting plans are underway to boost funding for cultural exchange programs, broadening international networks and skills for artists. These initiatives aim to create a vibrant and diverse arts and culture sector, with educational outreach and mentorship programs focusing on cultivating artist entrepreneurs.

Our efforts to enhance HR management and social welfare are of utmost importance. They include prioritizing Women's Empowerment and Child Protection and improving workforce quality through competency-based training at Training and Work Training Centres/ *Balai Latihan Kerja* (BLK).

A new, selected president and vice president of Indonesia, Prabowo and Gibran, aims to boost policies that seek to enhance educational quality via the expanded Smart Indonesia Card program, revamping university curricula to be more project-based and aligned with industry needs, especially in vocational and polytechnic education.

The leadership plans to increase research and innovation funding to 1.5-2.0% of GDP, aiming for alignment with industry needs. This plan includes scholarships for underrepresented groups and establishing digital libraries to boost literacy. BRIN will utilize the National Research Roadmap (RIRN) under Presidential Decree No. 38 of 2018 to ensure research aligns with broader economic goals (See Figure 37).

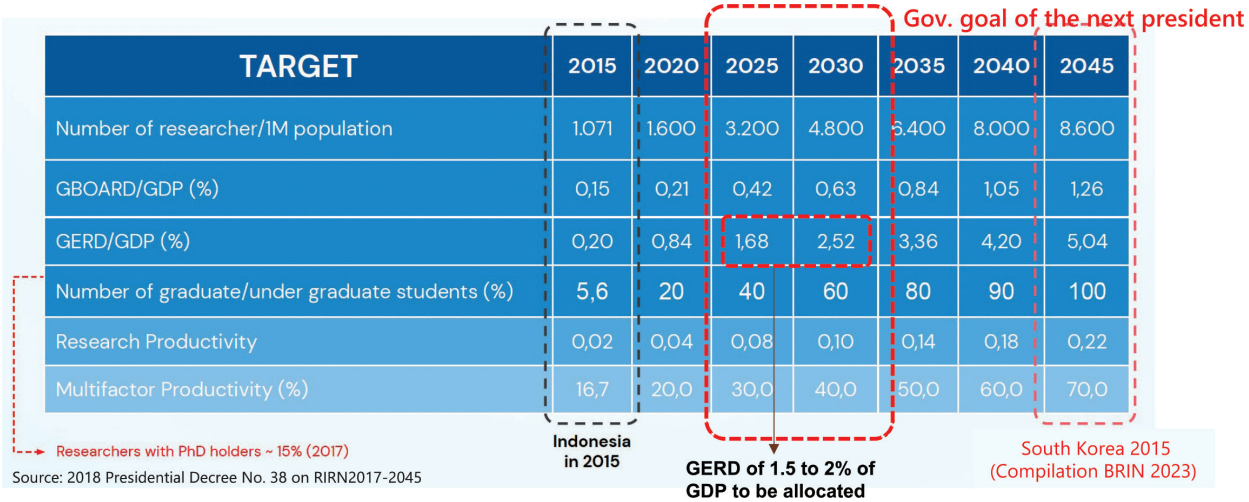


Figure 37 National Research Roadmap

Source: BRIN (2023)

The strategy aims to enhance digital literacy across all educational levels, promoting a digital culture and improving vocational education in technical fields. It suggests establishing a minimum wage for private school teachers in early childhood education, *madrasahs* (islamic school), and foundation-based schools, and enhancing religious education with scholarships for both national and international programs.

Partnerships are being formed between private companies and state enterprises to provide scholarships and internships for university and vocational school graduates. Initiatives are in place to improve the welfare of lecturers, researchers, and extension workers and boost the capacity of higher education institutions to better serve the youth.

A new education system in Indonesia focuses on character building from a young age, emphasizing morality, discipline, and creativity. The initiative encourages universities and businesses to engage in scientific research and national development and promotes global cooperation.

4 Basic Research Trends in Indonesia

4.1 Public Funding Allocation and Basic Research Promotion Policy

Public funding for research is managed by government organizations such as BRIN, LPDP, and KEMENDIKBUDRISTEK, supporting diverse R&D activities and playing a vital role in enhancing Indonesia's research and innovation landscape (See Table 8). These public funding programs play a crucial role in advancing Indonesia's research and innovation ecosystem by providing financial support for scientific investigations, technological developments, and capacity building in research and higher education.

Table 8 List of Indonesian Government Public Funding Programs in R&D

Organization	Funding Program	Supporting Outline
BRIN	· 8 program of Advanced Indonesian Research and Innovation (Riset dan Inovasi untuk Indonesia Maju – RIIM)	· These initiatives are designed to provide financial assistance and resources to researchers, scientists, and institutions across various fields. The schemes cover diverse areas, promoting collaboration, technology development, and academic excellence (Universities, research centres, or private entities)
	· *Hari Layar* (OceanXplorer)	· Research and innovation facilitation and funding schemes to provide open and inclusive access for researchers/lecturers and students to utilise BRIN's research vessel facilities.
	· *Program BARISTA - Bantuan Riset bagi Talenta Riset dan Inovasi* (Research Support for Research and Innovation Talents)	· Focuses on providing support to active final-year students at the Diploma 4 and Strata levels (S1, S2, S3) from their universities. The primary goal of the program is to assist students in completing their final projects through research collaboration within BRIN work units.
	· Facilitation Programme for Utilisation of Research and Innovation Results	· To promote the application of research and innovation outcomes, thereby enhancing the competitiveness of Micro, Small, and Medium Enterprises (MSMEs), fostering a robust innovation ecosystem, and contributing to regional and national economic development. This program collaborates with private entities.
MoF (LPDP)	Education program (LPDP Scholarship)	· LPDP Scholarship service expanded beyond exclusive management by LPDP, fostering collaboration with entities like LPDP, KEMENDIKBUDRISTEK, and the Ministry of Religious Affairs
	Research (RISPRO program)	· RISPRO: Competition Research: Applied research for product commercialisation or policy implementation involving various institutional partners. Mandatory/Assignment Research: Strategic research is directed by Board of Trustees, and regional innovation projects. Invitational Research: Industry-focused research addressing specific themes aligned with RIRN. International Collaboration Research: Research conducted in partnership with external parties through joint calls or co-funding mechanisms.

	Cultural activities funding	· Facilitate the cultural sector, production of cultural activities, and media production with some entities.
	Higher Education funding	· In collaboration with universities, the Directorate General of Higher Education manages funding for higher education program activities.
DIPI KEMENDIKBUDRISTEK	· Research grant and publication	· 70-80% for research grants, 10-20% reinvested for future use, and up to 10% for scientific publications and audits
	Incentives for public higher education	The awarding of the achievement of KPI of higher education in the form of incentives is stipulated in the Decree of KEMENDIKBUDRISTEK No. 135/E/KPT/2021
	Matching Fund Program	Matching Fund Program fosters collaboration between university personnel and business entities through joint projects funded by industry partners and KEMENDIKBUDRISTEK.
	Competitive Fund Program COVID19 research	The competitive fund was established to spur research within the framework of the Independent Campus competition, which is open to both public and private. Provides specialised funding for research on the prevention, detection, and treatment of novel coronavirus infections (COVID-19). - Priorities: vaccines, diagnosis, medications, treatment - Funds range: Rp 60 million to Rp 1 billion per year (maximum 3 years)

In Indonesia, critical organizations like BRIN, DIPI, and the Ministry of Finance (MoF) are central to allocating public research funds (Figure 38). BRIN allocates for IDR 10.513 billion (90%), while local government (Ministry of Home Affairs) allocates for IDR 982 billion (8%), and IDR 247 billion (2%) from LPDP (LPDP Financial Statement 2022). The MoF is instrumental in managing state finance, including budgeting and fiscal policies crucial to research financing.

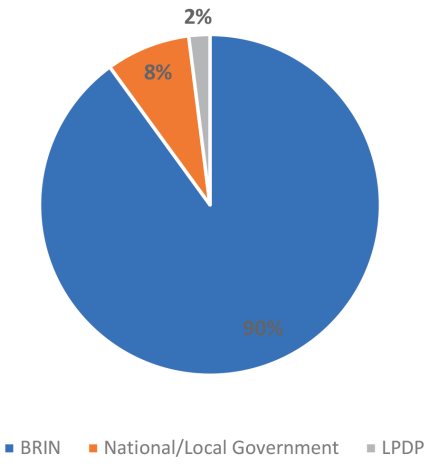


Figure 38 Distribution of research spending in the government sector in 2022

BRIN was allocated IDR 10.51 trillion in 2022 (BRIN, 2023b). This consolidation aims to prevent redundant research and enhance efficiency, coordinating national research endeavours with entities such as the Ministry of Finance and BAPPENAS.

Furthermore, BRIN engages in various collaborative research funding schemes with stakeholders like the education ministry based on formal agreements (Dzulfikar, 2019). In 2022, government research spending was IDR 11.74 trillion, 0.06% of GDP, with BRIN's expenditure representing 90% of this total (Figure 39; BRIN, 2023b). At the higher education level, research funding in 2020 totalled IDR 3.03 trillion, about 0.02% of GDP, with state institutions receiving 65% and private universities 35%.

DIPI is also essential for advancing the national research ecosystem. With AIPI, DIPI helped create a 'non-State Budget Research and Technology Endowment Fund' that provides flexible and sustainable grants to academic and private researchers (DIPI, 2022). Funding sources include government grants, national and international donors, philanthropy, fundraising events, and royalties from intellectual property commercialization. (DIPI, 2022):

While DIPI's budget currently varies based on diverse funding sources, it remains small relative to global standards (as described in Figure 38). However, this presents an exciting opportunity for growth. Indonesia's GDP was IDR 19.58 quadrillion in 2022. According to standards set by BRIN, UNESCO (United Nation Educational, Scientific, and Cultural Organization), and the World Bank, an ideal research budget should be 1% of GDP, equating to IDR 195.8 trillion for that year. This potential for growth in DIPI's budget could significantly advance the national research ecosystem, inspiring a new era of innovation and discovery.

4.1.1 Research and Development Support managed by the MoF

Through LPDP, the MoF effectively manages the Education Endowment Fund, which is crucial for ongoing scholarship and research funding programs. The fund is strategically invested, and the returns are used to sustain educational initiatives, establishing a self-sustaining financial model. In 2022, LPDP's assets under Management were Rp125.57 trillion, with a return of Rp 6.385 trillion (LPDP, 2023a).

LPDP strategically disburses budgets to advance education, research, cultural programs, and higher education. The endowment fund allocation for disbursement services is explained as follows:

- Education (Budget 2022: Rp101.12 billion), the LPDP Scholarship service was expanded to include collaborations with entities like KEMENDIKBUDRISTEK and the Ministry of Religious Affairs, offering various scholarships and enhancing the program with components like degree scholarships, pre-departure preparation and alumni management, and other programmes/scholarships as directed by the Board (LPDP, 2023b):
- LPDP's RISPRO program, a key research funding initiative with a 2022 budget of Rp7.99 billion, is designed to support research aimed at commercialization and practical implementation, fostering innovation and added value (LPDP, 2023b).

  Research funding is categorized into Competition Research, which focuses on applied research with commercial or policy objectives; mandatory/Assignment Research, which targets strategic themes and collaborations with KEMENDIKBUDRISTEK and BRIN; Invitational Research, which is tailored to industry-specific needs; and International Collaboration Research, which involves joint projects and co-funding with international entities.

- In 2023, LPDP's RISPRO program achieved remarkable funding realizations, a testament to its effectiveness and impact: Rp24.4 billion for Invitation, Rp10.9 billion for Competition, and Rp3.6 billion for International Collaboration. Furthermore, BRIN's RISPRO Mandatory RIIM received a substantial Rp49.3 billion, and KEMENDIKBUDRISTEK's PRIME Mandatory RISPRO was allocated a significant Rp7.7 billion (LPDP, 2023b). These impressive figures reflect the program's success in driving research and innovation forward. Culture: The Directorate General of Culture manages a Rp3 billion budget for cultural activities in 2022, funded through the Cultural Endowment Fund. This fund supports cultural enrichment and development, focusing on facilitating the cultural sector, producing cultural activities, and creating media content. Higher Education: The Directorate General of Higher Education collaborates with universities to manage a Rp7 billion budget for enhancing higher education in 2022. This funding, sourced from a research endowment fund, aims to improve campus rankings and push universities towards international standards. The fund supports initiatives like incentives for PTNBH/ The State University with Legal Entity Status universities and world-class university development, standard programs for PTNBH universities, and education reserve funds.
- LPDP has steadily increased its funding from 2020 to 2024 (IDR 70.11 billion to IDR 182.11) across education, research, culture, and higher education sectors. The education budget grew from IDR 61.12 billion in 2020 to IDR 141.12 billion in 2024, research funding from IDR 4.99 billion to IDR 17.99 billion, cultural activities from IDR 1.00 billion to IDR 8.00 billion, and higher education from IDR 3.00 billion to IDR 15,000 billion by 2024 (LPDP, 2022). This increase illustrates LPDP's commitment to enhancing Indonesia's educational and research capabilities.

The 2023 funding allocation reflects LPDP's strategic investment in various sectors: 47% of education funds support the LPDP Scholarship program, 43% enhance KEMENDIKBUDRISTEK-led educational initiatives, and 10% back the Ministry of Religion's academic programs. In research, 21% of funds support the LPDP Research program, 31% fund KEMENDIKBUDRISTEK's research initiatives, and 47% are allocated to BRIN-directed research projects, aligning with national research priorities.

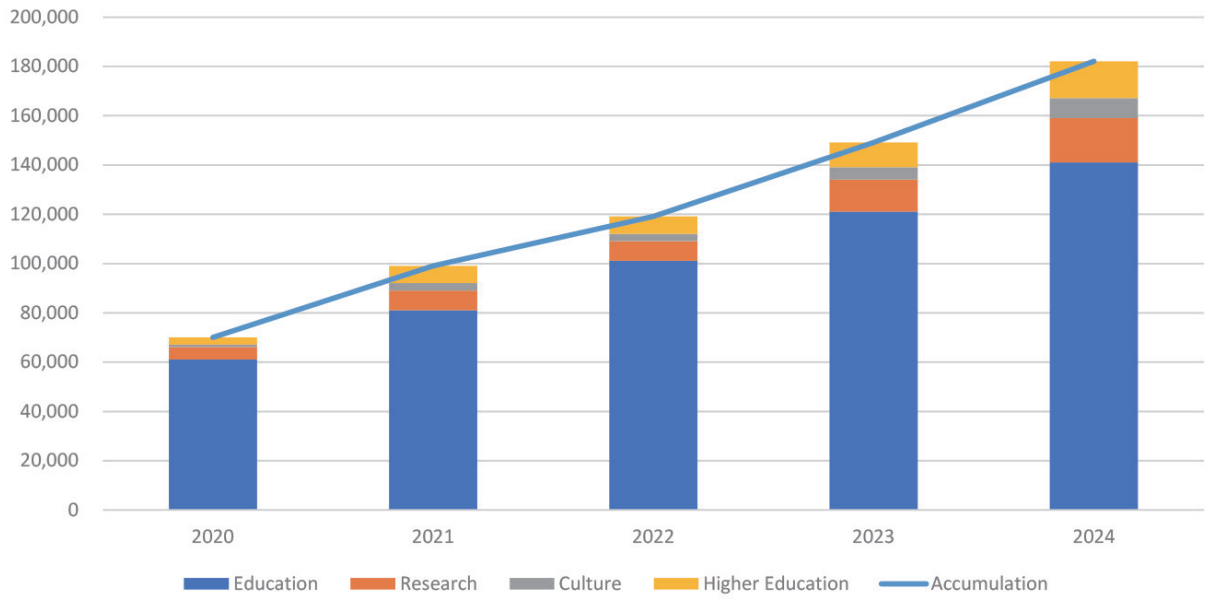


Figure 39 Endowment funds distribution for 2020-2024 in Billion Rupiah

Source: LPDP (2022)

4.1.2 Research and Development Support managed by KEMENDIKBUDRISTEK

KEMENDIKBUDRISTEK provides three key funding mechanisms to support R&D, all of which are aligned with the goals and aspirations of our stakeholders: incentives for public higher education institutions, a matching fund program, and a competitive fund.

Incentives for Public Higher Education

Incentives for public higher education are awarded based on institutions' performance against established KPIs (Kemendikbudristek, 2024a), as per the Decree of the Director General of Higher Education, Research and Technology No. 135/E/KPT/2021. These incentives are utilized for various purposes, including upgrading facilities and infrastructure as per the Electronic Procurement Service catalogue, enhancing human resource capacities through lecturer and staff competency development, subsidizing tuition fees, supporting the eight Merdeka Campus activities, managing COVID-19-related needs, and facilitating Tri Dharma activities of higher education (teaching, research, and community service). The utilization of these funds is reported back to the Directorate General of Higher Education, Research and Technology.

Matching Fund Program

Launched in 2021, the Matching Fund Program has been instrumental in enhancing the research ecosystem by fostering collaborations between universities and businesses. These joint projects, supported by industry partners and KEMENDIKBUDRISTEK, are addressing real-world challenges (Kemendikbudristek, 2024a). The *Kedaireka (Kampus merdeka)* platform, a testament to our collective efforts, is facilitating these partnerships by linking Indonesian researchers with local and international industrial entities, promoting knowledge exchange and a vibrant research environment. Your continued support is crucial in maintaining and expanding these valuable collaborations.

In 2022, the program allocated IDR 1 trillion in total funding. It is a key enhancement resulting from the collaboration facilitated by the Kedaireka platform (Kemendikbudristek, 2024b). In 2022, there was total funding of USD 40 M with additional industry co-funding (USD 50 M), supporting 5500 proposals across 300 universities and polytechnics and engaging 1000 industrial partners (Kemendikbudristek, 2024b). This collaboration has significantly boosted Indonesia's position in the Global Innovation Index, climbing from 87th in 2021 to 61st in 2023.

Competitive Fund Program

For 2024, KEMENDIKBUDRISTEK has introduced two funding schemes under this program (Kemendikbudristek, 2023a). Scheme A focuses on commercialising research products and applying academic expertise to solve industrial problems, targeting environmental and waste management areas. Scheme B aims to utilize academic knowledge for community empowerment and to enhance public sector efficiency, involving collaborations with government and other entities to foster societal improvements and governance efficiency.

The Competitive Fund, established as part of the Independent Campus competition, supports vocational tertiary institutions in transforming to produce globally competent graduates. Aiming to foster an ideal vocational education environment, it is available to public and private institutions (Kemendikbudristek, 2023b).

Since its inception in 2020, the Competitive Fund program has significantly enhanced the alignment of vocational higher education with industry requirements. It supports curriculum updates, boosts human resource capabilities,

establishes industry partnerships, and promotes innovative teaching methods.

Up to 2023, the Vocational Competitive Fund has supported 79 vocational universities (public and private) across 387 study programs (Kemendikbudristek, 2023b). It has facilitated the establishment of teaching factories within these programs, enhancing practical education and fostering closer ties with industry.

4.1.3 Research and Innovation in Combating COVID-19

In response to the COVID-19 crisis, Kemenristek and BRIN have launched the Litbangjirap (Research, Development, Assessment, and Application) initiative under Government Regulation No. 1 of 2020, focusing on quick prevention, detection, and response efforts. As a leading institution for R&D, Kemenristek/BRIN is pivotal in promoting pandemic-related research and innovation. A Research and Innovation Funding policy has been introduced to fast-track projects by supporting researchers and engineers across various sectors. The COVID-19 Consortium, facilitated by Kemenristek/BRIN, coordinates collaborative efforts based on specific operational guidelines.

The COVID-19 Consortium, aimed at addressing various aspects of the pandemic in Indonesia, operates under the guidelines of Presidential Regulation No. 16 of 2018 and Permenristekdikti No. 20 of 2018. This program, funding strategic and urgent research needs, encompasses R&D (TRL 1-6) and innovation (TRL 7-9), focusing on Vaccines, Screening and Diagnosis, and Medication and Therapy. Open year-round with periodic reviews, the consortium offered research funding from IDR 60 million to IDR 1 billion annually for up to three years in 2022.

4.1.4 Research and Development Support managed by BRIN

BRIN's Advanced Indonesian Research and Innovation (*Riset dan Inovasi untuk Indonesia Maju* -- RIIM) program comprises eight distinct schemes that offer funding and support to foster research and innovation across various sectors in Indonesia (Sari, 2024). These initiatives are designed to promote collaboration, technological development, and academic prowess, aiming to accelerate scientific and technological progress and create a thriving environment for research.

RIIM Competition

The RIIM Competition, aimed at research institutions, seeks innovative solutions in science and technology to achieve Q3 international journal publications and secure an intellectual property right annually. (Sari, 2024). Covering diverse fields like food, health, energy, aviation, and space, BRIN has allocated IDR 500 trillion for 2024.

RIIM Expedition

The RIIM Expedition Funding Scheme by BRIN funds research to explore Indonesia's natural and cultural resources, promoting collaborative studies. (Sari, 2024). Targeting diverse fields, it aims to enhance publications and national databases. In 2024, IDR 137.5 trillion is allocated to uncover and highlight Indonesia's cultural heritage (Sari, 2024).

RIIM Invitation

RIIM Invitations, a specific funding category by BRIN, are designed to advance Indonesian research and innovation through targeted projects at government and non-government institutions. These invitations can be either organized

by BRIN or proposed by various Ministries, Institutions, and Business Entities (Sari, 2024). They are divided into regular and strategic types, with BRIN allocating a substantial IDR 96 trillion for strategic and IDR 5 trillion for regular invitations in 2024. The Regular Invitation funds research activities addressing specific themes from proposers, focusing on national and international strategic issues. At the same time, the Strategic Invitation supports research that is aligned with BRIN's strategic plan, fostering collaborative efforts.

The expected outcomes of these initiatives include publications in international journals, registered intellectual property, and other agreed-upon outputs. Research themes vary widely, covering areas such as Terrestrial and Marine Biodiversity, Geology, Space Observation, Archaeological Excavations, and Advanced Technologies like Accelerator Technology for Medical and Industrial Applications. This diversity reflects Indonesia's commitment to leveraging its rich resources and scientific capabilities to address challenges and opportunities.

