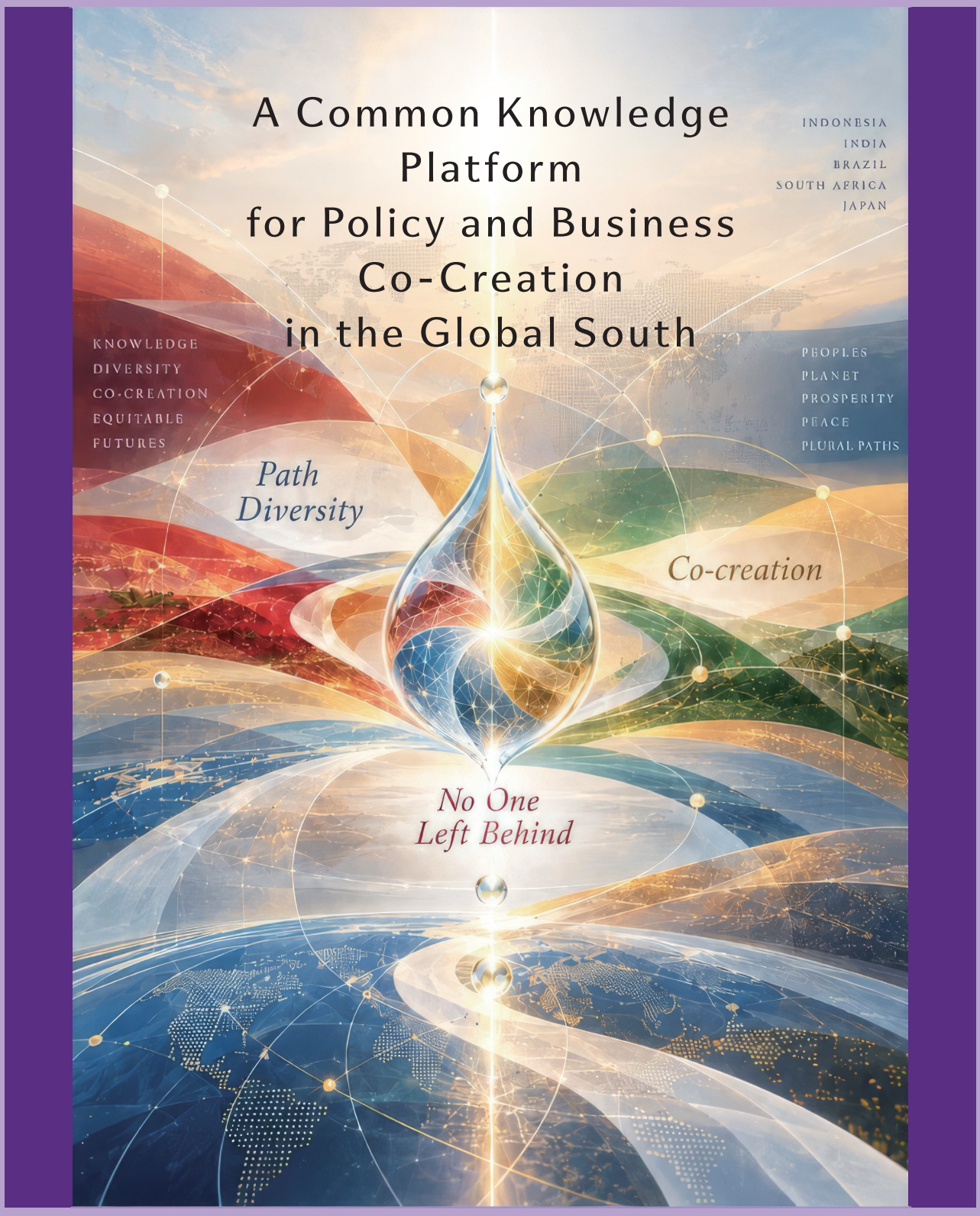
Global Five Epistemic Caucus



November 2026

Musashino Institute for Global Affairs (MIGA)

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Part Ⅰ.

Introduction

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Chapter 1: Introduction: A Formation of Global Five Epistemic Caucus (G5EC), the Outcome of the Tokyo Meetings and the Concept of a Common Knowledge Platform

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1. How the G5EC Concept Took Shape

1.1. Starting Point: Path Diversity in Global South Development

The concept of the Global Five Epistemic Caucus (G5EC) has its roots in work that began well before the Tokyo Meetings of October 2026. Its starting point lies in a series of studies and international policy proposals by the Musashino Institute for Global Affairs (MIGA), Musashino University, which reframe cooperation between Japan and the Global South, long understood as a one-way transfer of knowledge and technology, as co-creation built on the complementarity of different development experiences. In this report, the 'Tokyo Meetings' refers collectively to the G5EC Strategic Workshop held on 15 and 16 October 2026 and the Nexus Japan–GS Forum held on 19 October 2026.