RIIM Start-up (Research-based Start-up Companies)

The RIIM Start-Up funding program allocates IDR 24.9 trillion to support start-ups emerging from BRIN and community research, covering product development, marketing, and certification. It includes six months of mentoring, with successful start-ups receiving up to IDR 300 million annually for two years (Sari, 2024). (Sari, 2024). RIIM Health Innovation Product Testing

The Health Innovation Product Testing Scheme facilitates pre-clinical and clinical trials for health products such as drugs, vaccines, and medical devices through collaborations with industries and researchers from BRIN and other institutions (Sari, 2024). It includes three programs: pre-clinical trials, regulatory submissions, and clinical trial execution, with a 2024 budget of IDR 2 trillion. Applicants must submit comprehensive regulatory documents.

RIIM Agricultural Innovation Product Testing

The Agricultural Innovation Product Testing Programme collaborates with industries and inventors to test agricultural products, allocating budgets to designated testing institutions (Sari, 2024). Eligible items include superior plant varieties, fertilizers, and veterinary vaccines.

To qualify, proponents must provide an industrial business license, Good Manufacturing Practice documents, intellectual property proofs, and other regulatory documents (Sari, 2024). The head of the proposing industry must author the systematic proposal to ensure compliance and readiness for testing.

RIIM Research Collaboration Centre (Pusat Kolaborasi Riset – PKR)

The PKR funds collaborative research centres in specific fields for national and international standards. PKR offers Type I for academic collaborations and Type II, including industry for product development (Sari, 2024). Funding depends on annual performance evaluations

RIIM Collaboration

The RIIM Collaboration initiative by BRIN enhances national and international research partnerships, (Sari, 2024) with a 2024 budget of IDR 5 trillion. It focuses on collaborative research for high-impact outcomes, like publications and intellectual property creation, promoting global knowledge. Further details on specific partnerships are outlined in section 5.3.1.

In addition to the eight programs above, we will introduce three other research and development supports under the

management by BRIN.

Hari Layar (OceanXplorer)

Indonesia, as a maritime nation, seeks to align its national targets with global goals, leveraging synergies through scientific cooperation to address challenges affecting our geopolitical areas. BRIN supports the United Nations Decade of Ocean Science 2021-2030 through its *Hari Layar* program, providing access to research vessel facilities for projects that align with the Decade's goals. These projects span biodiversity, bioresource utilization, and marine anthropology, contributing to sustainable ocean-related economies. This initiative is bolstered by a partnership with OceanX and their vessel, OceanXplorer, offering 20 weeks of cruise time for deep-sea research that integrates with Indonesia's national research priorities, enhancing collaborative ocean science efforts.

Program BARISTA - Bantuan Riset bagi Talenta Riset dan Inovasi

The BARISTA Programme, designed to support final-year students at Diploma 4 and Strata levels (S1, S2, S3), facilitates their completion of final projects by integrating them into BRIN work units for research collaboration. The program aims to nurture potential researcher to conduct research and innovation talents while promoting joint publications, expanding cooperative networks with universities, and enhancing R&D activities. Financial support includes a tuition fee of up to Rp5,000,000 per semester for two semesters, paid directly to the college, and research assistance funds of IDR 3 million for Diploma IV/Bachelor's, IDR 6 million for Master's, and IDR 9 million for Doctoral degrees, transferred to students' accounts upon university approval of their project outputs. This initiative empowers students in their crucial final academic year, fostering significant research contributions.

Facilitation Programme for Utilisation of Research and Innovation Results

The Facilitation Programme for Utilisation of Research and Innovation Results, managed by BRIN's Deputy for Utilisation of Research and Innovation is designed to enhance MSME competitiveness and foster a robust innovation ecosystem. This initiative promotes the practical application of research through collaborations with local entities to boost regional and national productivity.

The program consists of three schemes: Technical Guidance on Research and Innovation Utilisation, which offers training to improve community capacity for environmental challenges. Grassroots Innovation Facilitation (FIAR) supports community-driven innovations. Facilitation of Science and Technology-Based Micro Enterprises (FUMI) aims to enhance MSME competitiveness by accelerating the commercialization of R&D technological products, enabling global competition.

4.1.5 Research and Development Support managed by DIPI

DIPI, supported by KEMENDIKBUDRISTEK and the MoF, emphasises elevating Indonesia's scientific and technological capacities while maintaining financial independence from the annual state budget cycle. (DIPI, 2016). It raises funds from various sources, including government, national, and international private donors, investing these in financial instruments to support its operations and objectives. The investment returns are specifically used to further DIPI's research goals, not the principal amount. Significantly, the MoF's endowment fund does not contribute directly to DIPI, highlighting its financial autonomy (LPDP, 2023b).

The allocation of DIPI's endowment fund proceeds, as approved by the Board of Trustees, follows a structured plan:

- 70-80% is allocated to research grants, including basic and matching grants.
- 10-20% is reinvested for future growth.
- Up to 10% supports operational needs.

These funds also support scientific activities and proposal management and ensure regular dissemination of research findings through publications and audits.

DIPI aligns its research priorities with Indonesia's National Research Master Plan 2017-2045 (RIRN), regulated in Presidential Regulation No. 38 of 2018 and collaborates on multiple fronts, including government, private sector, and international partnerships, adhering to strict approval processes and focusing on areas stipulated by the SAINS45 agenda and other collaborative agreements (DIPI, 2022). F DIPI, as an independent research funding agency, collaborates with various entities, including government and private sector funders, both domestically and internationally, with all partnerships requiring approval from DIPI's own Board of Scientific Directors (DPI) (DIPI, 2022). Collaboration models include (DIPI, 2022):

1. DIPI calls for funding high-quality basic research.
2. Joint calls for bilateral cooperation with both domestic and foreign funding institutions.
3. Multi-lateral cooperations such as joint funding schemes.

Additionally, DIPI supports two research schemes under Kedai Reka: Scheme A for advanced research and Scheme B for dedication, which are aligned with BRIN's Technology Readiness Level (TRL) system.

The TRL framework, detailed in Figure 40 divides the development of technology into stages from concept to commercialization. In this process, Indonesian universities and research institutions play a pivotal role, primarily contributing to the early stages (TRL 1-3) focusing on basic research. Their dedication and contribution to the advancement of technology are highly valued. The business sector, on the other hand, engages more in the later stages (TRL 7-9), aiming at market launch and commercialization. Despite the structured approach, technological development in Indonesia faces notable challenges during the intermediary stages (TRL 4-6), often described as the 'valley of death' due to high risks and failures in maturing technologies.

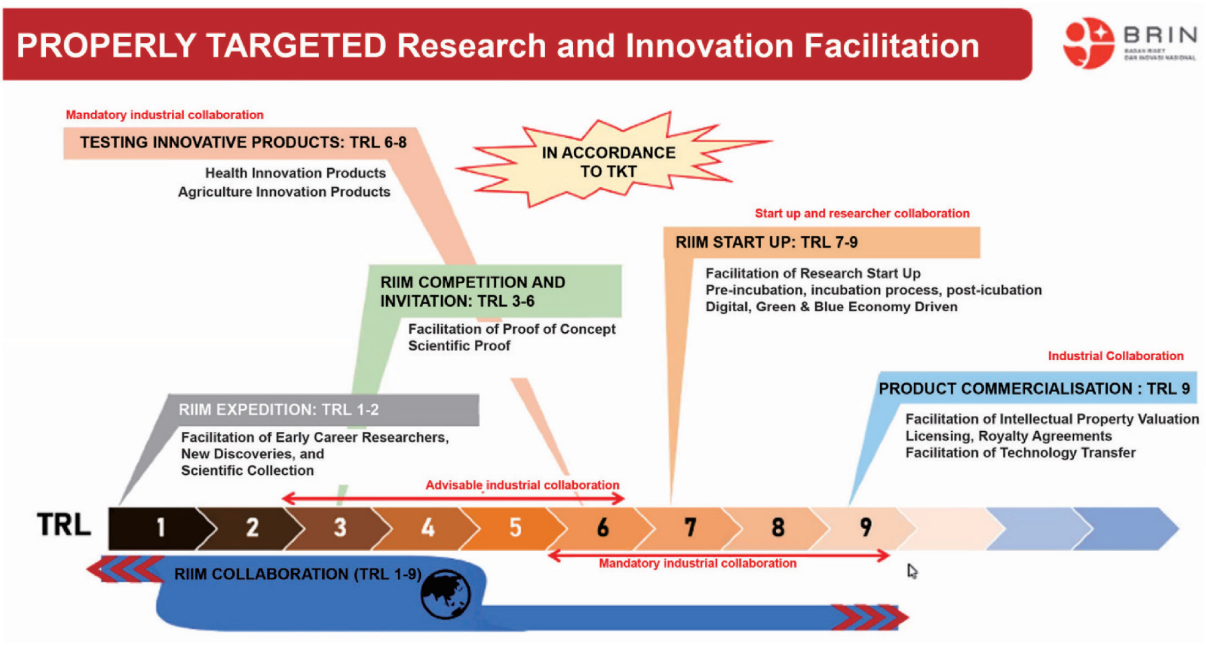


Figure 40 Technology Readiness Level Framework

Source: BRIN (2023)

4.2 Priority Areas of Research

4.2.1 National Indonesia's Research Project Priority

The **Presidential Regulation No. 38 of 2018** establishes Indonesia's national research framework under RIRN 2017-2045, setting strategic priorities to enhance the country's competitive edge. It spans sectors like Food, Energy, Health, and more, with focused budget allocations for 2020-2024 outlined in **Permenristekdikti No. 38 of 2019.** Presidential Regulation No. 38 of 2018 establishes Indonesia's national research framework under RIRN 2017-2045, setting strategic priorities to enhance the country's competitive edge. It spans sectors like Food, Energy, Health, and more, with focused budget allocations for 2020-2024 outlined in Permenristekdikti No. 38 of 2019. Key investments include IDR 1,040 trillion for agriculture, IDR 16,011 trillion for renewable energy, and funds for health (IDR 2,000 trillion), transport (IDR 5,216 trillion), and engineering innovations (IDR 2,663 trillion). Additional focuses cover defence (IDR 2,521 trillion), maritime infrastructure (IDR 1,771 trillion), education integration with societal challenges (IDR 713 trillion), and strategic issues like disaster management (IDR 4,148 trillion), totalling significant national investment in research and development.

This strategic alignment is part of Indonesia's broader aim to deliver impactful outcomes through national and sector-specific flagship products, as outlined in the 2020-2024 RPJMN/ National Medium Term Development Program. The research implementation is structured around a consortium-led approach, with budget allocations distributed according to the specific work breakdown structure or key technology focus. 70% of the APBN is utilized for integrated national flagships and 30% for ministry and institution flagships. This approach ensures a coordinated effort across various government levels and departments to advance the nation's science and technology sector.

RIRN and PRN articulate Indonesia's strategic vision from a long-term to short-term perspective, integrating

research with national development to foster an innovative society and enhance global competitiveness. BRIN is pivotal in advancing these goals, orchestrating various initiatives that promote scientific research and innovation across multiple sectors. As Indonesia's central research entity, BRIN ensures that its projects align with and support the nation's development priorities, focusing on innovation and the strategic application of research to tackle significant challenges and seize development opportunities.

Beyond BRIN, entities like LPDP bolster Indonesia's research infrastructure by financing higher education, research, and innovation, with programs like RIIM and RIND (Research and Innovation for Disaster Mitigation) focusing on areas such as biodiversity conservation and disaster mitigation. Partnerships with other national institutions and global organizations like WHO expand Indonesia's research capabilities. (Dzulfikar, 2019).

Additionally, companies like PT Bio Farma and academic bodies like the University of Indonesia enrich the research landscape through biotechnological advancements and comprehensive academic studies, enhancing national and international research collaborations. PT Bio Farma (Persero) leads in biotechnological advancements in pharmaceuticals and vaccines. At the same time, the University of Indonesia engages in extensive research across social and natural sciences. Collaborations with international organizations like the WHO enhance the global scope of Indonesia's public health research, collectively expanding the country's research capabilities nationally and internationally.

The SAINS45: Indonesia's Science Agenda Towards a Century of Independence, the book developed by ALMI in partnership with AIPI, outlines eight fundamental research areas. These domains underpin Indonesia's strategic focus on harnessing high technologies, with a special emphasis on renewable energy sources like solar, wind, geothermal, and hydrogen-based energies. This reflects Indonesia's equatorial advantage and the need for advanced material sciences to support energy conversion and storage. To be honest, Indonesia has a huge potential due to natural resources, location, and raw material, but high technologies are not well implemented due to some hindering factors. Reducing these factors and fulfilling necessities bring about confidence in Indonesia's future in high technologies.

The agenda also explores high-tech applications such as agro-mining and engineered geothermal systems (EGS), which aim to revolutionize traditional mining and enhance geothermal energy utilization. These initiatives emphasize the development of materials that can withstand extreme conditions and support high-resolution prospecting technology for deeper geothermal exploration. For hydrogen energy, the push is towards designing materials capable of efficient hydrogen gas absorption and release, advocating for strategic partnerships and funding alignments to propel scientific and technological innovation at a national level.

4.2.2 Academia-Research Flagship

Here are some major universities in Indonesia with research flagships based on interviews with their representative IPB University has developed the Agromaritime 4.0 concept to rejuvenate Indonesia's economy by harnessing the country's vast land and marine resources for wealth generation in island communities. This flagship project addresses climate change, technological advancements, and COVID-19 impacts, promoting sustainable development and a digital economy through sector-wide collaboration, aiming to transform villages into thriving growth centres.

UI, a frontrunner in research, is making significant strides in medical technology, food security, energy, and green infrastructure. It has positioned itself as a leader in essential technologies such as AI and the Internet of Things (IoT). This leadership role underscores UI's commitment to advancing these technologies and its potential to shape the

future in these areas.

UGM's community service program, KKN (*Kuliah Kerja Nyata*/Student Study Service), actively engages communities by providing practical solutions and knowledge in tourism, entrepreneurship, healthcare, and engineering, including solar energy and water management. By 2025, UGM aims to centralize these resources in a repository and enhance its research focus to include AI, blue energy, medical advancements, agriculture, and social sciences, aligning with emerging global trends and challenges.

ITB's research priorities span a wide spectrum, including ICT (Information and Communication Technology), transportation, energy engineering, infrastructure, disaster management, and health. Led by experts like Dr. Rino Rakhmata Mukti, their diverse research efforts encompass Earth and planetary sciences, environmental engineering, and materials science. This breadth of research showcases ITB's broad impact across multiple scientific domains, demonstrating its comprehensive approach to research and development.

Indonesia's leading universities, including IPB, ITB, UGM, and UI, are aligning their research with national priorities as outlined in the PRN. IPB focuses on agricultural development, ITB on engineering advancements, while UGM and UI expand their efforts across health, engineering, and social humanities. This diverse research approach supports holistic development, contributing to national growth by addressing a wide range of societal needs and challenges, as detailed in Table 9. Additionally, BRIN, an essential research entity in Indonesia, focuses on engineering, energy, and health to tackle national challenges like infrastructure and sustainable energy. Its extensive research efforts significantly enhance life quality and drive national development.

Table 9 Number of research projects per PRN focus themes on selected institutions.

PRN Focus Theme	BRIN	IPB	ITB	UGM	UI
Food	13	6			
Energy	15				1
Health	15	1		3	3
Transportation	7		1		
Engineering	17	2	4	1	4
Defence and security	4				
Maritime	4	1		5	
Social humanities, education, arts, and culture	6			3	2
Multidisciplinary and cross-sectoral	10		2	1	1

4.3 Private Sector Contributions and Funding Organizations

In Indonesia, diverse funding mechanisms support research and innovation, particularly within the private sector. These include direct grants from public sector entities like BRIN and DIPI. A report on the mapping of philanthropic institutions illustrates the significant role of private philanthropy in research funding, highlighting contributions from corporate philanthropy arms, family foundations, and intermediary organizations such as Unilever Indonesia,

Eka Tjipta Foundation, and PT Adaro Energy Tbk. These entities, driven by generous and strategic interests, support research across multiple disciplines. According to Figure 41 and Table 10 in the report, 29 philanthropic organizations focus notably on social and economic issues, which represent about 26% of the funded research, followed by 18% in science and technology, with other areas like humanities, environment, health, and financial literacy also receiving targeted funding.

Figure 41 Supported Research Themes/Issues Philanthropic Entities

Research funding methods include 48% from calls for proposals, 38% through internal partnerships (Syndicate), and 14% from other sources, with the primary motive being to fulfil the internal needs of philanthropic organizations. These organizations utilize research to guide program planning and development, emphasizing evidence-based approaches. For example, Unilever issues terms of reference to research institutions, collaborates on developing research instruments, and requires progress and final reports to ensure outcomes align with expectations. Beneficiaries of this funding, detailed in Table 10 and Table 11 (see annexe 3) include universities, NGOs, and independent research institutions selected based on credibility, reputation, and the ability to deliver research that aligns with the funders' themes and interests.

Funded projects reflect the priorities of their funders, encompassing societal development, educational initiatives, health studies, and environmental sustainability. The Eka Tjipta Foundation (ETF) offers scholarships across academic levels. It prioritizes employment within the Sinar Mas group for outstanding recipients, contributing to scholarships and industry collaboration ("Eka Tjipta Foundation," n.d.). Another important player, The Tanoto Foundation allocated IDR 157 billion in 2020 to programs aimed at educational enhancement and stunting prevention, supporting their strategic goals to boost Indonesia's academic standing and catalyze medical research (Times, 2021). The Bakrie Centre Foundation emphasizes education, health, and environmental sustainability, notably through its AI-enhanced TB screening initiatives and national programs to eradicate tuberculosis. Its efforts engage numerous social

organizations and beneficiaries, illustrating the tangible outcomes of its projects in the education and health sectors) (*BCF | Bakrie Foundation – Building Leaders*, n.d.).

The study acknowledges the limitations of government funding in addressing research scarcity. It underscores the importance of synergies with non-governmental actors, highlighting the growing role of corporate philanthropy in research funding. While philanthropic institutions are invested in research for program development, the benefits often remain internal, advocating for a new approach that promotes societal contributions. To foster a conducive research environment, the study calls for deregulation and incentivizing philanthropic support through policy reforms like tax benefits and simplified licensing. It proposes establishing a Philanthropy Law to enhance the role of these institutions in Indonesia's research landscape. Further studies are recommended to explore the potential and trends of corporate philanthropy and to implement these recommendations effectively.

4.4 International Cooperation and Collaboration in Basic Research

4.4.1 Current Status of International Cooperation and Collaboration of Indonesia with Several Major Countries

Indonesia actively engages in global research through BRIN and DIPI, which manage diverse collaborations and bilateral initiatives with organizations like MRC (England's Medical Research Council) and RCUK (The Research Council UK) to address critical issues and enhance international cooperation.

International Cooperation and Collaboration Managed by BRIN

Indonesia, through BRIN, has significantly advanced international cooperation in basic research with its RIIM programs, including the RIIM Kolaborasi (RIIM collaboration) program, which fosters extensive international research collaborations. This initiative aligns with BRIN's goal to elevate Indonesia's global research stature by facilitating joint projects and co-funding. Nationally, Indonesia is a proud participant in the e-ASIA Joint Research Program, a multilateral initiative among East Asia Summit (EAS) members. This inclusive program, involving countries like Australia, Japan, China, and the U.S., is aimed at fostering innovation and economic development in East Asia, and Indonesia's active involvement is a testament to its growing influence in the global research community.

Indonesia's international cooperation policies emphasize strategic partnerships in research with priority countries sharing common interests, exemplified by the SEA-EU JFS. This scheme involves collaboration on critical themes like "*Circular Economy*" and "*Clean, Accessible, and Secure Energy Supply*," requiring a consortium with partners from three countries. The 8th SEA-EU JFS Call for Proposals in 2024 has seen participation from countries including Austria, Belgium, Brunei Darussalam, Bulgaria, Cambodia, Czech Republic, Germany, Malaysia, Myanmar, Spain, Switzerland, Thailand, the Philippines, Türkiye, Indonesia, the coordination of DIKBUDRISTEK and BRIN, focusing on thematic contributions that enhance global scientific cooperation and sustainable development (Sari, 2024).

Furthermore, Indonesia's global research collaborations extend beyond specific projects to include academic agreements and joint research endeavours with major universities and research institutes worldwide. Figure 42 presents Indonesia's active role in international research and development through partnerships with several major countries. This comprehensive approach includes partnerships with organizations like the International Development Research Centre and the Bill & Melinda Gates Foundation, which support various health and development initiatives.

Additional collaborations with research bodies such as the German Research Foundation and the Scientific and Technological Research Council of Turkey underscore Indonesia's commitment to advancing a broad spectrum of scientific and technological fields (Sari, 2024).

Indonesia's research ties with China are robust, highlighted by the collaboration between BRIN, the MOST-CHINA, and the NSFC, and the Institute of Deep-sea Science and Engineering at the Chinese Academy of Sciences (IDSSE-CAS), coordinated by Indonesia's Coordinating Ministry for Maritime Affairs and Investment (CMMAI). This partnership focuses on deep-sea research using the IDSSE's Tan-Suo-Yi-Hao vessel and the Fendhouze Human Occupied Vehicle, capable of reaching depths up to 11,000 meters, reflecting a significant commitment to advancing science and innovation between the two nations.

Further enhancing educational cooperation, the Memorandum of Understanding (MoU) signed in 2015 between Indonesia's Ministry of Education and Culture, Research and Technology and the Ministry of Education of China aimed to bolster higher education links. The MoU facilitated various initiatives, including expanding Mandarin teaching and integrating Mandarin with vocational training in Indonesia. This agreement, spanning collaborations in language proficiency tests, curriculum development, and scholarship provisions, has significantly strengthened educational and vocational cooperation between Indonesia and China.

Indonesia's partnerships with the European Union (EU), Southeast Asia, Australia through the Department of Foreign Affair and Trade (DFAT) and Australia National University (ANU), and Japan, facilitated by agencies like the JSPS, are strategic in nature, focusing on enhancing educational and research capacities and driving sustainable development and technological innovation.

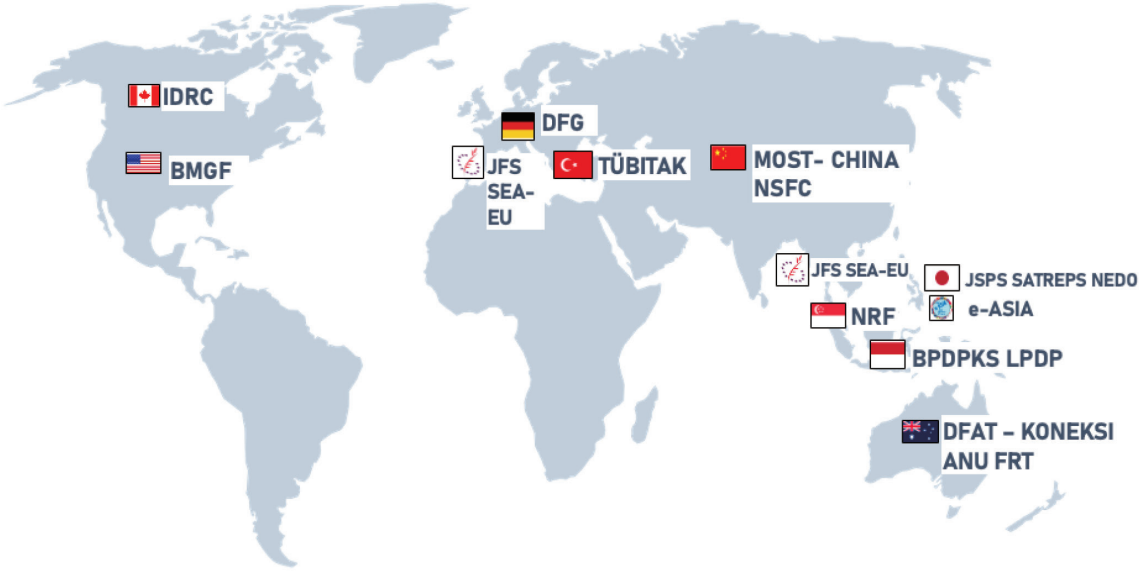


Figure 42 International cooperation of Indonesia with several major countries

Source: Sari (2024)

International cooperation and collaboration managed by DIPI

DIPI has actively engaged in bilateral cooperation initiatives with global research organizations to tackle critical issues. In 2016, DIPI partnered with MRC and RCUK for joint research calls funded by the Newton Fund and

supported by LPDP, focusing on tropical infectious diseases and environmental challenges, including climate change. These projects, spanning two to three years each, demonstrate DIPI's role in managing impactful international research, including overseeing five funded projects and contributing to major initiatives like the SEA-EU JFS from 2018 to 2022 and the 2020 DIPI-LPDP joint call in health, advanced materials, and marine sciences (DIPI, 2022).

Other international cooperation and collaboration

Research collaboration in Indonesia, supported by international donors, has propelled numerous key projects (Annex 10.2). Based on Elsevier Data 2024, various grants were awarded to Indonesia from 2013 to 2022. Among these, notable initiatives like the The Global Challenge Research Fund (GCRF) Action Against Stunting Hub and the GCRF Trade, Development, and Environment Hub, funded by the UK's Medical Research Council and Economic and Social Research Council, respectively, target crucial areas such as nutrition and environmental sustainability. This collaboration highlights the significant impact of foreign funding on addressing Indonesia's pressing challenges.

Various global sources contribute to Indonesia's research landscape, with significant support from the European Union's Horizon 2020 Framework Programme and the Australian Research Council (ARC) through initiatives like EGI-Engage and ARC Discovery Projects. These efforts underline the international scope and collaborative nature of research funding that drives scientific progress in Indonesia across multiple disciplines, including health, environment, and trade.

The influence of foreign-funded research extends to policy-making and societal development in Indonesia, with projects like the UK-Indonesian Consortium to Identify Biomarkers for Dengue Disease and financial planning for natural disasters funded by the Medical Research Council and the Natural Environment Research Council, respectively. These collaborations advance scientific innovation and enhance public health outcomes and disaster resilience, demonstrating the broad and beneficial impact of international research partnerships on Indonesian society.

4.4.2 Current Status of International Cooperation and Joint Research with Japan

Indonesia's collaboration with Japan through the e-ASIA Joint Research Program (e-ASIA JRP) has effectively addressed critical areas like environmental protection, material science, and innovative technologies. Recent initiatives include the 2023 focus on ecological research, the 2021 emphasis on advanced materials using computer technology, and prior calls spanning water resource management, marine science, alternative energy, and disaster risk reduction.

The Japan Society for the Promotion of Science (JSPS) is critical in facilitating academic exchanges, with projects under the SATREPS and NEDO enhancing sustainable development efforts. Moreover, Japan's involvement in the Joint Funding Scheme between Southeast Asia and the EU (SEA-EU JFS) expands the scope of collaborative efforts, reflecting a robust and dynamic partnership (Sari, 2024).

The SATREPS program has significantly advanced collaborative research between Japan and Indonesia, engaging both government bodies and higher education institutions. This initiative spans diverse fields, including microbiology, chemistry, and catalysis, focusing on sustainable development and innovation. Additionally, NEDO has enhanced international cooperation, particularly in technology, through initiatives like Kaizen, which has improved productivity and industrial practices globally (Jin, 2018).

Looking ahead, Japan aims to deepen research ties with Indonesia and ASEAN, focusing on environment, energy, bioresources, and health through the SATREPS and SICORP programs, with projects like the Joint Laboratory for

Biological Resources and Biodiversity at BRIN, which aims to develop tropical biological resources using advanced biomass techniques (JASTIP, 2024).

Further cementing the partnership, Japan supports human resource development, hosting 58,478 Indonesian nationals under the Technical Intern Training Program and 25,337 under the Specified Skilled Worker system, making Indonesians the second-largest group in Japan after Vietnamese (MOFA, 2023). This commitment extends to sectors such as fisheries and caregiving, enhancing the skillset of Indonesian workers in Japan and fostering mutual cultural and professional respect.

Indonesia is a significant contributor to the international student population in Japan, with 4,709 students enrolled in Japanese higher education institutions, ranking fifth globally and first in government-sponsored students. In response to Japan's goal to host 400,000 international students by 2033, ASEAN, including Indonesia, is a priority in Japan's educational exchange policies. Programs like the "*Asia KAKEHASHI Project+(Plus)*" and the "*Sakura Science Exchange Program*" facilitate youth exchanges, enhancing academic and cultural ties between the two nations (MOFA, 2023).

Japan has been a steadfast supporter of study abroad programs for Indonesian officials since 1991, a testament to our enduring commitment to fostering international cooperation. This support has benefited approximately 3,000 administrative personnel through degree programs and practical training. Recent collaborations include the establishment of a joint research office between Akita University and Trisakti University, as well as capacity-building initiatives with Indonesia's government ministries aimed at boosting manufacturing productivity. Furthermore, Japan actively promotes cultural and interfaith understanding through programs involving Islamic boarding school teachers, with the aim of fostering pluralistic coexistence and expanding these efforts in the future (MOFA, 2023).

4.4.3 Other International agreements between top universities and international cooperation programmes of funding agencies

Indonesia strengthens its research capabilities through international collaborations, such as the Indonesia-Korea NRF Joint Research Program with the National Research Foundation of Korea, enhancing knowledge exchange and fostering joint projects across various academic fields. These initiatives promote collective efforts to tackle global challenges and advance scientific understanding. Building on this, partnerships within the APAC (Asia-Pasific) region, like the collaboration with the Australian Research Council from 2013 to 2020, have resulted in 16 grants for projects addressing critical issues such as food security, environmental conservation, and education, demonstrating Indonesia's commitment to collaborative research.

Leading Indonesian universities like IPB, ITB, UI, and UGM are at the forefront of these international efforts. Their dedication extends beyond national borders, actively engaging with renowned international bodies secure funding for impactful projects, as they are likely presented in Table 12. For example, ITB's projects, such as "*A Systems Analysis Approach to Reduce Plastic Waste in Indonesian Societies (PISCES)*", focus on analyzing socio-economic drivers of plastic use and finding systemic waste reduction solutions. Similarly, UGM and UI are deeply involved in public health and disaster preparedness projects, with UGM developing strategies for malaria prevention in young children and UI working on improving public health outcomes through nutrition and disease treatment projects.

IPB's dedication to environmental and agricultural challenges is evident in projects like "*Towards a Fire Early Warning System for Indonesia (ToFEWSI)*" and initiatives promoting sustainable agriculture practices in the palm

oil industry. These collaborative efforts with global partners highlight IPB's role in addressing climate change and supporting agricultural sustainability, reaffirming its commitment to impactful international research.

Table 10 Top universities' research projects and their funding body from 2013-2023

Entity	Project Research	Funding Body	Year
ITB	EGI-Engage. Engaging the EGI Community towards an Open Science Commons	Horizon 2020 Framework Programme	2015
ITB	ENGAGE. Exploring National and Global Actions to reduce Greenhouse gas Emissions	Horizon 2020 Framework Programme	2019
ITB	A Systems Analysis Approach to Reduce Plastic Waste in Indonesian Societies (PISCES)	Natural Environment Research Council	2021
ITB	Cool Infrastructures: Life With Heat in the Off-Grid City	Economic and Social Research Council	2020
ITB	Factors affecting childhood exposures to urban particulates (FACE-UP)	Medical Research Council	2021
ITB	Discovery Projects award	Australian Research Council	2022
ITB	Urban hybriD models for AiR pollution exposure Assessment (UDARA)	Natural Environment Research Council	2017
ITB	Linkage Projects award	Australian Research Council	2014
ITB	Towards a Fire Early Warning System for Indonesia (ToFEWSI)	Natural Environment Research Council	2017
ITB	Discovery Projects award	Australian Research Council	2014
ITB	Newton RCUK-SEA -- Capacity Building in STEM to ensure sustainable community development and a successful astronomical observatory in Timor	Science and Technology Facilities Council	2017
UGM	ARC Future Fellowships award	Australian Research Council	2020
UGM	Linkage Projects award	Australian Research Council	2018
UGM	Linkage Projects award	Australian Research Council	2022
UGM	Discovery Projects award	Australian Research Council	2020
UGM	Linkage Projects award	Australian Research Council	2022
UGM	Discovery Projects award	Australian Research Council	2017
UGM	Reducing malaria morbidity and mortality in early life in an area co-endemic for falciparum and vivax malaria.	Wellcome Trust	2013
UGM	Discovery Projects award	Australian Research Council	2020
UI	GCRF Action against Stunting Hub	Medical Research Council	2019
UI	Two-month Regimens Using Novel Combinations to Augment Treatment Effectiveness for drug-sensitive Tuberculosis: the "TRUNCATE-TB" trial	Medical Research Council	2014
UI	BuildERS. Building European Communities' Resilience and Social Capital	Horizon 2020 Framework Programme	2019

UI	High Dose Oral Rifampicin to Improve Survival from Adult TB Meningitis - (HARVEST) Trial	Medical Research Council	2019
UI	Making health financing work for the poor: An evaluation of equity in health systems financing in Indonesia	Medical Research Council	2017
UI	RESilient Emergency Preparedness for Natural Disaster Response through Operational Research(RESPOND-OR)	Engineering and Physical Sciences Research Council	2019
UI	ARC Future Fellowships award	Australian Research Council	2014
UI	UK-Indonesian Consortium to Identify Biomarkers Predictive of Dengue Disease Severity.	Medical Research Council	2017
UI	Discovery Projects award	Australian Research Council	2013
UI	Improving diagnosis of brain infections in Indonesia using novel and established molecular diagnostic tools.	Medical Research Council	2019
UI	Cathelicidins As Novel Therapeutic Antivirals For Dengue Infection	Medical Research Council	2019
UI	Improving Community Resilience and Sustainability Through Operational Research Capacity Building in Southeast Asia (CREST-OR)	Engineering and Physical Sciences Research Council	2020
UI	Point of care tests in the diagnosis of chronic and allergic aspergillosis	Medical Research Council	2019
UI	Development of serology diagnosis of chronic aspergillosis and histoplasmosis in Indonesia	Medical Research Council	2017
UI	Discovery Projects award	Australian Research Council	2018
UI	Discovery Projects award	Australian Research Council	2017
UI	Exploring the potential of civic engagement to strengthen mental health systems in Indonesia.	Medical Research Council	2017
IPB	NDC ASPECTS. Assessing Sectoral Perspectives on Climate Transitions to support the Global Stocktake and subsequent NDCs	Horizon 2020 Framework Programme	2021
IPB	Towards a Fire Early Warning System for Indonesia (ToFEWSI)	Natural Environment Research Council	2017
IPB	Ecological management to benefit ecosystem services and sustainable production in smallholder oil palm systems in Malaysia and Indonesia	Biotechnology and Biological Sciences Research Council	2020

4.5 Key Institutions and Personnel Involved in Basic Research

4.5.1 Major Institutions and Prominent Researchers and the Indonesian Alumni Association (PERSADA)

Major Institutions and Prominent Researchers Based on National Research Priority (PRN)

The PRN program for 2020-2024 has awarded significant funding to a consortium of researchers and institutions in Indonesia, guided by BRIN's decision No. 78/II.7/HK/2022. This funding supports projects across nine critical areas, including food, energy, health, and more, detailed in Table 18 to Table 25 in Annex 10.3, showcasing a broad

commitment to advancing Indonesia's research capabilities in key sectors.

In the food sector, research under PRN 2020-2024 is spearheaded by figures like Roni Ridwan and Wahyuni from BRIN, who focus on agricultural enhancements such as cattle nutrition and chilli fruit nutrition, respectively. This research, primarily conducted at BRIN, signifies its crucial role in rural advancements with support from other institutions like IPB, enhancing crop yields and livestock productivity through innovative breeding and cultivation techniques.

The energy theme sees researchers like Semuel Pati Senda and Latifa Hanum Lalasari from BRIN leading projects on biogas technology and lithium battery development. These initiatives are crucial for Indonesia's energy sustainability, involving multiple universities like UI and Universitas Sebelas Maret, who contribute to broader energy solutions, including pyrolysis and gasification technologies.

Health-focused research includes initiatives by Eriawan Rismana and Nandang Suhendra from BRIN, who work on synthesizing paracetamol and developing hip arthroplasty technologies, respectively. Tutik Wresdiyati from IPB University is working on the development of standardised herbal medicines for diabetes and hypercholesterolemia. This sector benefits from the contributions of various academic institutions, highlighting collaborative efforts towards enhancing medical technologies and healthcare outcomes in Indonesia.

Transportation research is dynamically led by BRIN's Wimpie Agoeng and Noegroho Aspar, focusing on infrastructure technologies such as the Structural Health Monitoring System for Railroad Bridges. This area also includes innovations like floater designs for aircraft from Sayuti Syamsuar and Triyono from Universitas Sebelas Maret, which are dedicated to revolutionising Indonesian fast train wall manufacturing through integrated extrusion. This illustrates a comprehensive approach to improving transportation technologies and infrastructure.

Engineering research under the PRN is directed by BRIN's Dany Perwita Sari and Hanif Yuliani, pioneering earthquake-resistant construction techniques. Their efforts are complemented by institutions like ITB, which contributes to engineering innovations such as automated face recognition systems, showcasing a robust engineering research environment in Indonesia.

In defence and security, researchers like Rika Andiarti and Bambang Setiadi from BRIN are enhancing national security through projects like developing advanced rocket technology to develop Rhan 450 defence rockets with a flying range of 100 km and radar systems. These initiatives are crucial for bolstering Indonesia's defence capabilities through innovative research and technology.

Maritime research, led by Budi Saksono and Heri Purwoto from BRIN, focuses on developing functional food products from marine resources like seaweed, highlighting sustainable approaches to health and nutrition. This theme is supported by broader projects at institutions like UGM, which advance maritime research and development.

In the humanities, researchers such as Agus Eko Nugroho and R. Siti Zuhro from BRIN address societal challenges through policy research on disaster risk management and regional autonomy. These efforts are supported by academic projects at UGM and UI, which explore community management and cultural preservation, aiming to strengthen societal structures and cultural heritage.

Lastly, multidisciplinary research is tackled by figures like Suyadi and Arif Nurkanto from BRIN, who focus on environmental conservation and public health improvements such as mangrove restoration and food technology to combat stunting. This wide-ranging research involves institutions like ITB and Universitas Brawijaya, emphasizing collaborative efforts to address complex societal challenges through integrated research approaches.

These diverse research projects under the PRN program advance scientific knowledge and foster collaborative

innovation across various domains, positioning Indonesia as a leader in addressing national and global challenges through research.

Major Institutions and Prominent Researchers Based on SDG Targets

In Indonesia, the most impactful research institutions contributing to the SDGs are a mix of leading universities and notable non-academic entities, as depicted in (Figure 43). In contrast, Figure 14 discusses the top institutions based on scholarly outputs. CIFOR, for instance, is a standout, ranking a commendable second for its pivotal role in forestry management and poverty reduction, aligning with SDGs 13 and 15.

The Ministry of Health, a formidable player, is ranked fourth, making significant contributions to health policy and SDG 3. The Eijkman Institute for Molecular Biology, a key player in infectious disease research, is ranked tenth, enhancing health-focused scholarly outputs and contributing to SDG 3. These diverse institutions each bring unique and significant contributions to achieving the SDGs through their high-quality, influential research.

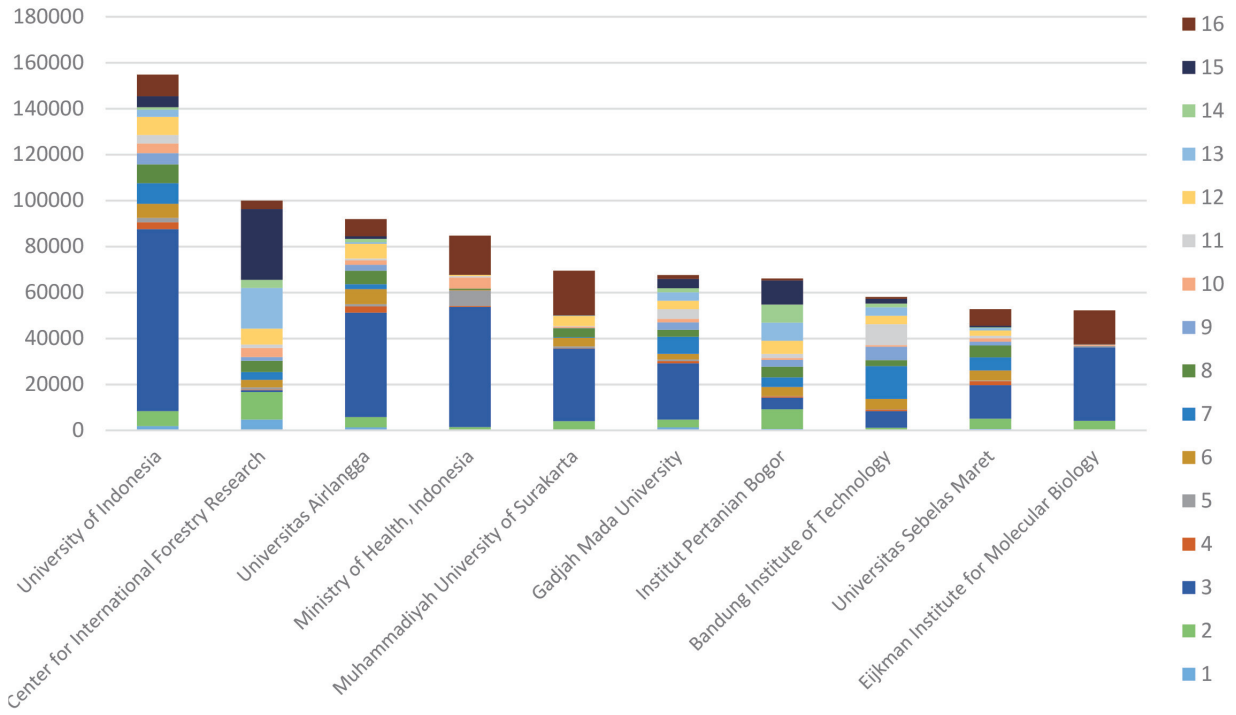


Figure 43 The top 10 institutions based on citations and its breakdown by SDG targets

Beyond the institutions driving impactful research, individual researchers play a crucial role in advancing the SDGs in Indonesia. This section highlights three distinguished researchers in Indonesia, each an expert in fields relevant to specific SDG targets (Table 11). Their extensive scholarly work and contributions significantly impact their disciplines and influence broader policy and practice, demonstrating their dedication to addressing global challenges. Through their innovative research, these individuals push the boundaries of knowledge and contribute to shaping a sustainable future for Indonesia and the wider world.