MIGA's core idea is Path Diversity: Global South countries should chart new development paths of their own, based on their own knowledge and judgement, without simply replicating the European or East Asian models. In the study of civilisational evolution, this corresponds to a multilinear view of civilisational evolution.

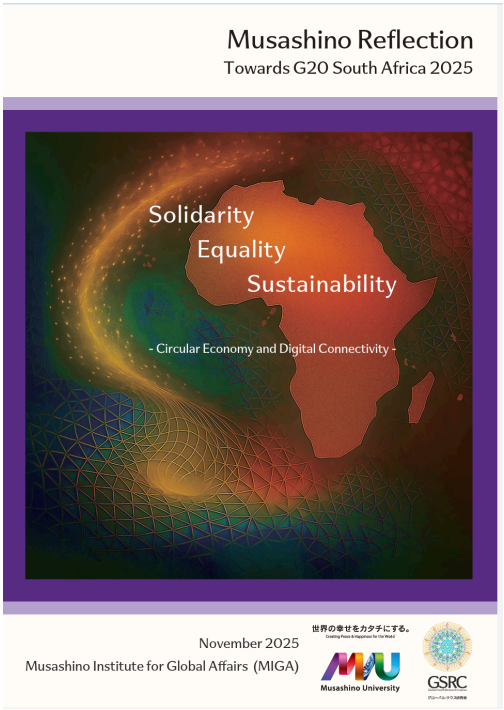
The idea was first set out in the policy proposal *MIGA Policy Package "Path Diversity" for "No One Left Behind"*, compiled in November 2024. The proposal organised a model of the multilinear view of civilisational evolution, presented a 'leapfrog development model' as a concrete form of multilinear evolution, and analysed the conditions that would make such development possible.

This was followed in November 2025 by *Musashino Reflection: Circular Economy and Digital Connectivity*, which presented the construction of a global circular economy system built on digital connectivity as a concrete form of the leapfrog development model. Treating the leapfrog model as a concrete expression of the multilinear view, and the construction of such a circular economy system as the method for realising it, the document examined sector by sector the policy issues that this construction

would require. It covered the circular economy, digital connectivity, cyber-physical systems (CPS), the role of research institutions and new forms of infrastructure finance. Building on this work, at the G20 Social Summit side event in South Africa (Dynamic Governance for a Resilient Global South: Innovative Strategies for Inclusive Growth in G20), a proposal was made to carry forward the experience of Indonesia, India, Brazil and South Africa, which held the G20 presidency in four consecutive years, by bringing those four countries together with Japan in a Global Five Epistemic Caucus. From the policy proposal stage that preceded the Tokyo Meetings, G5EC was thus positioned as an initiative to carry forward the achievements of the four presidencies and to connect knowledge with practice.

Figure 1. "Path Diversity for 'No One Left Behind'" (left), and "Musashino Reflection Towards G20 South Africa 2025" (right)





1.2. The Legacy of Four Consecutive Global South G20 Presidencies

The experience of the four Global South countries that held the G20 presidency in four consecutive years (Indonesia in 2022, India in 2023, Brazil in 2024 and South Africa in 2025) forms an important historical foundation for the G5EC concept. Under differing political and economic conditions, each brought issues such as digitalisation, development, inclusion, energy transition, industrialisation, inequality and finance into international policy deliberations.

The G20 presidency, however, rotates every year. This raises the question of how the research, policy proposals, personal networks and project experience accumulated under each presidency can be

carried over to the next and developed further. G5EC aims to reconnect what the existing G20 and T20 networks have accumulated and to build on it a lasting foundation for mutually complementary cooperation. Japan joins this effort as a partner, connecting its experience in industry, research, technology, finance, human resource development and institution building with the policy and industrial knowledge that each of the four countries has developed, and so opening up new possibilities.

1.3. Developing the Concept in 2026: Consultations with Research Institutions in the Four Countries

In 2026, MIGA moved to give concrete shape to the G5EC concept and held a series of consultations with leading research institutions in the four countries: the Centre for Strategic and International Studies (CSIS) in Indonesia, the Research and Information System for Developing Countries (RIS) in India, the Institute for Applied Economic Research (IPEA) in Brazil and the South African Institute of International Affairs (SAIIA) in South Africa. All four have long been closely involved in policy research and international deliberations in their countries.