Table 11 List of Top 3 Indonesian Authors Contributing to each SDG

SDG	Author	Affiliation	Citation Count
1	Dartanto, Teguh	UI	353
1	Yuda, Tauchid Komara	UGM	117
1	Laksono, Agung Dwi	BRIN	115
2	Buchori, Damayanti	IPB	1168
2	Irham, Irham	UGM	95
2	Hadju, Veni	Universitas Hasanuddin	73
3	Alisjahbana, Bachti	Padjadjaran University	2429
3	Harapan, Harapan H.	Universitas Syiah Kuala	6697
3	Pranata, Raymond	Pelita Harapan University	4039
4	Santoso, Harry B.	UI	460
4	Samsudin, Achmad	Indonesia University of Education	529
4	Serevina, Vina	State University of Jakarta	28
5	Januraga, Pande Putu	Universitas Udayana	182
5	Merati, Tuti Parwati	Universitas Udayana	220
5	Efendi, Ferry	Universitas Airlangga	168
6	Kusworo, Tutuk Djoko	Universitas Diponegoro	869
6	Moersidik, Setyo Sarwanto	UI	151
6	Sudarno, Sudarno	Universitas Diponegoro	119
7	Purwanto, Agus	Universitas Sebelas Maret	745
7	Ambarita, Himsar	University of North Sumatra	708
7	Ashari, Mochamad	Institut Teknologi Sepuluh Nopember	334
8	Berawi, Mohammed Ali	UI	128
8	Majid, M. Shabri Abd	Universitas Syiah Kuala	125
8	Sukono, null	Padjadjaran University	83
9	Berawi, Mohammed Ali	UI	551
9	Sutopo, Wahyudi	Universitas Sebelas Maret	158
9	Sasmoko, Sasmoko	Bina Nusantara University	360
10	Kosen, Soewarta	Independent Consultant	6607
10	Trinugroho, Irwan	Universitas Sebelas Maret	321
10	Esquivias, Miguel Angel	Universitas Airlangga	207
11	Widiyantoro, S.	ITB	648
11	Meilano, Irwan	ITB	476
11	Irsyam, Masyhur	ITB	523
12	Budihardjo, Mochamad Arief	Universitas Diponegoro	316

12	Herdiansyah, Herdis	UI	127
12	Latief, Yusuf	UI	127
13	Murdiyarso, Daniel	IPB	4182
13	Moeliono, Moira M.M.	CIFOR	502
13	Nasruddin, Nasruddin	UI	248
14	Jompa, Jamaluddin J.	Universitas Hasanuddin	1734
14	Wardiatno, Yusli	IPB	473
14	Anggoro, Sutrisno Pramudyo	Universitas Diponegoro	308
15	Prasetyo, Lilik Budi	IPB	323
15	Imron, Muhammad A.	UGM	525
15	Fa, J. E.	CIFOR	1456
16	Sensuse, Dana Indra	UI	177
16	Hidayanto, Achmad Nizar	UI	327
16	Nurmandi, Achmad	Muhammadiyah University of Yogyakarta	136

To name a few examples, Dr. Teguh Dartanto, Dean of the Faculty of Economics and Business at Universitas Indonesia, significantly impacts SDG 1 with 17 scholarly publications and 353 citations, highlighting his role in poverty reduction and social protection policy development. Professor Damayanti Buchori of Institut Pertanian Bogor, addressing SDG 2, advances sustainable agriculture and biological control methods through her extensive research output and high citation count, contributing to global efforts against hunger.

At the Bandung Institute of Technology, researcher S. Widiyantoro focuses on SDG 11 with 57 publications and 648 citations, reflecting the influence of his work on urban sustainability. His research on sustainable cities is recognized for impacting regional and international practices, driving the agenda for sustainable urban development. Together, these academics exemplify the vital contributions of individual researchers to advancing the SDGs in Indonesia through influential and policy-shaping scholarly work.

Prominent Indonesian Researcher on Selected Institutions

From 2013 to 2022, data from SciVal (Table 12), highlights leading Indonesian researchers across top universities and BRIN. At BRIN, Ahmad Fudholi stands out with 35 publications and an h-index of 35, supported by notable researchers like Muhammad Adly Rahandi Lubis and Widya Fatriasari. IPB's Anuraga Jayanegara leads in agricultural sciences with 193 outputs and an h-index of 28. ITB's Achmad Munir and Trio Adiono, along with UGM's Abdul Rohman, who has 284 outputs and an h-index of 36, and UI's Achmad Nizar Hidayanto, are prominent figures in their fields, significantly contributing to academic advancements and research in Indonesia.

Table 12 Prominent Indonesian researchers on selected institutions

Institution	Name	Scholarly Output	h-index
BRIN	Fudholi, Ahmad	35	35
BRIN	Lubis, Muhammad Adly Rahandi	23	23
BRIN	Fatriasari, Widya	22	20
BRIN	Laksono, Agung Dwi	21	17
BRIN	Kurniawan, Edi	17	9
BRIN	Sitorus, Agustami	17	8
BRIN	Septama, Abdi Wira	15	12
BRIN	Windarsih, Anjar	15	14
BRIN	Prakosa, Jalu A.	15	8
BRIN	Handayani, Murni	14	11
IPB	Jayanegara, Anuraga	193	28
IPB	Wardiatno, Yusli	129	18
IPB	Irzaman, I.	120	14
IPB	Prasetyo, Lilik Budi	116	12
IPB	Kusmana, Cecep	110	13
IPB	Batubara, Irmanida I.	109	18
IPB	Sumantri, Cece	106	16
IPB	Marimin, Marimin	106	15
IPB	Siregar, Iskandar Zulkarnaen	101	13
IPB	Madduppa, Hawis H.	98	18
ITB	Munir, Achmad	376	17
ITB	Adiono, Trio	210	17
ITB	Yuliarto, Brian	205	37
ITB	Suwarno, Suwarno	194	23
ITB	Khairurrijal, Khairurrijal	191	28
ITB	Wenten, I. G.	163	38
ITB	Nugraha, Andri Dian	156	18
ITB	Khayam, Umar	155	16
ITB	Widiyantoro, S.	150	29
ITB	Iskandar, Ferry	148	46
UGM	Rohman, Abdul	284	36
UGM	Nugroho, Hanung Adi	233	19
UGM	Triyana, Kuwat	153	27
UGM	Rochmadi, Rochmadi	142	18

UGM	Nugroho, Lukito Edi	141	14
UGM	Adji, Teguh Bharata	138	14
UGM	Hidayat, Risanuri	130	14
UGM	Budiman, Arief	128	19
UGM	Setiawan, Noor Akhmad	126	13
UGM	Cahyadi, Adha Imam	115	18
UI	Hidayanto, Achmad Nizar	375	21
UI	Sensuse, Dana Indra	243	14
UI	Latief, Yusuf	181	10
UI	Nasruddin, Nasruddin	181	23
UI	Sari, R. F.	171	16
UI	Sahlan, Muhamad	168	19
UI	Gozan, Misri	159	17
UI	Hermansyah, Heri D.	158	16
UI	Saleh, Rosari	158	22
UI	Santoso, Harry B.	157	17

Prominent Researchers of Indonesian Alumni Studied in Japan (PERSADA)

PERSADA (*Perhimpunan Alumni dari Jepang*/Japanese Alumni Association), funded by governmental and private scholarships, serves as a significant platform for Indonesian students and trainees, integrating with the ASEAN Council of Japan Alumni (ASCOJA) to foster regional collaborations. With 17 regional offices across Indonesia and a Tokyo branch, PERSADA partners with organizations like the Harmony Centre and the International Youth Association of Japan to conduct programs such as the Indonesian-Japanese Youth Exchange and the Japan Education Fair in Jakarta. These initiatives enhance educational and cultural exchanges, promoting advanced studies and reinforcing the ties between Indonesia and Japan, as evidenced by their broad, inclusive approach to engaging alumni across various disciplines.

Indonesian alumni who attended Japanese universities, a source of immense pride for us, have made significant contributions to science and development in Indonesia and Japanese universities, as shown in Table 15. Professors Laksana Tri Handoko and Edvin Aldrian, for instance, have held influential roles such as the IPCC WGI Vice Chair and have been instrumental in advancing climate science in Indonesia. Other notable alumni, such as Prof. Dr. Arif Satri and Prof. Dr. Mukhamad Najib, have enhanced academic leadership within Indonesia. Internationally, Indonesian scientists like Prof. Brian Yuliarto and Dr. Warsito Purwo Taruno are recognized among the top global researchers for their innovations in industrial technology and inventions like Electrical Capacitance Volume Tomography, demonstrating the significant global impact of Indonesian researchers trained in Japan.

4.5.2 Main Trends of Young Indonesian Students Education and Study Abroad

Indonesia, home to over 52 million students and 250,000 schools, is exploring the educational dynamics and trends in studying abroad among its youth, which is crucial for advancing its Science, Technology, and Innovation (STI) sectors (World Bank, 2023a). This analysis delves into Indonesia's educational landscape, focusing on how various educational pathways, both domestic and international, are preparing the future workforce, particularly in Basic Research. The analysis covers educational attainment, outbound mobility ratios, and scholarship opportunities to understand Indonesia's strategic positioning in the global science and technology fields, highlighting the role of its youth in driving these advancements.

In Indonesia, secondary education includes SMA (*Sekolah Menengah Atas/* general high schools) and SMK (*Sekolah Menengah Kejuruan/* vocational high schools), each under the Ministry of Education, Culture, Research, and Technology. SMKs are designed to provide vocational and technical training, preparing students for immediate employment in specific industries, reflecting a significant shift in the balance between general and vocational education in recent years (Figure 44). This dual-track system is integral to Indonesia's strategy to enhance its technological and vocational workforce, aligning with national economic and industrial development goals.

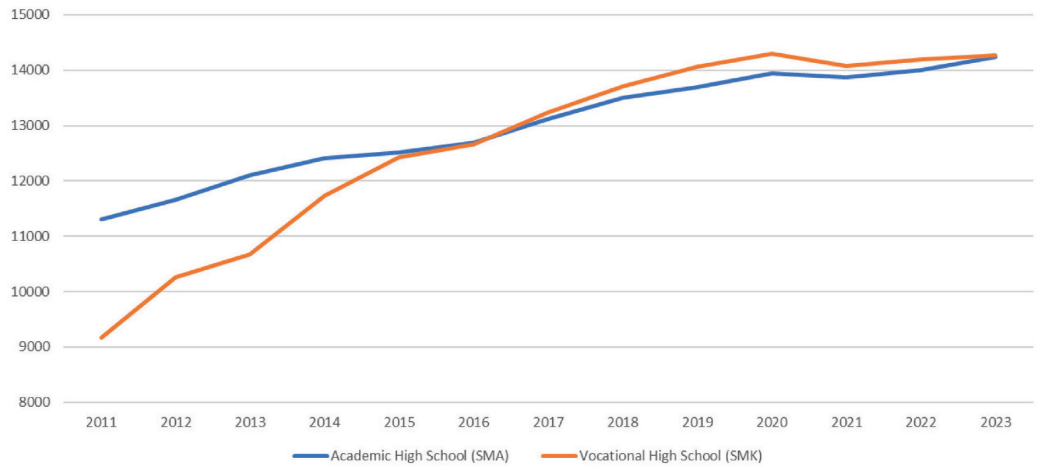


Figure 44 Comparison of SMA and SMK in Indonesia (Kemendikbud)

Historically, general high schools (SMA) outnumbered vocational high schools (SMK) in Indonesia. Still, this trend shifted around 2017 due to the government's Revitalisasi SMK program, outlined in Presidential Instruction No. 9 of 2016. This initiative aims to enhance vocational education quality and competitiveness, responding to job market demands. As of 2023, the rise in SMKs, primarily operated by private entities, reflects a significant engagement in private sector education, with 74.11% of vocational schools being private *(Statistik Persekolahan SMK 2022/2023*, 2023). This statistic underscores the prevalence of private entities in providing vocational education nationwide.

The student demographic in SMKs reveals a notable gender imbalance, with a higher male enrolment, particularly in fields like Information and Communication Technology and Engineering Figure 45. This trend contributes to Indonesia having the lowest percentage of women in the tech industry in the region at 22%, compared to neighbouring countries such as Thailand (42%), the Philippines (35%), and Singapore (41%), highlighting a significant area for

potential gender inclusion improvement (Chew, 2023).

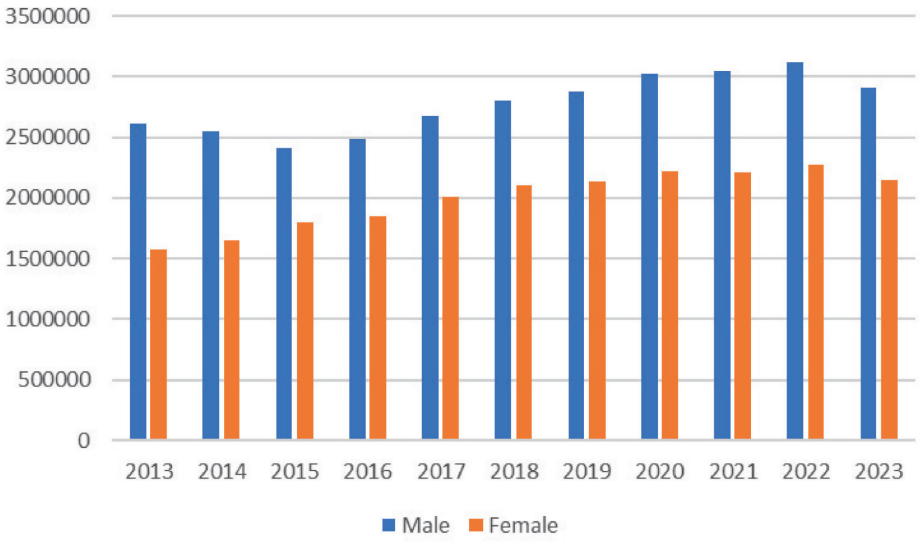


Figure 45 Number of vocational high school students based on gender

Looking one step further from SMA and SMK, Figure 46 illustrates the historical trends in the Gross Enrolment Ratio (GER) for Indonesian education. It indicates the ratio of total enrolment, regardless of age, to the population of the age group officially designated for each educational level.

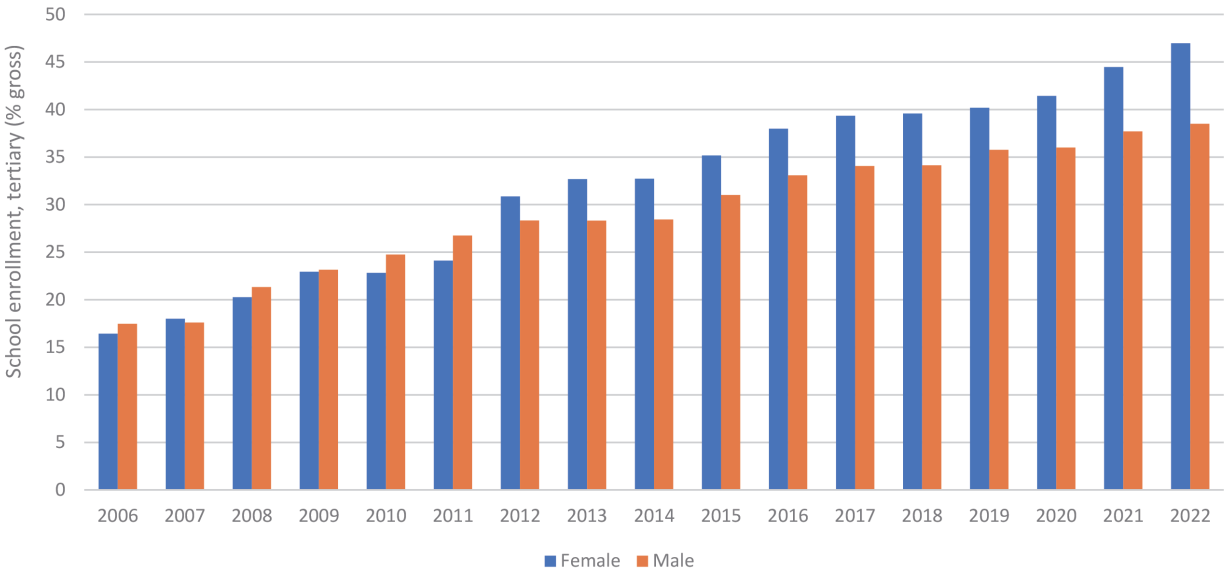


Figure 46 Percentage of gross school enrolment, male and female, tertiary 2006-2022

Over the years, tertiary education enrollments in Indonesia have seen a consistent rise for both genders, with male enrollment increasing from just over 20% in 2006 to around 45% by 2022, while female enrollment started at a similar

level but surpassed males annually, reaching just under 50% by 2022. This trend indicates a narrowing gender gap in tertiary education, with females consistently outpacing males in recent years. Indonesia's emphasis on enhancing secondary education quality to boost human capital competitiveness, mainly focusing on equal access for men and women to tertiary education, has likely facilitated increased female participation in higher education (Qurniawan & Jasmina, 2021). Despite these positive trends, the overall GER for tertiary education in Indonesia remains comparatively low. It has increased by 20% from 2002 to 2017, resulting in a GER of 36.3%, which is lower than neighboring countries like Malaysia (42%) and Thailand (49.3%) (Dilas et al., 2019).

However, the fluctuating government expenditure on tertiary education, as depicted in Figure 47 raises concerns. It shows varying investment levels across several ASEAN countries from 2007 to 2018, highlighting the financial commitments and challenges in further enhancing tertiary education access and quality in Indonesia. This situation calls for a more consistent and increased government investment in tertiary education.

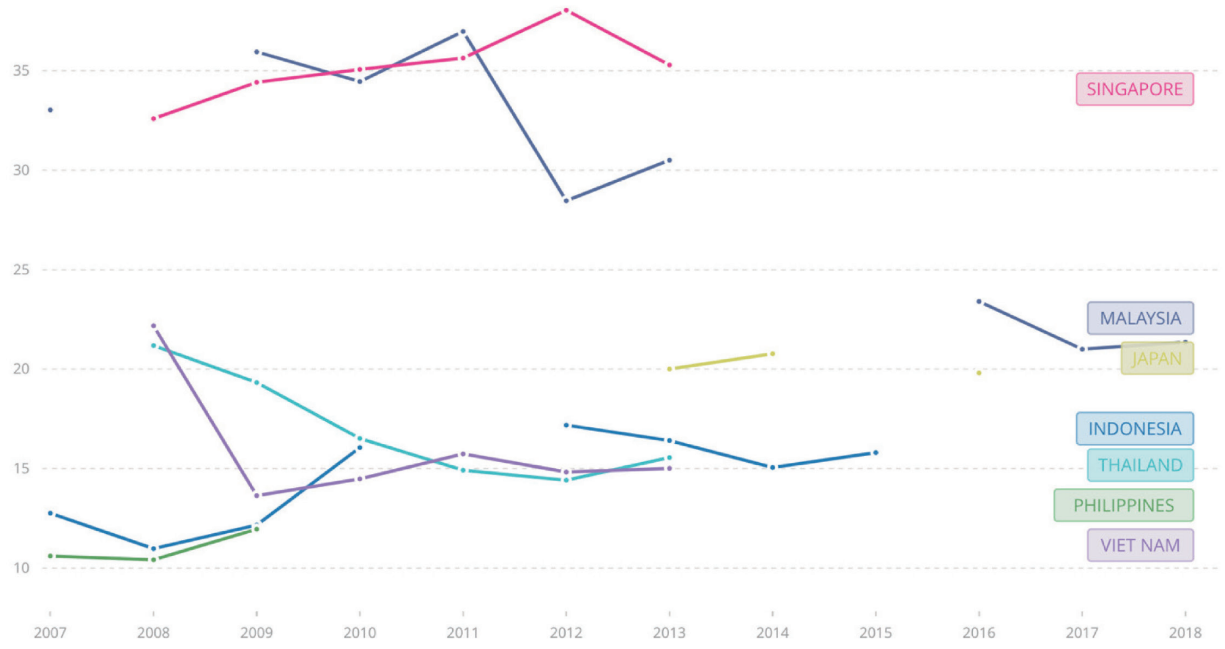


Figure 47 Government expenditure on tertiary education in South East Asian countries 2007-2018

In 2007, Indonesia's investment in tertiary education was relatively low at 13% of total educational spending, trailing behind neighbours like Singapore (33%) and Thailand (21%) (World Bank, 2020). Over the years, while expenditure on tertiary education in Indonesia has shown volatility, it remains a smaller portion of the overall educational budget, suggesting competition with other academic priorities despite a commitment to higher education.

In contrast, in 2021, the Indonesian government allocated approximately IDR120 trillion (about US$8 billion) to its education endowment fund, focusing significantly on scholarships for local and overseas studies (Yamin, 2022). This is modest compared to Japan's ¥10 trillion (US$82 billion) fund initiated in 2022 to foster innovation and education (Lewis, 2022). reflecting different scales of investment in human capital development relative to national populations.

Indonesia has been emphasizing "inclusivity" in its educational strategy by expanding the LPDP to cover

scholarships not just for graduate studies but also for undergraduate students, including specific programs for diverse groups such as armed forces, police, civil servants, students from Eastern Indonesia, women in STEM, and those from underdeveloped regions (3T areas). This approach aims to broaden access to higher education and research opportunities, ensuring a diverse academic and professional advancement representation. This inclusive strategy contrasts with Singapore's targeted enrolment of top high school students into premier universities, showcasing Indonesia's broader commitment to enhancing educational and research opportunities across various societal segments (KEMENDIKBUDRISTEK and LPDP).

In addition, Figure 48 shows the 2017 Outbound Mobility Ratio for ASEAN countries, indicating the percentage of students studying abroad relative to total tertiary education enrolment at home.

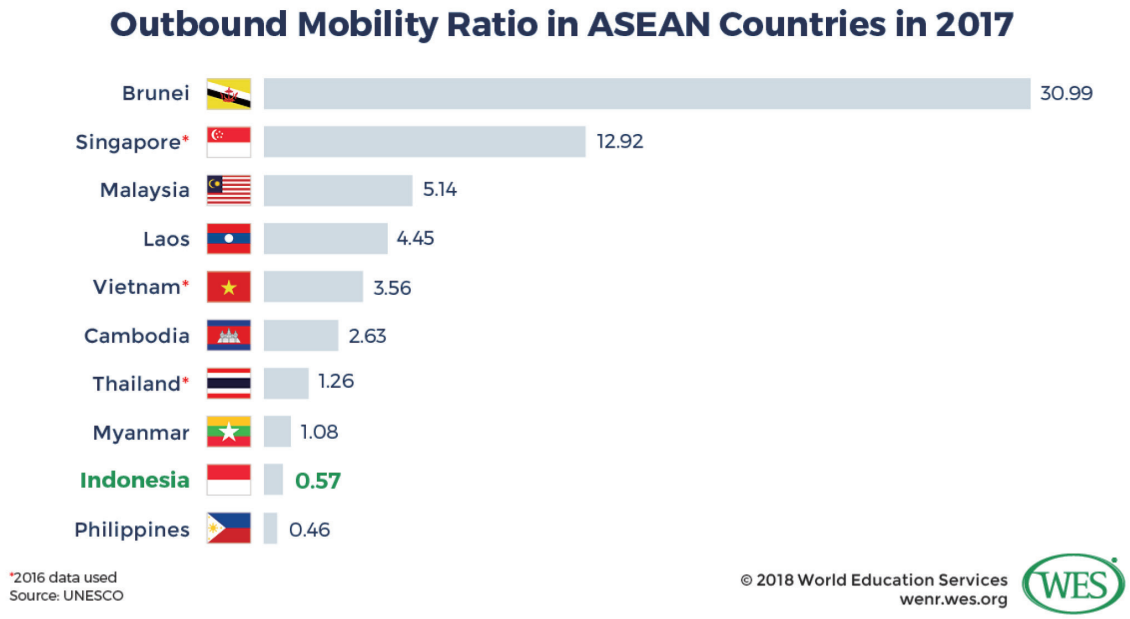


Figure 48 Outbound Mobility Ratio in ASEAN Countries in 2017

Source: Dilas et al. (2019)

In 2017, Indonesia's Outbound Mobility Ratio was 0.57, one of the lowest in ASEAN, reflecting the minimal percentage of Indonesian tertiary students studying abroad. Despite this, UNESCO data shows a 62% increase from 1998 to 2016 in Indonesian students enrolling in bachelor's programs abroad, totalling 47,317 in 2016. While 81% of Indonesian respondents consider studying abroad driven by a desire for skill enhancement and higher-quality education, substantial economic constraints may limit this potential. Government initiatives like the LPDP scholarship program, which has supported 35,536 scholars since its inception, highlight efforts to bolster international education, with 45.41% attending foreign universities in 2022.

The low outbound mobility ratio may not signify poor educational quality but a solid domestic educational infrastructure or financial and cultural barriers to studying abroad. From 2006 to 2016, university enrolment in Indonesia surged by 68%, with nearly 3.7 million to 6.1 million people increasing (Dilas et al., 2019). However, public universities could only accommodate 18% of high school graduates in 2010, pushing more middle-class students to consider overseas education. The demand for higher education continues to exceed the local supply, prompting a significant portion of the population to look abroad for opportunities.

The primary destinations for Indonesian students abroad include Australia, Malaysia, the US, Egypt, Japan, the UK, and Germany, accounting for over 60% of the total number of students studying abroad. (Figure 49). Australia remains a top choice due to its proximity, quality of education, and English-language instruction, with student numbers growing 29.5% from 2008 to 2018 (Figure 50). Japan attracts students with its renowned education system, safety, and government efforts to increase international student numbers through scholarships and supportive university services (EduAll, 2023). These trends illustrate Indonesian students' challenges and aspirations in the

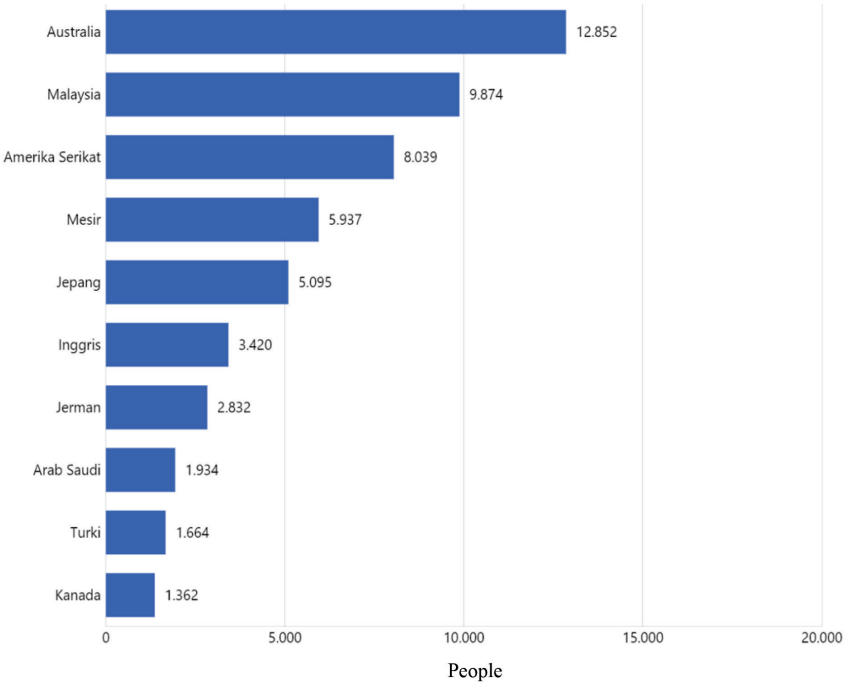


Figure 49 Top 10 Destination Countries of Indonesian Degree-Seeking Students in 2020

Source: Katadata (2023)

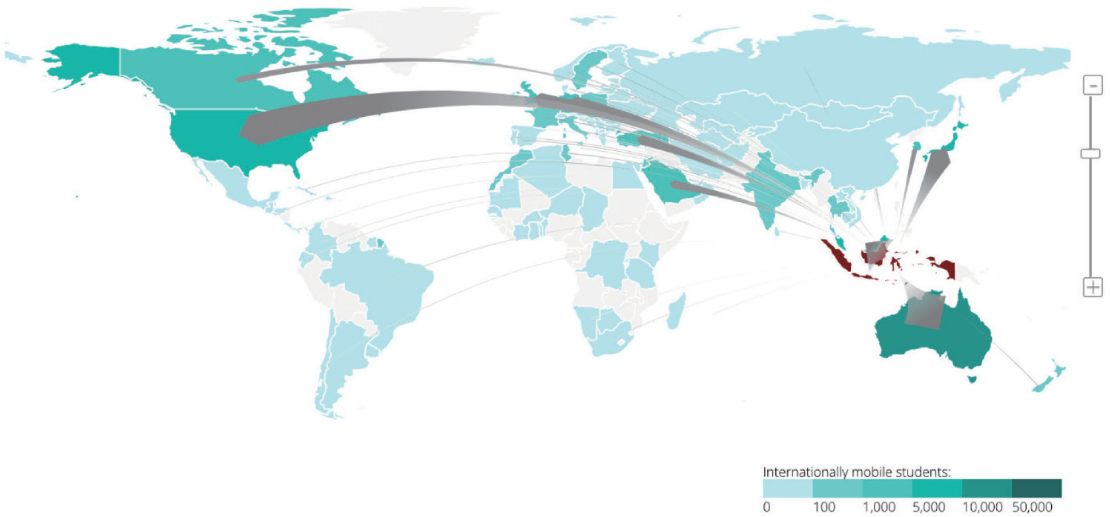


Figure 50 Global Flow of Tertiary-Level Indonesia Students

Source: UNESCO Institute for Statistics (2023)

global educational landscape.

This overview of Indonesia's educational system shows changing gender dynamics in vocational education, rising tertiary enrolments, and complex government funding. The increase in students studying abroad highlights the global aspirations of Indonesian youth, which is crucial for the research industry. Despite challenges, Indonesia's commitment to improving education domestically and internationally remains strong as it seeks to meet the demands of its growing population.

5 Research Findings from FGDs and Interviews

This study's reliance on interviews is due to the limited official data. Indonesian research institutions such as BRIN and universities like IPB, UGM, UI, and ITB are pivotal in the research ecosystem, enhancing potential STI collaborations with Japan. Here, our study aims to enrich the analysis with expert insights for a comprehensive evaluation. Mutual engagements including expanded scholarships and business collaborations are crucial for advancing Indonesian-Japanese research partnerships in advanced STI. The breakdown of interviewees is shown in Annex 10.4 and comprises experts from diverse backgrounds, ranging from university researchers to policy makers and business researchers.

5.1 FGD and Interview Survey Methodology

The interview survey methodology, encompassing FGD and individual interviews, were conducted to fill gaps in official data, capturing expert insights not found in public sources. This approach ensures comprehensive stakeholder engagement, providing relevant data to assess Indonesia's R&D status, challenges, and future directions. The study will conduct a comprehensive FGD involving approximately 50 participants in Bogor in January 30, 2024, exploring perspectives from policy actors, scholars, R&D funders, academia, and the private sector. Individual interviews will target stakeholders actively involved in Indonesia's STI sectors, delving into details like R&D budgets and the qualifications of researchers. These discussions are intended to align with the study's framework and the Japan Science and Technology Agency (JST) objectives, providing crucial data to enhance Japan-Indonesia technical cooperation.

This approach allows the exploration of various R&D dimensions and adaptation to emerging research needs. Specifically, the study seeks to:

(1) Assess the status and future directions of R&D and innovation in Indonesia,

(2) Identify critical focus areas, challenges, and opportunities within Indonesian R&D,

(3) Offer insights to help stakeholders align strategies and foster effective collaborations,

(4) Improve understanding of regional R&D dynamics and gatheing information for promoting collaborations between Indonesia and other Asia-Pacific countries, including Japan.

FGD and stakeholder interviews engage key figures in structured discussions to gather in-depth views on Indonesia's R&D landscape. Stakeholder perspectives are broadly categorized into regulators and recipients, focusing on:

(1) Overview of Indonesia's science and technology capabilities,

(2) Major science and technology policies and organizations,

(3) Trends in basic research and development, and

(4) Implications for Japan-Indonesia science and technology cooperation.

The stakeholder interview process is critical for grasping Indonesia's scientific and technological capabilities, key policies, research trends, and the implications for Japan-Indonesia cooperation. This process starts with formulating

comprehensive questions on Indonesia's scientific strengths, policies, and collaborative efforts with Japan. Stakeholder mapping then identifies key participants, including government officials, policymakers, academic researchers, and industry experts, categorizing them based on their relevance, influence, and potential contributions. After mapping, formal and personalized communication with stakeholders is established, ensuring clarity and respect. This process often requires flexibility in scheduling.

Interviews are conducted using the Delphi method, a structured forecasting technique that anonymously involves multiple rounds of expert questionnaires to refine and achieve consensus on the issues discussed (Zartha Sossa et al., 2019). The process aims to refine responses towards consensus, distilling discourse without being influenced by authoritative voices.

Participants include stakeholders from universities, government research institutes, funding agencies, and private research entities, as detailed in Table 26 in the Annex. Seventeen stakeholders from 13 organizations were interviewed and expected to provide complete or partial responses. Labelling is an effective method for categorizing and explaining interview results, especially in complex fields like science and technology.

Responses are organized and categorized according to the labelling format shown in Figure 51, facilitating practical data analysis and linking diverse perspectives. This method identifies consensus or disagreement among stakeholders, enhancing the understanding of critical issues. Labelling simplifies data and provides deeper insights, maximizing the value of the information collected.

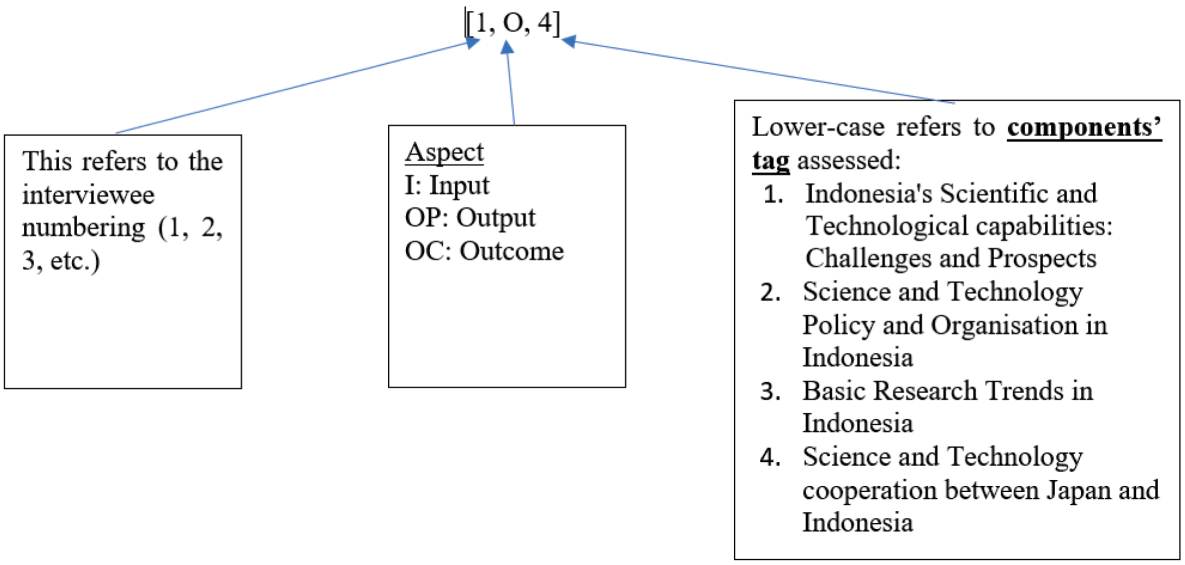


Figure 51 FGD and Stakeholder Interview Identification Code

FGD and individual interviews have revealed several common grounds among stakeholders and underlying challenges in promoting science, technology and innovation. The R&D budget is often restrictive and requires enhanced support shown in the policy recommendation. Furthermore, deficit of the comprehension in STI, systematic roadmap for fostering human resources, and decent regulatory governance prevent R&D environment from further development. To tackle these issues, it is necessary to introduce integrated procurement approach and enhancement of academia-industry-government collaboration in pursuit of increasing societal impact in R&D.

5.2 Key Barriers and Challenges for Science and Technology Policies and Organizations

In Indonesia's STI sector, developing a competitive industry ecosystem is crucial to fostering innovation. Establishing a corruption-free environment with inclusive and streamlined processes for industry engagement is essential for aligning research with industry demands, leading to effective outcomes. However, challenges like resource misallocation due to limited demand or flawed strategies can hinder the development of impactful R&D initiatives. In this context, strategic resource management emerges as a powerful tool that can prevent resource misallocation and ensure effective outcomes, thereby highlighting its importance [4, I, 2].

Additionally, enacting Law No. 11 of 2019, which reorganized research management and governance, has led to inefficiencies and debates over the optimal structure for R&D oversight. [3, OP, 1]. *Tingkat Komponen Dalam Negeri*/ Domestic Component Level (TKDN) regulations in Indonesia, designed to promote local manufacturing, often get bogged down in administrative procedures, reducing their effectiveness. For TKDN to truly benefit local production, it needs integration with local manufacturing capabilities and supportive policies for impactful funding in licensing and commercialization, ensuring research aligns with industry needs for practical and marketable outcomes [5, OC, 3].

In Indonesia's STI sector, the role of BRIN is crucial, and it is recommended that it operate on a demand-driven research model that aligns closely with national needs and priorities, ensuring research is relevant and impactful. Establishing clear, strategic directions for research priorities is vital, with well-defined targets and scopes that align with national development goals and society's pressing needs. For Indonesia's STI sector to effectively contribute to national development, challenges such as ensuring continuity in policy, focusing comprehensively on crucial R&D pillars, and addressing limited funding must be strategically tackled. This approach will enhance the efficacy and impact of R&D efforts nationwide [10 & 12, I, 2].

Indonesia's STI legal framework has been revamped with the enactment of Law No. 11 of 2019, updating the previous law and establishing a solid foundation for the country's STI governance, with key players including BRIN, KEMENDIKBUDRISTEK, and BAPPENAS. The anticipated government regulation (PP) under development aims to provide clear implementation guidelines for STI policies, which is crucial for advancing R&D in Indonesia [1, I, 2]. Despite these efforts, industry engagement and optimal use of resources and incentives require enhanced focus. Additionally, R&D in Indonesia often prioritizes administrative over substantive research activities, prompting researchers to seek collaborations outside national borders for less bureaucratically hindered opportunities. Funding programs like RIIM (Riset Inovasi Indonesia Maju) face delays that hinder research progress. [6, I, 1]. At the same time, university offices like KUI (Kantor Urusan Internasional/International Affairs Office) offer vital support in accessing international and national funding, highlighting the complex dynamics influencing R&D activities in Indonesia.

As a pivotal organization in Indonesia, BRIN is poised to lead transformational changes in the R&D sector, driving research that is both practical and aligned with national development needs. Positive trends such as improved remuneration for STEM professionals and expanded international educational opportunities are expected to significantly influence the future direction and impact of R&D in Indonesia. [10, OP, 3]. Yet, BRIN also faces challenges in managing its resources effectively to increase job satisfaction and efficiency, shifting from focusing on quantitative targets to emphasizing the real-world impact of research projects [10, I, 2].

During the first session of the JST FGD on January 30th, 2024, discussions focused on the intricacies of science

and technology policy in Indonesia, particularly the role of BRIN. Overall, the session featured presentations from AIPI, BAPPENAS, BRIN, KEMENDIKBUDRISTEK, and DIPI, covering topics such as including unstable funding, the absence of a cohesive research roadmap, regulatory hurdles in data collection, and the need for enhanced industry collaboration. These issues underscore the critical need for a comprehensive approach to bolster the research ecosystem, ensuring adequate data utilization and fostering stronger industry ties to translate research into tangible economic benefits. Critical discussions from the JST FGD also emphasized the need for progressive policies to nurture talent and strengthen international collaborations to leverage global expertise. Recommendations include expanding scholarship programs, enhancing industry collaborations through initiatives like matching funds, and establishing joint research centres with international partners to improve research outcomes and innovation in renewable energy and disaster resilience.

5.3 Enhancement of R&D budget and development of funding

Only about 10% of the 1.5 trillion IDR annual R&D budget in Indonesia is allocated to the industry sector. The government facilitates matching programs between universities and industries to foster idea exchange. Yet, university interest in BRIN's funding schemes remains low due to the lack of support for laboratories, materials, or equipment, unlike previous support from institutions like LIPI. Internationally, collaboration efforts include the SIMATEK consortium, with initiatives like the Netherlands contributing 9.5 billion IDR for a livestock project with a university, demonstrating the potential for joint or independent funding from international agencies [6, I, 3].

The LPDP administers extensive research funding in Indonesia, including native and collaborative programs with entities like BRIN, managing selection and evaluation. At the same time, the LPDP provides substantial investment funds exceeding 13 trillion IDR. Universities access a mix of funding sources, from internal budgets to international consortiums, with LPDP focusing on development-oriented research and open to philanthropic contributions, such as from the Bill & Melinda Gates Foundation, and corporate social responsibility initiatives from companies like PT SMI [8, I, 1]. This complex funding landscape supports a broad spectrum of research necessary for Indonesia's advancement in STI despite challenges like protracted funding processes and the need for more comprehensive support beyond financial grants [6, I, 2].

In Indonesia, a diverse range of funding sources from national and international bodies supports R&D. The Directorate General of Higher Education (DIKTI) and the BRIN provide substantial external funding, often guided by data from the LPDP. This includes ad hoc government grants from BAPPENAS aligned with Indonesia's development goals and specialized funding for student research through programs like PKM [7, I, 1].

Non-schematic research in Indonesia involves collaborative projects not reliant on regular funding, partnering with institutions like Bank Indonesia and Japanese entities. For example, a university may host up to 24 research centres under its Research and Innovation Institute (LRI), with faculties managing funds to support specific research needs such as sample analysis. Like the Daiwong funding scheme, corporate collaborations also facilitate joint projects between universities and companies. Combining regular and flexible sources, this diverse funding approach supports a broad spectrum of research activities, enhancing academic research and industry-academia collaboration to transform research into practical innovations [12, I, 3].

Internally, universities offer competitive grants to nurture young researchers, while international funds such as Erasmus enhance research capabilities. [7, OP, 1]. The Directorate of Research (DRI) within universities manages

both schematic, regular funding from sources like KEMENDIKBUDRISTEK, and non-schematic initiatives such as the RISPRO competition and the RIIM program funded by LPDP but managed by BRIN. These efforts underscore the dynamic approach to fostering research and innovation across Indonesia's academic sector [11, I, 1].

Institutions like BRIN and its predecessor, BPPT, in Indonesia's STI field exhibit contrasting funding approaches influencing R&D perceptions. BPPT employed a top-down method, aligning research with government roadmaps and needs, such as those of the Ministry of Energy and Mineral Resources, ensuring relevance to specific governmental goals. Conversely, BRIN adopts a more flexible, bottom-up approach, granting researchers greater autonomy in topic selection without strictly adhering to government-defined research themes. While offering flexibility, this method on the whole results in fewer amount of research funds for existing recipients and more inclusive calls of research proposals, as allocations are based on varying criteria not solely tied to government priorities, allowing for a broader exploration of scientific inquiries [10, I, 1].

In Indonesia, there is a significant call for research funds to be strategically aligned to meet national needs and produce measurable impacts, with a push for more precise guidelines to conduct effective research. Personal experiences, like those navigating the RISPRO funding landscape, illustrate the broader challenges of securing and utilizing funds within the STI field. The distinct approaches of BPPT and BRIN, alongside calls for more integrated research efforts, reflect the desire to optimize research directions and effectiveness in Indonesia. [10, I, 3].

5.4 Nurturing STI Talents and Building Up their Career Paths

Indonesia lacks a cohesive grand design for human resources development in STI, leading to inefficiencies and missed opportunities compared to countries like Malaysia, which invests significantly in education. [2, I, 1]. This deficiency results in a disconnect between STI policy and practical research activities, compounded by bureaucratic inefficiencies and rigid funding structures. The need for a national grand design was also stressed in Indonesia's STI landscape to establish clear research focus areas lacking structure. [2 & 10, I, 1]. A more integrated approach is needed to align research lab activities with national STI objectives and streamline funding and administrative processes to enhance research effectiveness.

Global benchmarks suggest a country should invest about 2% of its GDP in R&D and maintain at least 2% of its population as researchers to contribute to national development effectively. [3, OP, 3]. In Indonesia, however, comprehensive data on researchers is lacking, as the BPS (Statistics Indonesia) primarily tracks the population based on education levels and employment status rather than specific details on researchers [9, OP, 3].

In the STEM field, underemphasis and low enrollment rates (24.33%, see also 2.1.2) reflect a disparity between national focus and global trends despite recent incentives to attract more graduates into STEM careers. (Kemendikbudristek, 2020). This situation highlights the ongoing challenges in developing a skilled STEM workforce to meet industry needs [12, I, 2].