In July 2026, consultations with RIS set out the G5EC concept, which would turn the achievements of the four G20 presidencies into sustained cooperation, together with the direction of linking research with concrete projects. In the same month, a visit to Indonesia included consultations with CSIS Executive Director Yose Rizal Damuri and colleagues, which confirmed CSIS's positive intention to participate in the Tokyo Meetings in October and to cooperate with the initiative.

During a visit to Brazil in August, discussions were held with research and industry stakeholders, and views on the G5EC concept and the Tokyo Meetings were also exchanged with IPEA. These discussions explored ways of linking the research and industrial cooperation built up between Japan and Brazil to wider joint projects among the five countries. Around the same time, consultations with the Stimson Center in Washington confirmed the direction of connecting G5EC's activities with T20 research and policy deliberations as a partnership between mutually independent entities.

At the end of September, consultations were held in South Africa with SAIIA Chief Executive Elizabeth Sidiropoulos on substantive participation in, and shared ownership of, G5EC. The South African side raised concrete issues such as scaling up start-ups, critical minerals, the cost of capital and local value creation. These consultations made it clearer still that the initiative would move forward with each country taking part in shaping its content, building on Japan's initial presentation of the concept.

Throughout these consultations, emphasis was placed on three points: each institution making use of its existing research findings and policy networks, respect for each country's issues and priorities, and research institutions acting as joint intellectual partners in the initiative. Cooperation under G5EC accordingly took shape as a process in which the five countries pool their knowledge and experience to shape its content together.

1.4. The Basic Role of G5EC and the Path to the Tokyo Meetings

Through these consultations, three priority areas for G5EC's practical work became clear: joint engagement in international rule-making, business collaboration including start-ups, and the sharing of national growth and development strategies. G5EC is thus an initiative that seeks to carry knowledge gained through research into both policymaking and corporate business and investment.

Mutual understanding and complementarity among countries following different development paths also call for a common platform. In addition to the exchange of research findings and experience, such a platform would identify possibilities within diverse bodies of knowledge, link them to policies and projects, and feed the resulting experience back into each country's knowledge. This report refers to this platform as the Common Knowledge Platform (CKP) and regards G5EC as one concrete instance of it. Section 3 discusses the CKP and the Epistemic Connectivity on which it rests.

Importantly, the G5EC Strategic Workshop on 15 and 16 October 2026 built on the consultations and confirmations of willingness to participate that had preceded it. It served as a forum for thorough examination, across research, industry and policy, of the concrete new possibilities that cooperation among the five countries could create.

This was followed on 19 October by the Nexus Japan–GS Forum, where the possibilities for cooperation were discussed further with Japanese industry and policy stakeholders, and the representatives of the four countries each set out their views on the way forward. As the two meetings differed in purpose and outcome, the next section examines them separately. The decisive point in the formation of the G5EC concept is that, before the Tokyo Meetings, the policy experience accumulated through the four consecutive Global South G20 presidencies had already been linked with MIGA's proposals, laying the groundwork for intellectual and practical cooperation among the five countries.

2. Outcomes of the Tokyo Meetings, 15, 16 and 19 October 2026

2.1. Two Phases of the Tokyo Meetings

The discussions in Tokyo in October 2026 took place through two meetings that differed in purpose and participation: the G5EC Strategic Workshop on 15 and 16 October and the Nexus Japan–GS Forum on 19 October. The former examined in depth, on the basis of individual papers submitted by participants, the potential for cooperation among the five countries in research, policy and industry. The latter, through a broader dialogue that included Japanese policy and industry stakeholders, discussed how cooperation could be developed into concrete projects and institutions; in its final session, representatives of research institutions from the four countries each set out what G5EC means from their own perspective. The two meetings must therefore be treated as distinct.

On the first day (15 October), the Strategic Workshop covered Session 1 (AI, Semiconductors and Industrial Development), Session 2 (Common Knowledge Infrastructure and Human Resource Development) and Session 3 (Regional Development and Innovative Finance). On the second day (16 October), it covered Session 4 (Energy, Critical Minerals and Circular Industrialisation), Session 5 (Deep Tech, Supply Chain ESG and Space Business), Session 6 (The Experience of Four Consecutive Global South G20 Presidencies) and Session 7 (Concluding Discussion). Across all seven sessions, participants tested the feasibility of the papers' proposals against the conditions for implementation in each country. The sectoral papers in Part II of this report are accordingly the product of joint research: each author revised their paper as needed in response to the criticisms, questions and suggestions raised on 15 and 16 October. The records of discussion, for their part, document the support, objections, reservations and unresolved issues raised in the sessions.