Improving working conditions for researchers, especiallly, improving researcher remuneration in basic science is vital to attracting and retaining talent, enabling researchers to focus on pioneering work without financial concerns. Addressing productivity pressure with low remuneration requires a comprehensive approach, including policy reform and enhancing research infrastructure to strengthen Indonesia's R&D environment [6, I, 3]. In Indonesia, universities receive internal funding mainly for new and doctoral lecturers, providing 20-75 million IDR annually, alongside 'hibah fakultas' grants offering 15-30 million IDR. External sources, such as Hibah Bima, require a SINTA (Science

and Technology Index) score for eligibility, focusing on research and dedication projects. Additionally, 'Kedai Reka,' facilitated by KEMENDIKBUDRISTEK [6, I, 1], supports industry-academia collaboration, splitting funding 50:50 and allowing lecturers to showcase projects for industry bidding, potentially reaching up to 10 billion IDR. However, the reimbursement model used by Kedaireka presents challenges in funding access for researchers.

Issues like the consistent concentration of top universities in Java and challenges faced by early-stage startups indicate underlying equity and support gaps in the educational and entrepreneurial ecosystem, suggesting the need for targeted initiatives to address these disparities.

Compared to countries like Japan and South Korea, where researchers enjoy higher quality of life and job security, Indonesian researchers face multiple challenges, including insufficient policy alignment, funding flexibility, and quality of life, highlighting the need for comprehensive reforms to enhance the STI sector and make research careers more fulfilling and stable in Indonesia [3,4, I, 3].However, R&D execution faces challenges due to its management primarily by non-full-time government staff rather than professionals, slows progress. The innovation in fields like astronomy highlights a transition to practical applications. Funding constraints are notable, with the R&D budget from the APBN being relatively small. It was initially proposed at 24 trillion IDR but was reduced to 7 trillion IDR, about 0.08-0.1% of the GDP. LPDP allocates a significant portion of its funds to scholarships, with less than 10% directed towards research, reflecting a broader issue of underinvestment in R&D from public and industry sources [3, 1, 3].

5.5 Fragmented Data landscape of STI Talents and Human Resource Management

In Indonesia's STI sector, the fragmented data landscape presents a challenge in understanding the full spectrum of PhD holders and researchers, as information is spread across various institutions like universities, the Ministry of Education, and BRIN [3, OP, 3]. Despite available data on platforms like DIPI, there's a lack of clarity in categorizing roles within the R&D field, such as planners, researchers, and engineers, which complicates the management of human resources. Many PhD holders are still not employed in their areas of expertise, indicating a significant underutilization of qualified personnel. This situation also implies the need for better data integration and its utilization that leads to strengthening Indonesia's R&D capabilities [2, OP, 3].

In Indonesia's STI sector, in leveraging human capital effectively for R&D, researchers, particularly those in government roles, may lack managerial capabilities, which poses a challenge [1, I, 1]. Improving data collection and categorization and developing strategies to utilize better and enhance the skills of PhD holders and researchers is crucial. A comprehensive database of researchers would enable informed policymaking, strategic resource allocation, and effective planning, helping to identify investment priorities and promote collaboration across academia, industry, and government.

5.6 patent and commercialization of basic research

Moreover, in the domain of patents, Indonesia confronts significant challenges in the accessibility and management of patent data. Universities play a pivotal role in supporting the patent process from submission to commercialization. Despite concerted efforts to boost patent activity, WIPO has flagged Indonesia for falling below the minimum threshold (around 12%) for local patents. This reflects a broader issue in translating the increasing number of patents

into commercial successes. It underscores the pressing need for improved systems for patent accessibility and a more strategic approach to commercializing innovations to enhance their practical implementation [11, OP, 3].

In Indonesia, the patent system struggles with development and scaling, mainly due to the gap between registration and practical application in industry or business, under the jurisdiction of KEMENKUMHAM. Student programs like the Creativity Program/Program Kreativitas Mahasiswa (PKM) often end without transitioning projects to further development or commercialization, limiting the potential for student innovations to become sustainable ventures. [4, OP, 1].Despite efforts to enhance industry-academia connectivity and funding schemes to facilitate product testing and market application, challenges persist in transforming research into successful business solutions [11, OP, 3].

5.7 Basic Research Trends and Investment Status and Expectations

Indonesia invests only 0.1% of its GDP in R&D, one of Southeast Asia's lowest rates, and BRIN predominantly uses it. Challenges like market failures and corruption hinder additional investment, affecting STEM opportunities and resulting in low postgraduate rates in these fields. Despite diverse funding sources, the combined governmental and industrial investment remains insufficient for significant research advancements, underscoring the need for a more robust R&D environment and balanced funding strategies. [4, I, 3].

In Indonesia, R&D funding comes from public sources like the APBN and private contributions, with BAPPENAS overseeing the budgeting process. Currently, R&D investment is at 0.9% of the national budget, with intentions for increase (Figure 3).

BRIN plays a pivotal role by offering tax deductions to industries engaging in research, encouraging international partnerships, and implementing top-up mechanisms to support researchers, alongside promoting postdoctoral opportunities to broaden the scope and impact of Indonesian research [8, I, 1]. Despite these tax incentives, there is a noticeable lack of engagement from the corporate sector, which hinders the innovation. Bridging the gap between academic research and commercial start-up ventures, as potential products of domestic research, is essential to fostering economic growth and technological advancement in Indonesia [5, I, 2].

Efforts to recognize and incentivize research through awards and an integrated research administration system managed by BRIN are in place. [13, I, 1]. BRIN aims to streamline research processes and enhance collaborations by separating administrative tasks in the future, indicating a move towards more effective research funding and management strategies.

In Indonesia, the distinction between budgeting and financing for R&D is crucial. Budgeting often includes allocations from local and national sources such as Bappeda Litbang (Regional Development Planning Agency for Research and Development). At the same time, financing involves specific R&D support from donor agencies like LPDP and BPDPKS (Palm Oil Funding Agency). Public funds are mainly provided by KEMENDIKBUDRISTEK, with significant contributions from LPDP and BRIN overseeing research activities. Various ministries and international agencies like USAID support R&D, with additional private financing from corporations and bank scholarships. [2, I, 1].

Indonesia's STI sector is challenged by a focus on research quantity over quality, driven by regulatory incentives, which often leads to research with limited innovative value. The venture capital ecosystem is underdeveloped, constraining the growth of startups outside the e-commerce sector. [4, OP, 3]. Examples like Gojek and Tokopedia,

which achieved success through international venture capital, illustrate the potential and challenges Indonesian entrepreneurs face. A stronger focus on supporting diverse sectors beyond e-commerce and enhancing venture capital availability is essential for nurturing innovation and advancing the country's STI field [3 & 4, OC, 3].

5.8 Enhancing international cooperation through participation in international funding programs

There is a critical need to bolster basic science in Indonesia as it underpins sustainable development and innovation amidst concerns that applied science may become quickly outdated. As a means of enhancement, it is important to promote international cooperation through participation in renowned international funding programs. Enhancing basic science can be supported by improved policy directions that facilitate knowledge exchange, such as incorporating training components in significant projects like the Indonesia-China bullet train (KCIC), which can significantly enhance workforce skills and experience [7, OC, 4].

International agreements, such as the Korea-Indonesia Science and Technology Cooperation (KOSKO) pact, are also pivotal in enhancing technological capacities. Collaborating with technologically advanced nations like South Korea benefits from knowledge transfer and the building of local expertise. Including provisions for Principal Investigators (PIs) fosters technology acquisition and local capability development. [2, 3, 5 & 12, I, 1].

Securing international funding is challenging for Indonesia, a middle-income country often ineligible for grants targeted at lower-income nations, limiting research financing and collaboration opportunities. BAPPENAS aims to raise research budget allocations to 1% of GDP. The per-researcher allocation remains low despite an overall research budget of about 30 trillion IDR. While substantial, the LPDP funding limits initial investments and sample analyses. Still, there's consensus that more than just government funding will be needed to boost innovation. A more effective strategy is proposed with a 40:60 government-to-industry funding balance to drive technological advancement [4, I, 1].

5.9 Utilization of Science and Technology to contribute to solving societal issues

Based on UNDP (United Nation Development Program) definition, Civil Society Organizations (CSOs) are voluntary organizations with governance and direction coming from citizens or constituency members, without significant government-controlled participation or representation. In Indonesia, CSOs involved in R&D face significant challenges, primarily due to difficulties in obtaining formal recognition. This impacts their eligibility for government funding and jeopardizes their financial sustainability. This situation forces them to rely heavily on fluctuating external donations to cover operational costs, including staff salaries. [1, I, 1]. Additionally, the current funding landscape in Indonesia is highly restrictive. Funds are often earmarked for specific projects without provision for broader activities essential for a robust R&D environment, such as policy dialogue and capacity building

In Indonesia, R&D challenges are significant, particularly for CSOs struggling with formal recognition and stable funding, leading to reliance on inconsistent external sources. This situation limits essential activities like policy dialogue and capacity building, restricting the development of the R&D sector and its societal impact. Furthermore, in the STI field, especially STEM, limited focus and opportunities for graduates, alongside regulatory hurdles, make research financially burdensome. Addressing these issues requires comprehensive reforms, including policy

adjustments, industry engagement, and a balanced focus on applied and fundamental sciences to enhance Indonesia's R&D effectiveness.

Furthermore, the limited understanding and prioritization of STI in Indonesia contribute to its underutilization in addressing societal issues such as poverty and inequality. This gap between STI policies and practical applications calls for a closer alignment of STI initiatives with national socio-economic challenges to enhance their societal impact. [1, I, 2].

UGM's KKN program integrates academic knowledge with community service, empowering society through student-led projects across Indonesia. Initiatives span diverse areas like tourism, poverty alleviation, UMKM development, medical interventions, and engineering solutions such as solar energy and disaster risk mitigation. These projects offer tangible benefits to communities while enhancing students' practical learning experiences. [6, OC, 1].

The KKN program lacks comprehensive data but plans a repository by 2025 to analyze its impact. Future research in Indonesia should align with global trends in AI, blue energy, medical advancements, agriculture, petrochemicals, animal husbandry. There's a push for Asian-centric social science research to ensure scientific progress resonates with cultural contexts and societal needs. [6, OP, 3]. Integrating these perspectives in balance alongside scientific advancements ensures that technology and science are culturally sensitive, socially relevant, and technically sound, grounding innovations in cultural understanding and societal needs for a holistic approach to research and innovation [6 & 7, I, 3].

6 Recommendations for Strengthening Science and Technology Cooperation between Japan and Indonesia

This chapter review the previous chapters and summarizes the current status and challenges of STI in Indonesia. On this basis, we suggest approaches to internal challenges and implications for strengthening cooperation with Japan, and overview its future opportunities.

6.1 Current Status and Trends in Indonesian STI Development

In Indonesia, while R&D investment has increased, it remains low compared to GDP, highlighting the need for more significant funding to spur innovation and economic growth. Bureaucratic inefficiencies and political interference complicate effective resource allocation.

In Indonesia, STI development is closely tied to the country's basic research funding policies. With institutions like BRIN and DIPI at the forefront, the allocation of IDR 10.51 trillion to BRIN and a total government research expenditure of IDR 11.74 trillion (0.06% of GDP) in 2022 reflects a strategic focus on enhancing research capabilities. However, this investment must meet the ideal 1% GDP target suggested by BRIN's head, signalling a need for increased funding to boost innovation. The establishment of DIPI's non-State Budget Research and Technology Endowment Fund offers competitive grants. Yet, its fluctuating budget highlights ongoing challenges in securing stable research financing.

Indonesia's STI development is guided by significant policies like the National System of Science and Technology Law (Sisnas Iptek Law), aiming to transition to a knowledge-based economy. The establishment of BRIN and the merger of educational and research ministries into KEMENDIKBUDRISTEK highlight efforts to strengthen the nation's STI framework. The creation of BRIN and the merger into KEMENDIKBUDRISTEK streamlined Indonesia's STI framework, aligning research with national and global priorities. However, the this restructuring introduces uncertainties regarding research funding distribution between these entities.

In terms of R&D output, number of research papers have increased and the Asia Share has also increased. However, since the citation has been fluctuated and few papers are published in high-impact top journals, disparity with the global research impact is considered as a challenge. A lack of collaboration between academia and industry has shown the necessity of strengthen ties with each other to promote commercialization and innovation in research.

Indonesia's rise in deep tech startups shows innovation potential, yet a gap exists in STI advancement. However, non-technological startups account for majority and little tech ventures implies room for diversity. Addressing underrepresentation in STEM through joint educational and research programs with Japanese institutions can enhance Indonesia's capacity in crucial scientific and technological areas.

Indonesia has updated its patent system to quicken patenting and boost investment, fostering innovation. Despite this progress, challenges persist with ASEAN's complex patent laws, language barriers, and the need for more substantial intellectual property rights to attract global companies.

Foreign researchers in Indonesia must secure research permits and visas as mandated by Government Regulation

No. 41 of 2006 and comply with local intellectual property and specimen transfer laws to foster international research collaboration.

Indonesia's STI development now emphasizes human capital and proficiency, aligning with President Widodo's goals and the Sisnas Iptek Law. This strategic positioning is based on the ambition of becoming a global leader by 2045, as is represented in the establishment of RIPIPTEK or presenting PRN 2020-2024 (*Prioritas Riset Nasional*). Strategies in human resources put emphasis on digital literacy in national education, professional education and human development. Under these goals, partnership among private companies, state-owned companies and educational institutions will increase opportunities of scholarship and internship.

6.2 A Strategic Approach towards the Solution to the Problems in Indonesia

Taking into account the above status quo and challenges in Indonesia, a strategic approach is needed in order to advance STI development in Indonesia:

1. Increase Research Funding: Aim to boost research investment to 1% of GDP to enhance support for innovation and technology development.
2. Enhance Collaboration between Research Institutions and Industries: Strengthen ties between research institutions and industries to promote the commercialization of research outcomes, spurring economic growth.
3. Improve Research Infrastructure: Invest in advanced research facilities to attract top talent and encourage innovation.
4. Establish Centres of Excellence: Focus expertise in critical areas like agriculture and health by creating specialized research centres, similar to the Joint Laboratory for Biological Resources with Japan.
5. Participation in international cooperation programs and expand Access to International Funding: Encourage participation in programs like the EU's Horizon Europe and the UK's GCRF to foster international collaboration.
6. Strengthen Intellectual Property Rights (IPR) Protection: Enhance the intellectual property framework to protect and incentivize researchers, attracting more foreign investment.
7. Develop Science Communication Platforms: ncrease the visibility and impact of research through dedicated platforms that engage policymakers, industry, and the public.

These strategies showcase how Indonesia can advance its socio-economic development and global competitiveness by fostering interdisciplinary initiatives, enhancing international collaborations, and improving technology commercialization.

Doing so will leverage basic research trends to significantly enhance Indonesia's STI landscape, positioning us as a global leader in science, technology, and innovation.

6.3 Challenges and Countermeasures in Indonesian-Japanese Science and Technology Cooperation

Challenges in Indonesian-Japanese science and technology cooperation include differing research priorities, where Japan focuses on innovation. At the same time, Indonesia addresses socio-economic needs, hindering alignment—both countries' bureaucratic inefficiencies and administrative barriers slow joint project initiation and execution. Additionally, compared with Japan's advanced facilities, Indonesia's limited institutional capacity and research infrastructure restrict Indonesia's ability to engage in high-impact research. These disparities and cumbersome regulatory frameworks make collaborative efforts less effective and limit Indonesia's potential to leverage emerging technologies for innovation.

Language and cultural differences challenge effective collaboration between Indonesian and Japanese researchers, leading to miscommunications that can hinder joint projects. Both countries should foster mutual understanding and streamline processes through strategic partnerships and capacity-building to bridge these gaps. Although Indonesia and Japan share values in many areas, including politics and society, and have historically enjoyed a long-standing history of friendly relations, the existence of these discrepancies could result in missed opportunity for cooperation.

Examples of science and technology cooperation between Indonesia and other countries include the following:

- The Bandung Institute of Technology (ITB) and the Netherlands-based Eijkman Institute have conducted interdisciplinary collaborative research combining engineering and biological sciences, resulting in the development of diagnostic tools for tropical diseases.
- The SATREPS program, a collaborative initiative between Japan's Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA), focuses on joint research in disaster mitigation and energy sustainability, contributing to strengthening Indonesia's global connectivity.
- Technology transfer initiatives, such as Gadjah Mada University's (UGM) collaboration with private companies to commercialize herbal medicines, serve as excellent examples of turning research outcomes into marketable products.

To further strengthen scientific and technological cooperation between Indonesia and Japan, several additional recommendations to strengthening Indonesia's STI capacity can be made:

1. Expanding Collaborative Research Platforms: Indonesia and Japan should consider establishing joint research centres or platforms that focus on specific areas of mutual interest, such as renewable energy, biotechnology, or information and communication technology. These platforms can serve as hubs for collaborative research projects, knowledge exchange, and capacity-building initiatives. By pooling resources and expertise, both countries can accelerate the development of innovative solutions to shared challenges.
2. Enhancing Academic and Researcher Mobility: Promoting the mobility of academics and researchers between Indonesia and Japan can foster stronger ties and facilitate knowledge transfer. Initiatives such as joint degree programs, research fellowships, and exchange visits can provide opportunities for Indonesian and Japanese researchers to collaborate more closely and learn from each other's experiences. This can also help Indonesian researchers gain exposure to Japan's advanced research environment and technological capabilities.
3. Leveraging Private Sector Engagement: Encouraging greater involvement of the private sector in R&D

collaboration can lead to more practical and market-driven outcomes. Indonesia and Japan can explore mechanisms to incentivize private companies to invest in joint research projects, technology transfer, and innovation. Public-private partnerships can also be a valuable tool for addressing industry-specific challenges and developing technologies that have commercial potential.

4. Strengthening Strategic Communication: Enhancing strategic partnerships and communication can help address challenges in Indonesia-Japan cooperation and promote socio-economic growth. Initiatives such as research centers, exchange programs, interdisciplinary projects, cultural exchanges, and language training programs can bridge research capacity gaps, improve communication, and strengthen collaboration.
5. Fostering a Culture of Innovation: To sustain long-term collaboration and strengthen STI cooperation, both Indonesia and Japan should focus on cultivating a culture of innovation within their respective countries. This involves not only investing in research and development but also promoting entrepreneurship, creativity, and risk-taking. Educational institutions and government policies should encourage critical thinking, problem-solving, and interdisciplinary approaches to research. By nurturing a vibrant innovation ecosystem, Indonesia and Japan can create a conducive environment for scientific and technological advancement.

By implementing these recommendations, Indonesia and Japan can further enhance their scientific and technological cooperation, leading to mutual benefits and contributing to global scientific progress.

7 Reference

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8 Annexe

8.1 Habibie Award Recipients and Their Affiliations

Table 13 Recipients of the Habibie Award and their Institutional Affiliations

Year	Field of expertise	Name	Affiliation
1999	Basic Science	Prof. Dr. Moehammad Barmawi	Bandung Institute of Technology
1999	Engineering Science	Dr. Ir. Dicky Rezady Munaf, MS, MSCE	Bandung Institute of Technology
2000	Basic Science	Prof. Moehaad Barmawi, PhD	Bandung Institute of Technology
2000	Engineering Science	DR. Ir. Dicky Rezadi Munaf, MS.MSCE	Bandung Institute of Technology
2001	Basic Science	Dr Terry Marl	University of Indonesia
2001	Engineering Science	Prof. Dr. Ir. Aryadi Soewono	Bandung Institute of Technology
2001	Social Sciences	Prof. Dr. Hj. Edi Sedyawati	University of Indonesia
2001	Cultural Sciences	Prof. Dr. Taufik Abdullah, APU	Gajah Mada University
2003	Basic Science	Prof. Dr. Bambang Hidayat	Bandung Institute of Technology
2003	Medical Science and Biotechnology	Prof. Dr. Sangkot Marzuki	Eijkman Institute for Molecular Biology
2003	Cultural Sciences	Prof. Dr. I Made Bandem	The Indonesian Institute of the Art
2004	Basic Science	Dr. Laksana Tri Handoko	National Research and Innovation Agency
2004	Engineering Science	Dr. Wilson Walery Wenas	Bandung Institute of Technology
2005	Basic Science	Prof. Dr. Djoko Tjahjono Iskandar	Bandung Institute of Technology
2005	Medical Science and Biotechnology	Prof. SjamsulArifinAchmad, B.Sc., Ph.D	Bandung Institute of Technology
2006	Basic Science	Freddy Perrnana Zen. M.S., M.Sc.. D.Sc	Bandung Institute of Technology
2006	Medical Science	Prof. DR. Dr. A_skandar Tjokroprawiro	Airlangga University
2006	Economics	DR. Thee Kian Wie	University of Indonesia
2007	Basic Science	Prof. Dr. Sri Widiyantoro	Bandung Institute of Technology
2007	Medical Science and Biotechnology	Prof. Dr. Elfin Yulinah Sukandar, Apt	Bandung Institute of Technology
2007	Social Sciences	Dr. H.C. Rosihan Anwar	Indonesian Journalists Association
2007	Cultural Sciences	Dr. H.C. Taufiq Ismail	Independent
2008	Basic Science	Drs. Jatra Supriatna, M.Sc. PhD	University of Indonesia
2008	Medical Science and Biotechnology	Dr. Herawati Sudoyo, MS., Ph.D	University of Indonesia

2008	Engineering Science	Dr. Bambang Widiyatmoko, M.Eng	National Research and Innovation Agency
2008	Cultural Sciences	Prof. Dr. Sardono W. Kusumo	Jakarta Institute of Arts
2009	Basic Science	Prof. Dr. Edi Tri Baskoro	Bandung Institute of Technology
2009	Engineering Science	Dr. Nurul Taufiqu Rochman	National Research and Innovation Agency
2009	Cultural Sciences	Ajip Rosidi	Independent
2010	Engineering Science	Dr.-Eng. Eniya Listiani Dewi, B.Eng., M.Eng	National Research and Innovation Agency
2010	Cultural Sciences	Prof. Dr. Adrian Bernard Lapian	National Research and Innovation Agency
2010	Harmonisation of Religious Life	Prof. Dr. Ahmad Syafii Maarif and Prof. Dr. Franz Magnis Suseno, SJ	Independent
2011	Basic Science	Prof. Dr. Soekarja Somadikarta	University of Indonesia
2011	Social Sciences	Prof. Dr. Ir. Sajogyo	IPB University
2012	Basic Science	Prof. H. Effendy, M.Pd., Ph.D	State University of Malang
2012	Medical science	Prof. DR. Dr.Teguh Santoro Sukamto	University of Indonesia
2013	Basic Science	Dr. Anto Sulaksono	University of Indonesia
2013	Medical Science and Biotechnology	Prof. Irwandi Jaswir	Universitas Islam Internasional Malaysia
2013	Engineering Science	Prof. Mohammad Nasikin	University of Indonesia
2013	Cultural Sciences	Prof. Abdul Hadi Wiji Muthari	Paramadina University
2014	Basic Science	Dr Eng Ferry Iskandar	Bandung Institute of Technology
2014	Engineering Science	Ahmad Agus Setiawan, ST, M.Sc, Ph.D	Gajah Mada University
2014	Social and Political Sciences	Prof. Dr. Salim Said	The Islamic University of Indonesia
2014	Cultural Sciences	Nobertus Riantiarno	Independent
2015	Engineering Science	Dr Eng Wisnu Jatmiko M.Kom	University of Indonesia
2015	Social Sciences	Prof Dr Nina Herlina, MS	Padjajaran University
2015	Cultural Sciences	Prof Emeritus Drs Abdul Djalil Pirous	Bandung Institute of Technology
2016	Basic Science	Prof. Hendra Gunawan, Ph.D	Bandung Institute of Technology
2016	Medical Science and Biotechnology	Raymond R. Tjandrawinata, Ph.D., M.S., M.B.A	Unika Atma Jaya
2016	Engineering Science	Prof. Ir. Tommy Firman, M.Sc., Ph.D.	Bandung Institute of Technology
2016	Cultural Sciences	Prof. Dr. Sapardi Djoko Damono	Independent
2017	Basic Science	Prof. Khairurrijal	Bandung Institute of Technology
2017	Engineering Science	Prof. Suryadi Ismadjiyang	Universitas Katolik Widya Mandala Surabaya
2017	Legal studies	Prof. Bagir Manan	Mahkamah Agung RI

2018	Basic Science	Prof. dr. Eng Mikrajuddin Abdullah	Bandung Institute of Technology
2018	Medical science	Prof. dr. Rovina Ruslami SpP, PhD	Padjajaran University
2018	Engineering Science	Prof dr Edvin Aldrian B. Eng, M.Sc	University of Indonesia
2019	Basic Science	Prof. Dr. Ivandini Tribidasari Anggraningrum	University of Indonesia
2019	Medical science	Prof. dr. Adi Utarini M.Sc. MPH, Ph.D.	Gajah Mada University
2019	Engineering Science	Prof. Dr. Ir. Tati Latifah Erawati Rajab	Bandung Institute of Technology
2019	Social and Political Sciences	Prof. Dr. Eko Prasojo, Mag.rer.publ.	University of Indonesia
2019	Cultural Sciences	Dr. (H.C) I Gusti Ngurah Putu Wijaya, S.H.	ISI Yogjakarta
2020	Basic Science	Prof. Dr. Euis Holisotan Hakim	Bandung Institute of Technology
2020	Basic Science	Dr. Suharyo Sumowidagdo	National Research and Innovation Agency
2020	Medical science	Dr. Puspita Lisdiyanti, M.Agr., Chem.	National Research and Innovation Agency
2020	Engineering Science	Prof. Dr. Ir. Daniel Murdiyarso, MS.	IPB University
2020	Cultural Sciences	Prof. Dr. Yasraf Amir Piliang, MA.	Bandung Institute of Technology
2021	Basic Science	Prof. Dr. Muhammad Hanafi, M.Sc	Pancasila University
2021	Medical Science and Biotechnology	Prof. dr. Nicolaas C. Budhiparama, Ph.D, Sp. OT(K)., FICS	Nicolaas Institute of Constructive Orthopaedic Research & Education Foundation
2021	Engineering Science	Prof. Dr. Ir. Subagjo, DEA	Bandung Institute of Technology
2021	Cultural Sciences	Dr. (HC) Nyoman Nuarta	Independent
2022	Basic Science	Prof. Dr. Ocky Karna Radjasa, M.Sc	National Research and Innovation Agency
2022	Medical Science and Biotechnology	Drg. Ika Dewi Ana, M.Kes., Ph.D	Gajah Mada University
2022	Engineering Science	Prof. Dr. Riri Fitri Sari, M.M., M.Sc	University of Indonesia
2022	Philosophy	Naufan Noordyanto, S. Sn., M.Sn	Sepuluh November Institute of Technology
2023	Philosophy	Prof. Dr. Oman Fathurahman, M.Hum	Syarif Hidayatullah State Islamic University Jakarta

8.2 Prominent Researcher and leading Institution based on the Research Project aligned with the PRN 2020-2024

Table 14 Leading research project focusing on 'Food', its prominent researcher, and institutions based on PRN

Title	Researcher	Institution
Development of Premix Combo in supplying nutritional nutritional needs of nutrigenomic to improve the immune system and the productivity of beef cattle seeds	Roni Ridwan	BRIN
Artificial Light Application to Increase Accumulation of Chili Fruit Nutrition Metabolites For the Development of New Superior Straits Chili with Productivity and High Nutrition	Wahyuni	BRIN
Assembly of rice varieties through radiation mutations to increase the productivity and resistance of pests and the main disease	Sobrizal	BRIN
Assembly of environmentally friendly probiotics to support national priorities for superior beef cattle	Windu Negara	BRIN
Improvisation and application of superior biological agent technology for controlling leaf blight disease in onion plants	Nur Laili	BRIN
Nano Formulation of Bioactive Bacterial Compounds to Prepare Palm Oil (Elaeis Guineensis Jack), which is resistant to Pathogen Ganoderma Boninense and Identification	Bedah Rupaedah	BRIN
Exploration of fatty acids from insects to increase the productivity and metabolism of beef cattle seeds	Ki Ageng Sarwono	BRIN
Development of National Standards for searching for oil palm seeds in the context of superior seed guarantee (further research)	Bambang Prasetya	BRIN
Technology Precision Cultivation of Biological Organic Fertiliser and Control of Plant Pending Organisms (OPT) through the Smart Farming System	Ikhsan Guswenrivo	BRIN
Superior microbial-based biostimulant agents to support the production of onions with potentially high yields and resistant salinity stress	Rumella Simarmata	BRIN
Land-based soil -based soil -based resistance to the resistance and systemic tolerant of shallots and garlic integrated with the Smart Agriculture Management System	Sarjiya Antonius	BRIN
Low-Density Polyethylene (LDPE) and High Fiber Low-Density Biodegradable Innovations and High Natural Fiber Powder to Support Cultivation of Chili Plant Precision	Firda Aulya Syamani	BRIN
Breeding Varieties of Sorghum Mutant Midrib Midrib for Livestock Feed in order to support the productivity of pogasi cattle	Teguh Wahyono	BRIN
Increasing the availability and commercialisation of 10 superior varieties and quality chilli seeds with 150% national average productivity	Awang Maharijaya	IPB
Provision and commercialisation of superior varieties of quality seeds (200% average national productivity) supported by environmentally friendly and sustainable production technology to increase the competitiveness of shallots	Sobir	IPB
Genetic mapping, development of molecular markers, and galai architectural gene introgression in an effort to assemble new types of rice varieties with high production	Miftahudin	IPB

Development of varieties and technology of Green Super Rice rice cultivation	Bambang Sapta Purwoko	IPB
An increase in the added value of Bali cows through cross-breeding with wagyu cattle to produce beef seeds producing premium meat	Jakarta	IPB
Beef cattle are graded through predictions of quality carcass quality with the development of ultrasonographic hybrid devices and electricity.	Mokhamad Fakhrul Ulum	IPB
Clonal propagation of superior palm oil planting material high production of saturated and unsaturated fatty acids from modern breeding with cisgenesis technology	Hayati Minarsih Iskandar	PT Riset Perkebunan Nusantara
Selection of growth nature, feed efficiency and resistance to DNA and Deep RNA Sequencing Marking Diseases to produce new seeds of superior chicken (Allope Chicken Channel)	Wempie Pakiding	Universitas Hasanuddin
The production of frozen cows in Bali is polled to support the production of superior beef cattle seeds/seeds.	Hasbi	Universitas Hasanuddin
The production of superior quality Bali polled cattle through modern biotechnology that is integrated from upstream to downstream based on participatory breeding.	Zulkharnaim	Universitas Hasanuddin
Biological fertiliser plus products and technology for high corn production and disease-resistant to dry land	Ali Ikhwan	Universitas Muhammadiyah Malang
High yield and multi-characterised rice assembly: genomic integration, soil characteristics, and microclimate using the GIS (Geographical Information System) approach	Nono Carsono	Universitas Padjadjaran

Table 15 Leading research project focusing on 'Energy,, its prominent researcher, and institutions based on PRN

Title	Researcher	Institution
Biogas Production Technology Innovation with Gas Mix Reactor	Semuel Pati Senda	BRIN
Research and Development Making Red and White Lithium Battery Raw Materials	Latifa Hanum Lalasari	BRIN
Passive Cooling Technology Innovation Based on Nanobubble Fluid and Nanofluids in Thermal Management Aspects for Improving the Safety of Large Types and SMR.	Mulya Juarsa	BRIN
Development of the technology of manufacturing the prototype of zirconium products as a support for the reactor structure	Kris Tri Basuki	BRIN
Loop Heat Pipe Prototype as a Passive Cooling System in Nuscale Reactor Pond Water	M. Hadi Kusuma	BRIN
PLTP Condensing Turbine Material Development in 2022 (2nd Year / Phase II)	Agus Hadi Santosa Wargadipura	BRIN
Development of PLTN Simulator Type of SMR PWR	Syaiful Bakhri	BRIN
Extraction Technology Nickel-Mangan-Cobalt (NMC) compounds from Indonesian laterite nickel ores and industrial waste (urban mining) as lithium-nickel battery precursors with selective and environmentally friendly methods	Widi Astuti	BRIN
Human Factors Study on Operations and Design of Main Main Modular Reactor Control Room	Sigit Santoso	BRIN

Study of Tsunami Threat Potential Studies and Mitigation With Detailed Data from Sumber Mulak Scenarios on Gosong Beach, West Kalimantan Province	Widjo Kongko	BRIN
Analysis and modelling of dispersion and radiation consequences for the development of the PWR-100mwe prototype of accident conditions are postulated in the candidate for Gosong Beach, Sungai Raya District, Bengkayang Regency, West Kalimantan.	Muhammad Budi Setiawan	BRIN
The catalytic reaction of used cooking oil into diesel fuel (green diesel) using a clay-based catalyst	Robert Ronal Widjaya	BRIN
Development of Simplification Model Radiological Risk Calculation of a Nuclear Accident Reactor PWR	Jupiter Sitorus Pane	BRIN
Development of solid bihydrogen storage material based on sorbent carbon material	Deni Shidqi Khaerudini	BRIN
Development of probabilistic safety analysis software based on AI	Julwan Hendry Purba	BRIN
Development of biodiesel-water emulsion technology and its performance test as an alternative fuel for drying rubber rubber	Dadi Rosadi Maspanger	PT Riset Perkebunan Nusantara
Evaluation of meteorological hazards, vulnerability and risk assessment of the feasibility of the Nuclear Power Plant (PLTN) installation around Gosong Beach, Singkawang	Deni Septiadi	Sekolah Tinggi Meteorologi, Klimatologi, dan Geofisika – BMKG
Design and Development of Integrated Pyrolyzer and two-stage gasification (IPTG) for Bio-Oil and Electricity Production that is efficient and environmentally friendly using biomass waste	Adi Surjosatyo	UI
Local nanoparticles synthesis, characterisation, thermal properties of nanofluid hybrids as coolants in the Modular Modular Reactor (SMR) cooling system model	Tri Yuni Hendrawati	Universitas Muhammadiyah Jakarta
Development of Modular Technology-Multi Function Pack to support the electric vehicle industry and lithium battery-based energy storage	Muhammad Nizam	Universitas Sebelas Maret
Demographic Study for Community Safety in the Radius of the Nuclear Emergency Planning Zone of West Kalimantan	Yarlina Yacoub	Universitas Tanjungpura
Smart Battery Charging and Swapping Monitoring System (SBCSMS) based on IoT for battery-based electricity vehicles in achieving domestic energy independence	Muhammad Zakiyullah Romdlony	Universitas Telkom

Table 16 Leading research project focusing on 'Health', its prominent researcher, and Institutions Based on PRN

Title	Researcher	Institution
Development of Paracetamol and Intermediate Synthesis Technology continuously with the priority of using domestic raw materials to encourage the independence of the raw material industry	Eriawan Rismana	BRIN
Development of Production Technology Total Hip Arthroplasty for Degenerative Hip Bone Patients	Nandang Suhendra	BRIN
Development of Phytopharmaca Blood Sugar Phytopharmaca Dosage: Technology Transfer, Testing of Pharmacodynamic Efficacy of Blood Sugar & Toxicity in Vivo Prototype Industrial Products	Sri Ningsih	BRIN

The development of hybrid compounds (radio-fluorescent) for image-guided surgery tumours	Hendris Wongso	BRIN
Potential Lantranculin A, a bioactive compound from Kantranculia sea sponge, for relatively safe cancer therapy	Peni Ahmadi	BRIN
Development of the formulation of red ginger and rosella as standardised Herbal drugs for antihypertensive in the independence of Indonesian biodiversity-based drug raw materials	Siti Irma Rahmawati	BRIN
Development of Injectable bone graft made from limestone for the Dental Filler application.	Nendar Herdianto	BRIN
Increasing the capacity of enzymatic amoxicillin synthesis and its intermediates (hydroxy phenyl glycine methyl ester)	Bambang Marwoto	BRIN
The development of external fixation production technology for medical devices	Muhammad Kozin	BRIN
Development of bioceramic coating techniques Titanium alloy as total implant material hip arthroplasty (THA)	Ika Kartika	BRIN
Development of Immunostimulant Bedecov® Standardised Herbal Medicines to Increase the Body Endurance	Kurnia Agustini	BRIN
Development of Aluminum Phosphate Gel Production Technology as an HPV recombinant vaccine	Etik Mardliyati	BRIN
Technology innovation production of compounds between 6-what as raw material for amoxicillin production	Ahmad Wibisana	BRIN
Development of Immobilisation Technology Penicillin Gasilase using nanomaterials for enzymatic amoxicillin production	Siswa Setyahadi	BRIN
The development of trypsin-similar protease (PST) from Indonesian lactic acid bacteria for digestive enzymes	Trismilah	BRIN
Potential antivirus and anticancer activity of complex compounds of Fe, Co, Ni, Cu, and Zn-Hydrazone-based 2-Thyhydantoin and Hydrazide-based hydrazone	Fahimah Martak	Institut Teknologi Sepuluh Nopember
Development of Antidiabetic Standardised Herbal Medicines and Antihypereterolemia from Undis Leaf Extracts and Ginger Extract	Tutik Wresdiyati	IPB
The effect of intra-articular injection exosomes of stem cells originating from adipose tissue and hyaluronic acid on regeneration of ovaries cartilage: biomolecular study, histopathological and radiological imaging	Ludwig Andre Pontoh	Rumah Sakit Umum Dr. Cipto Mangunkusumo
Development of polyherbal preparations containing zingibers officinale as phytofarmaka for immunostimulants	Eti Nurwening Sholikhah	UGM
Development of nano hydrogel preparations with spoony leaf -standard extracts (Plantago major L) for healing diabetes wounds	Triana Hertiani	UGM
Development of immunogen products as standardised herbal medicines and immunomodulator phytofarmaka candidates	Retno Murwanti	UGM
SHINTA DEVELOPMENT (Stem Cell Hepatic Intuitive Apparatus) as a Liver Extracorporeal Dialysis System for End-Stage Liver Disease patients	Chyntia Olivia Maurine Jasirwan	UI
Substitution skin therapy in burns with the biological graft of the patient's keratinocyte cell cultures and stem cells	Aditya Wardhana	UI

Design and evaluation of mesenchymal stem cell secretome products in regenerative treatment therapy and autoimmune disease	Delly Ramadon	UI
Dental implant prototype test with porous structures in vitro and in vivo	Chiquita Prahasanti	Universitas Airlangga

Table 17 Leading research project focusing on 'Transportation', its prominent researcher, and institutions based on PRN

Title	Researcher	Institution
Structural Health Monitoring System (SHMS) on the Railroad Bridge	Wimpie Agoeng and Noegroho Aspar	BRIN
Development of Floater Design for Testing Worthy of N219 AMPHIBII aircraft	Sayuti Syamsuar	BRIN
Development of natural polyurethane-fiber composite technology for railroad wall insulation components	Bambang Subiyanto	BRIN
The development of carbon electrodes in perovskite-based solar cells for electric vehicle applications	Natalita Maulani Nursam	BRIN
Study of Seaplane Port Facilities Needs for Flight Test N219A aircraft	Khusnul Setia Wardani	BRIN
Design and prototyping door systems for fast trains	Mulyadi Sinung Harjono	BRIN
Modelling performance of system propulsion rights Indonesia	Lukman Salahuddin	BRIN
Development of the Electric Bus Platform Medium resulting from the conversion from the diesel engine drive	Bambang Sudarmanta	Institut Teknologi Sepuluh Nopember
Redefining a new precast system of resilient slab-track structure for high-speed train	Bambang Piscesa	Institut Teknologi Sepuluh Nopember
Design of building prototype simulator driver desk fast Indonesian	Agus Windharto	Institut Teknologi Sepuluh Nopember
Design Engineering Prototyping Executive Seat Indonesian Fast Train	Bambang Iskandriawan	Institut Teknologi Sepuluh Nopember
The development of the communication system on the fast train	Adit Kurniawan	ITB

Development of the Internet of Things platform for sterilisation and mitigation of fast rail infrastructure disorders	Amin Suharjono	Politeknik Negeri Semarang
Modelling and optimisation of controls on the fast train braking system	Paryanto	Universitas Diponegoro
Development of Indonesian Fast Train Wall Manufacturing through Integrated Extrusion - Double Acting Fiction Stir Welding	Triyono	Universitas Sebelas Maret
Design of train control systems for fast train operations in Indonesia	Ahmad Sugiana	Universitas Telkom

Table 18 Top 10 leading research projects focusing on 'Engineering', its prominent researcher, and institutions based on PRN

Title	Researcher	Institution
Structure design and architecture of earthquake-resistant houses using concrete construction	Dany Perwita Sari	BRIN
Development of Antiaging Products with Raw Materials Aloe Vera Local Cultivation in Gunung Kidul	Sri Handayani	BRIN
Development of traditional food products ready for food in commercial sterilisation-based packaging	Asep Nurhikmat	BRIN
Development of Innovation of Earthquake Resistant and Fire -Resistant Composite Home Innovations Using Light Panels Sandwich Composites Nanocellulose/ PU Foam Core to Support Disaster Risk Reduction Mitigation Programs	Hanif Yuliani	BRIN
Application of Biological Fertiliser Products for Rami Plants	Priyo Wahyudi	BRIN
Development of endophytic mould as a producer of secondary anti-oxidant metabolites and natural skin whitening for cosmetic raw materials	Silva Abraham	BRIN
Development of Sandwich Sandwich Panel Polyurethane-Natural Commercial Scale for Earthquake Resistant House Wall Components Using Wood Construction	Sasa Sofyan Munawar	BRIN
Development of Big Facial Data Systems on Automatic Face Recognition for Automatic Border Control	Fadhil Hidayat	ITB
Development of Coconut Fiber Fiber Composites For Self Cooling Component Products Ceiling Earthquake Resistant Houses	Rilya Rumbayan	Politeknik Negeri Manado
Development of Big Data Urban Data Based Intelligence Based on Building Compliance Analysis of Regional Spatial Planning and Development Licensing In order to increase regional income and protection of urban environmental quality	Ahmad Gamal	UI
Development of artificial intelligence and database to identify the health of rubber plants	Alhadi Bustamam	UI
Study of anti-ageing Fito-squalene compounds from Noni Herbal Extracts (Morinda citrifolia L) Based on the Risk Association of Human Skin Aging with Polymorphism MMP-1, SOD2, GSTP1, Rage, and Tyr in the Indonesian Population	Anom Bowolaksono	UI
Increasing the scale of fibre production and biomass by side products from hemp (Boehmeria nivea)	Asri Peni Wulandari	Universitas Padjadjaran

Isolation The active component of the nutmeg fraction of the Fuli (Myristica arillus), as well as the antioxidant and antiaging activity test using the DPPH, ABTS and MTT Assay methods (second year)	Khairan	Universitas Syiah Kuala
Design of Innovation of Non-Invasive Cervical Cancer Screening Tools made from volatilome metabolites based on artificial intelligence	Monica Dwi Hartanti	Universitas Trisakti

Table 19 Leading research project focusing on 'Defence and Security', its prominent researcher, and institutions based on PRN

Title	Researcher	Institution
Dissemination of two-level Sonda Rocket Technology for the development of Rhan 450 defence rockets for 100 km flying range	Rika Andiarti	BRIN
Development of Full Polarimetric Synthetic Aperture Sensor Prototype Aperture Radar with Detection and Target Classification on Male UAV Platforms	Bambang Setiadi	BRIN
Development of Air Monitoring Systems and Integrated Environmental Radiation Based on Low-Cost Sensors and Real-Time Monitoring	Muhayatun	BRIN
Improvement of the Retractable Landing Gear System Puna Male	Andi Muhdiar	BRIN

Table 20 Leading research project focusing on 'Maritime', its prominent researcher, and institutions based on PRN

Title	Researcher	Institution
Functional food development for diabetics, based on seaweed use	Budi Saksono	BRIN
Development of Premium Karagenan Food Products from Eucheuma Cotonii Seaweed in Enzymatic	Heri Purwoto	BRIN
Cost-effective Photobioreactor Technology produces high-quality spirulina biomass and hygienic raw materials for seafood food products.	Awalina	BRIN
Study of Mini LNG Ship Production Technology to Improve the Competitiveness of National Shipyard Competitiveness	Buana Ma'ruf	BRIN
Omega 3 concentrates production as an effort to increase the added value of fish oil by prising freshwater fish processing units and sea fish to reduce imported products.	Sugeng Heri Suseno	IPB
Utilisation of fish catchment by the production of protein hydrolysis as raw material for making bioactive effervescent tablets	Tatty Yuniarti	Politeknik Ahli Usaha Perikanan
Continued - Characterisation of chemical, physical, and microbiological raw materials and innovative products MALSAI (MALSAI WBS 6 WP 63)	Dian Anggraini Suroto	UGM
Innovation of the use of seaweed-based polysaccharides in heat-resistant praline chocolate products as an effort to diversify and increase food security	Arifin Dwi Saputro	UGM
Continuation-Quick Method of Determination of the Quality of Raw Materials and Malsai Innovative Products (MALSAI WBS 6 WP 62)	Manikharda	UGM
Continued - Development of Standard Methods Determining the quality of raw materials and innovative products (Malsai WBS 6 WP 61)	Widiastuti Setyaningsih	UGM

Continued - Development of infrastructure systems of raw material quality and innovative products (Malsai WBS 6 WP 64)	Arima Diah Setiowati	UGM
Increased performance, durable power and functional nature of Sei Tuna (Thunnus sp) with the addition of angkak	Hardoko	Universitas Brawijaya
Improvement of smoked fish production with "Efhilink" fish fumigation equipment to support the improvement of the small industry	Marita Ika Joesidawati	Universitas PGRI Ronggolawe

Table 21 Leading research project focusing on 'Social Humanities', its prominent researcher, and institutions based on PRN

Title	Researcher	Institution
Policy strategy for financing natural disaster risk management	Agus Eko Nugroho	BRIN
Decentralisation and regional autonomy in the border region	R. Siti Zuhro	BRIN
MSME Entrepreneurship Development Model: Strengthening Ecosystem Core Components	Endang Sri Soesilowati	BRIN
Building Modern Political Parties: Strengthening Institutionalisation of Political Parties in Indonesia	Firman Noor	BRIN
The actualisation of concepts and models of resilience to be an inclusive and competitive rural community	Purwanto	BRIN
Strategy to Strengthen Indonesia's Role in the Indo-Pacific	Emilia Yustiningrum	BRIN
Floating Heritage Festival: Pinisi Ship Stage Articulation and Festival Actor Network for Investment of Maritime Cultural Arts Tourism	Yanti Heriyawati	Institut Seni Budaya Indonesia Bandung
Strengthening democracy from villages in the Pandemic Covid-19: Problematics of Development of Anti-Political Money Village Programs	Titin Purwaningsih	Komite Independen Sadar Pemilu
Development of Community Management of Pro-Millennial Tourism Destinations in the Digital Era	Tri Kuntoro Priyambodo	UGM
Creative Industry, Art and Culture Enriching in Supporting Quality and Sustainable Tourism (The National Priority Area (KSPN) in Indonesia	Muhamad	UGM
Acceleration of integration between institutions in strengthening natural resource and environmental governance in the Menoreh Kulon Progo area	Catur Sugiyanto	UGM
Carita Pantun Oral Tradition in Kanekes (Baduy): From Ancient Sundanese to Ich UNESCO's recognition	M. Yoesoef	UI
Development of Knowledge Management Integrated Audit and Development Audit Process to Improve Construction Safety Performance	Yusuf Latief	UI
Managing Naming Politics in Javanese Society: Development of the Javanese Name Database System as a Naming Reference in the Special Region of Yogyakarta	Askuri	Universitas Aisyiyah Yogyakarta
Analysis of innovation, business failure, and level of readiness of cooperative technology and creative industry startups in West Sumatra	Donard Games	Universitas Andalas

Socio-Economic Engineering and Migrant Fishermen Village Fishermen Based on Gender Equality and Social Inclusion (GESI) and Innovation in the Pandemic Covid-19 Era	Keppi Sukesi	Universitas Brawijaya
Determinant Factors for the Development of a Cashless Society to Support Economic Recovery When Pandemic is Moderated by Statistics and Science Data-Based Financial Technology (Study on the Use of BNI Mobile Banking)	Solimun	Universitas Brawijaya
Eucalyptus Oil Farmers Adaptation Strategy in Utilising Social Networks and Foodhabits Facing Pandemic Covid-19	M Chairul Basrun Umanailo	Universitas Iqra Buru
Shift in the Da'wah Movement of Tabligh Jamaah in Indonesia: Politics of Identity, Democracy, Islamic Khilafah, and Radicalism Countering in West Nusa Tenggara Province, DKI Jakarta, East Kalimantan, East Java, and North Sulawesi	Saipul Hamdi	Universitas Mataram
Model of Innovating Teaching Factory Product Vocational High School International Competition	Mochamad Bruri Triyono	Universitas Negeri Yogyakarta
Redesign of Innovative Products Fashion Bags Based on Mindi Wood Waste Waste in Krebet Bantul	Moh. Rusnoto Susanto	Universitas Sarjanawiyata Tamansiswa Yogyakarta
Mapping the value of the rice industry value for the policy of strengthening local rice refineries	Ahmad Humam Hamid	Universitas Syiah Kuala

Table 22 Leading research project focusing on 'Multidisciplinary research', its prominent researcher, and institutions based on PRN

Title	Researcher	Institution
Development of Restoration and Rehabilitation Technology (R/R Technology) Mangrove ecosystems based on Ecosystem Design, Biotechnology, and Community Development	Suyadi	BRIN
Quick Search for Anti-Tuberculosis Compounds from Indonesian Microbial Biodiversity with a Specific Target Approach	Arif Nurkanto	BRIN
Food Technology Innovation Prevents Stunting: Analysis of Stunting Decreased Stunting (Anemia Prevention) Through Nutritional Interventions of Flake Flake Flake Flakes (Purula) Based on Soy Hydrolysis to Prospective Brides Ready for Marriage Ready to Get Pregnant	Noer Laily	BRIN
GMOS additive food based on fro -fruit Kaling, which is produced through enzymatic reactions from local microbes for stunting prevention in Indonesia	Nanik Rahmani	BRIN
Extreme Rain Index for Flood Disaster Mitigation in Jakarta and Cross-Sectoral	Asif Awaludin	BRIN
The use of organic additives contains complex probiotic-biominerals producing milk-rich milk acids and essential minerals to reduce the prevalence of stunting in toddlers.	Ahmad Sofyan	BRIN
Development of the Drought Index Model for the Provision of Clean Water Distribution Information (Mothers) (2nd year)	Jalu Tejo Nugroho	BRIN
Innovation of local food products that are deficient in micronutrients to contribute to the acceleration of stunting decreases in Subang Regency (Continued)	Ainia Herminiati	BRIN

Utilisation of anchovy (Stolephorus sp) in sago starch-based noodle products to increase protein, phosphorus and calcium content, which has implications for increasing nutritional intake in children with stunting	Christina Litaay	BRIN
Initiation of Domestic Domestic Fortified Rice Kernel Kernel Products to Support Stunting Handling Acceleration Program	Mardonius Budi Kusarpoko	BRIN
Innovation of superior products in the region of West Sumatra (rinuak fish) as a source of protein in stunting control	Evi Susanti	Institut Kesehatan Prima Nusantara
Development of Machine Learning and Big Learning Machine Growth Monitoring Systems and Big Data Data Satellite Satellite Image	Soni Darmawan	Institut Teknologi Nasional Bandung
Implementation of satellite data for identification of active fault zones in Java, Sulawesi and Sumatra as input for renewing the source map and the dangers of the Indonesian earthquake	Endra Gunawan	ITB
Development of the Prediction Model of Quality and Quantity of Water-Based Remote Sensing: Case Study of Saguling Reservoir	Prayatni Soewondo	ITB
Design of Early Warning System Earthquake Based on Radon Gas Fluctuations and Ground Water Level	Sunarno	UGM
Development of drought models for sustainable food land management based on the nexus-spatial approach	Muhammad Dimyati	UI
Examining the factors that cause stunting in children in Wajak District: Integration of Cluster with Path Analysis with Statistics and Data Science Approaches	Adji Achmad Rinaldo Fernandes	Universitas Brawijaya
Intervention Change in behaviour and social behaviour based on family approaches through the empowerment of Posyandu and Dasawism cadres in preventing stunting and anaemia in the first 1000 days of life.	Nurul Muslihah	Universitas Brawijaya
Spatial modelling and Real-Time Monitoring System (RTMS) river quality to support regulations and sustainable water resource management policies	Syafrudin	Universitas Diponegoro
The nutritional content of Alabio sweet potato flour varieties of white varieties in the differences in the process of blanching and drying	Agung Nugroho	Universitas Lambung Mangkurat
Nutrigenomic-based nutritional research and public health in an effort to decline and prevent stunting (2nd year)	Ari Yuniastuti	Universitas Negeri Semarang
Exploration of fertility genes in local goats and boer as the first step to forming twin grooves in increasing the population of goats in the groin	Ning Setiati	Universitas Negeri Semarang

8.3 Details of private funding institutions and funded researchers

Table 23 List of Philanthropic Organizations and the Target Research Implementer

List of Philanthropic Organizations	Target Research Implementer				
	Individual	NGO	Amil Zakat	University	Others
Yayasan Unilever Indonesia	X	x	x	x	
Eka Tjipta Foundation	X				
Yayasan Buddha Tzu Chi Indonesia	X				
Dompet Dhuafa	X	x	x	x	
CSR PT Adaro Energy Tbk.		x		x	
Tanoto Foundation				x	
Pertamina Foundation	X	x		x	
KEHATI		x		x	
CT Arsa Foundation	X				
HDI Foundation		x			
Rumah Zakat	X		x		
LAZISMU			x	x	
Indonesia Danone Institute	X				
BAZIS DKI	X				
Baitul Maal Hidayatullah	X				
PKPU					x
Anwar Muhammad Foundation*					
The Habibie Centre	X	x	x	x	
Yayasan Danamon Peduli				x	
PT Indofood Sukses Makmur	X			x	x
CSR Aqua Danone	X	x		x	x
BAZNAS	X	x	x	x	
YAPPIKA					x
ACT (Aksi Cepat Tanggap)				x	x
Yayasan Baitul Hikmah El Nusa	X			x	
Citi Pekka Indonesia		x		x	
SEAMOLEC	X			x	x
Yayasan Tahija		x		x	
Indonesia Business Links		x			

*No information

Table 24 List of Research Institutions (Funding Receivers)

Research Institutions	
1. Women Research Institute	26. LPPM UKI
2. LPPM Universitas Pelita Harapan	27. LPPM IPB
3. PSHK	28. LPPM UMJ
4. Bina Swadaya	29. YLKI
5. PPIM UIN	30. INFID
6. Wahid Foundation	31. ICW
7. FITRA	32. CORE Indonesia
8. LPPM Universitas Matana	33. SMERU Research Institute
9. Maarif Institute	34. Yayasan Jurnal Perempuan
10. LPPM Universitas Paramadina	35. IRAI
11. Lab Sosiologi Universitas Indonesia	36. ELSAM
12. LPPM Universitas Moestopo	37. LSPP
13. Lemlit UHAMKA	38. Indobarometer
14. LP3ES	39. ASPPUK
15. LPPM Universitas Atmajaya	40. Sigma Research Indonesia
16. Lab Fisika Medis Universitas Indonesia	41. Mars Indonesia
17. LPPM Universitas Mercubuana	42. LPPM UNAS
18. Cirus Surveyor	43. Mochtar Riady Institute for Nanotechnology
19. KPA	44. TURC
20. Lemlit UNJ	45. Institute for Strategic Indonesia
21. PATTIRO	46. PPM Manajemen
22. LPPM Universitas Trilogi	47. Lembaga Pers Dr. Soetomo
23. Indikator Politik	48. Direktorat Riset dan Pengabdian Masyarakat UI
24. CIPS	49. Charta Politika
25. SMRC	50. SEDANE LIPS

8.4 Interviewees Details

Table 25 Interviewee Details

No	Stakeholders Position	Gender	Organization Name	Organization Category	Organization Website
1	Secretary of	Female	SMERU Research Institute	Private Research Institution	https://smeru.or.id/en
2	Consultant	Male	The Indonesian Science Fund (DIPI)	Funding Agency	https://dipi.id/id/tentang-kami/
3	Vice Director	Male	The Indonesian Science Fund (DIPI)	Funding Agency	https://dipi.id/id/tentang-kami/
4	General Secretary	Male	Indonesian Academy of Sciences (AIPI)	Academic Community	https://aipi.or.id/
5	Director of Research and Innovation	Female	National Research and Innovation Agency (BRIN)	Government Research Institution	https://brin.go.id/en
6	Lecturer at the Faculty of Animal	Male	Gadjah Mada University (UGM)	University (PTN-BH)	https://fapet.ugm.ac.id/
7	Head of Directorate of Community Service	Male	Gadjah Mada University (UGM)	University (PTN-BH)	https://pengabdian.ugm.ac.id/organisasidirpkm/
8	Head of Cooperation and Development Division of Research Funding Services	Male	Indonesian Endowment Fund for Education (LPDP)	Funding Agency	https://lpdp.kemenkeu.go.id/en/tentang/struktur-organisasi/
	Head of Cooperation and Scholarship Development Division				
	Head of Research Funding Division				
9	Directorate of Population and Labour Statistics, Deputy for Social Statistics	Female	Statistics Indonesia (BPS)	Government Research Institution	https://ppid.bps.go.id/app/konten/0000/Profil-BPS.html
		Female			
		Male			
		Female			
10	Engineer at the Energy and Manufacturing Research Organization	Female	National Research and Innovation Agency (BRIN)	Government Research Institution	https://brin.go.id/en
11	Directorate of Research and Innovation – IPB University	Female	Institut Pertanian Bogor (IPB)	University (PTN-BH)	https://dri.ipb.ac.id/
		Male			

12	Director of Research, Technology and Innovation Policy Formulation	Male	National Research and Innovation Agency (BRIN)	Government Research Institution	https://brin.go.id/en
13	Sub and Director of Higher Education and Science and Technology (BAPPENAS)	Female (2)	Directorate of Higher Education and Science and Technology (BAPPENAS)	Government	https://www.bappenas.go.id/unit-kerja/0103
14	Head of Research and Community Service Agency and Head of Innovation and Entrepreneurship Development Institute (LPIK), Bandung Institute of Technology/ ITB	Male (2)	Bandung Institute of Technology/ ITB	University (PTN-BH)	https://lppm.itb.ac.id/en/
15	Director	Male (2)	Directorate of Innovation and Science Techno Park, University of Indonesia/UI	University (PTN-BH)	https://research.ui.ac.id/RI/distp-director-profile/
16	Secretary and Analyst	Female (2)	Research Centre for Strategic and International Studies (CSIS)	Private Research Institution	https://www.csis.or.id
17	Head and analyst	Female (2) Male (1)	Indonesia Scholarship Forum	Community	http://forumbeasiswa.id

8.5 Interview Questions

8.5.1 Respondent background

Goal: Ensure that we understand the person's background and expertise well. This will help inform which questions can be included, facilitate the analysis, and allow for better follow-up.

Task: Quickly summarise the information collected before the interview to verify its accuracy with the respondent, adapt and add if needed.

Time: Max. 5 minutes

1. What is your role?

2. How are you currently working in the research and development field of science, technology, and innovation?

8.5.2 Indonesia's Scientific and Technological Capabilities: Challenges and Prospects

3. Could you explain what research and development budgets are available in Indonesia in the fields of science,

technology, and innovation?

4. Do you know the number of degree holders and researchers by field in Indonesia?
5. From the human resource development perspective, Could you explain the situation of science and engineering tertiary students in Indonesia and data on science and engineering tertiary higher education students overseas by country?
6. Do you know the status of the current thesis and patent analysis in Indonesia?
7. What do you know about competitiveness, university rankings, technology trade balance, technology-intensive companies, and entrepreneurship in Indonesia?
8. What kind of existence and prospect of Deep-tech unicorns, such as awards such as Habibie Prise and other prestigious science and technology awards in Japan and abroad, are available in Indonesia?

8.5.3 Major science and technology policies and organizations

9. Could you explain Indonesia's hierarchical structure of government policy implementation related to STI and related laws and measures (presidential orders, laws, policies, plans, etc.)?
10. Could you explain the organizational chart and outline of science and technology?
11. What are the existing and future major science and technology policies in Indonesia?
12. What kind of existing procedures and related systems are used by foreign researchers to conduct research and development in Indonesia?
13. Do you know the outline of the patent system in Indonesia?

8.5.4 Trends in Basic Research and Development

14. What kind of public funds disseminators and other disseminating agencies (international, private) exist in Indonesia?
15. Could you give examples of details of the funding program system (identifying programs in which overseas researchers can participate, such as basic research, applied research, industry-academia collaboration, startup support, facility and base development, human resource development, etc.)? Also, could you give examples of funding with pre-, interim, and finish, follow-up evaluation, patent acquisition support, etc.?
16. What do you think about major research results, leading institutions and universities, leading
17. What kind of STI-based startups (Deep-tech) and unicorns are available in Indonesia?
18. What kind of international agreements between governments, international cooperation programs of funding agencies (national level), academic agreements at major universities and research institutes (leading institutions listed in (3)), international joint research at the leading researcher level (researchers listed in (3)), and cooperation policies of priority countries, etc. with Japan and other countries (China, South Korea, Australia, ASEAN, US, Europe?

8.5.5 Implications for Japan-Indonesia Science and Technology Cooperation between Japan and Indonesia

19. Could you explain existing and future collaboration between Japan and Indonesia in the Science and Technology Cooperation?
20. Could you describe the infrastructure required for existing and future cooperation?

8.5.6 General closing questions

Goal: Provide the opportunity for the respondent to share relevant information not directly elicited through the questions.

Task: Follow the questions and get clear details in case a contact or data source is given.

Time: Max. 10 minutes

21. Do you have any tips for experts we could contact and discuss?
22. Do you have any policies or datasets that are particularly useful for us?

Remind the respondent to sign and submit the consent form if not done already.

8.6 FGD Participants

Table 26 List of FGD Participants

No	Stakeholders Position	Organization's Name
18	DIRECTOR	BRIN
19	Koordinator Fasilitasi dan Pendanaan Risnov melalui Skema Match Fund	BRIN
20	Institute Secretary	SMERU Research Institute
21	Asia and Pacific Research Centre	JST
22	Research Assistant	CSIS
23	Lecturer/DPkM UGM	UGM
24	Director	Environmental Research Centre (ERC), IPB University
25	Assistant Director of Research Strategy and Development	IPB University
26	Staf	Kementerian PPN/Bappenas
27	Strategic Planning Manager	Tanoto Foundation
28	Sub-Coordinator for Overseas Education	Ministry of Education, Culture, Research and Technology
29	Analis Kebijakan Ahli Pertama	Kementerian PANRB
30	Program Officer	DIPI
31	Head of Research Organization for Energy and Manufacture	BRIN

32	Researcher	CSIS
33	Analyst	BRIN
34	Staff PTI	Bappenas
35	Senior Sustainability Expert	APP Group
36	Assistant Director Directorate of Research and Innovation	IPB University
37	Director For Research Facility	LPDP
38	Research Analyst	LPDP
39	Vice-Rector for Research, Innovation and Agro-maritime Development	IPB University
40	Head of International Research Institute for Environment and Climate Change,	IPB University
41	Secretary-General	Indonesian Academy of Sciences (AIPI)
42	Director of Higher Education and Science and Technology	BAPPENAS
43	Deputy Executive Director of the Indonesian Science Fund	DIPI
44	Sustainable Development Initiative Manager	Bakrie Centre Foundation.
45	Strategic Planning Manager Tanoto Foundation	Tanoto Foundation
46	Director of Research and Development)	University Indonesia
47	Associate Statistician	BPS-Statistics Indonesia
48	Head of research organization	Badan Riset dan Inovasi Nasional/BRIN
49	Digital Transformation	Tanoto Foundation
50	Advisor	DIPI
51	International Initiative and Research Officer,	Bakrie Centre Foundation
52	Head Strategic Communication & Partnership	Bakrie Centre Foundation
53	GM Pendidikan DD	Dompet Dhuafa
54	Lecturer	IPB
55	Staff	IPB
56	Koordinator Tim Statistik Demografi, Direktorat Statistik Kependudukan dan Ketenagakerjaan	Badan Pusat Statistik
57	Secretary of Physics Dept/ Program Director of ALMI	IPB University/ALMI

8.7 Follow-up Meeting Participants

Table 27 List of Follow-up Meeting Participants

No	Stakeholders Position	Organization's Name
58	Director of Research, Technology and Innovation Policy Formulation	BRIN
59	Director of Research Fund	BRIN
60	Secretary-General	AIPI
61	Executive Director	DIPI
62	Deputy Executive Director	DIPI
63	Consultant	DIPI

List of authors

[List of authors]

Takama Takeshi	CEO, PT su-re.co
Tri Atmaja	Researcher, PT su-re.co
Siti N. Indriani	Researcher, PT su-re.co
Fabian P. Wiropranoto	Researcher, PT su-re.co [interviews]
Gevy Febriani	Researcher, PT su-re.co [data collection]

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[Research Planning]

Saito Itaru	Fellow, Asian and Pacific Research Center, Japan Science and Technology Agency
Kobayashi Yoshihide	Chief, Asian and Pacific Research Center, Japan Science and Technology Agency
Azuma Mikiko	Manager, Asian and Pacific Research Center, Japan Science and Technology Agency

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For any inquiries regarding this report, please contact:

Asia and Pacific Research Center, Japan Science and Technology Agency

Science Plaza, 5-3, Yonbancho, Chiyoda-ku, Tokyo 102-8666, Japan

Tel: 03-5214-7556 E-Mail: aprc@jst.go.jp

https://www.jst.go.jp/aprc/