2.2. 15 October: Conditions for Putting Knowledge, Technology and People into Practice

In Session 1, participants considered the semiconductor industry and judged that analysing industrial value chains process by process is a useful method for identifying concrete opportunities for cooperation among the five countries. They also stressed that market size and resource endowments alone do not create competitive industries, and that each country's existing capabilities, institutions and commercial viability need to be examined. On AI, the discussion covered an initiative to convert the practical knowledge accumulated in factories and firms into intellectual assets and integrate it with the development of human capabilities, namely a project using cyber-physical systems to turn tacit knowledge into explicit knowledge. Further issues included responses to youth unemployment, poverty and inequality, together with fairness, accountability, ethical governance and the participation of the Global South in international rule-making. The promotion of neuro-symbolic AI was also discussed.

Session 2 raised the problem that the knowledge and personal connections gained through individual projects are lost when those projects end. The value of a common knowledge infrastructure was seen in establishing a cycle in which implementation experience generates knowledge, knowledge develops people, and people create new practice. The session also discussed epistemic justice, under which the experience and knowledge specific to each society are valued equally with knowledge originating in advanced countries. Participants identified advanced human resource development as the most important requirement for realising new multilinear evolution in Global South countries, and discussed the role of the higher education institutions responsible for it. Related proposals included joint master's and doctoral programmes built on partnerships among existing universities, scholarships, joint research and cooperation with international organisations.

Session 3 discussed the potential for integrated regional development that treats a river basin as a set of interrelationships among water management, agriculture, land use, urban planning, industry and disaster risk reduction. On finance, the discussion addressed both entry-stage funding for start-ups

and the lack of exits through which capital from existing investments can be sold or recovered and recycled into new investment. Measures under consideration included creating secondary markets, local-currency finance and making use of domestic institutional investors. A wholly new development finance mechanism was also proposed, using a blockchain-based platform to provide funding through security token offerings (STOs). These proposals were rigorously questioned on exchange rate risk, information asymmetry, investor protection, anti-money laundering measures, the legal framework and the rationale for first-loss capital. The discussion made clear that information, regulation, trust and risk-sharing must be designed together with the technical mechanisms.

The first day's discussions produced the prospect that a common knowledge platform such as G5EC could identify new opportunities for collaboration that lie beyond the reach of individual firms and researchers working on their own.

2.3. 16 October: Institutional Conditions for Industrial Co-creation and the Legacy of the G20 Presidencies

Session 4 considered energy cooperation, critical minerals, e-waste and circular industrialisation together. The pace of energy transition, resource conditions and the meaning of food and energy security differ from country to country, and participants agreed that Japan's experience should be consulted as a record of trial and error. On critical minerals, participants pointed to the need to link extraction and export to local processing, technology, employment and the development of industrial capabilities. Long-term purchase agreements and phased cooperation were considered, but questions concerning implementing bodies, finance and governance remained to be worked out.

In circular industries, participants emphasised that technologies for using waste as secondary resources need to be complemented by institutions for collection, sorting, local administration and quality standards, and that social policy measures must be carefully designed so that hasty regulation does not exclude people who earn their living in the informal sector. Experience from Japan-ASEAN cooperation through the AEM-METI Economic and Industrial Cooperation Committee (AMEICC) and from the review of the ASEAN Trade in Goods Agreement (ATIGA) within ASEAN was presented as a reference for public-private dialogue, traceability and the development of standards for remanufactured goods. These examples were offered as lessons from existing cooperation that G5EC can draw on and adapt.

Session 5 discussed the 'intermediate stage' of deep tech, including fusion, which runs from discovery through mass production, certification and customer acquisition to reinvestment. Participants pointed to the need to involve the Global South from an early stage in research, testing, components, standards and demand creation, well before mature technologies are ready for deployment. The supply chain ESG analysis raised questions about inconsistencies in national and regional data, the geographical distribution of impacts and applications to policy evaluation. On space and Earth observation, partic-

ipants noted that signing agreements alone does not create businesses or local capabilities, and called for cooperation on implementation pathways covering regulation, procurement, finance and demand.

Session 6 explored the issues raised by Indonesia in 2022, India in 2023, Brazil in 2024 and South Africa in 2025 during their G20 presidencies. The discussion on Indonesia identified the overlapping challenges of inclusive digitalisation, energy transition, accessible climate finance and green industrialisation, together with difficulties in finance, regulation and project development. The discussion on India emphasised co-creation among equal partners in areas such as supply chains, digital public infrastructure, financial inclusion and critical minerals, and making use of existing research networks such as DAKSHIN (the Development and Knowledge Sharing Initiative, a hub for Global South cooperation hosted by RIS). The discussion on Brazil addressed shared ownership and benefit-sharing, including the benefits of intellectual outputs and patents, in linking social inclusion, health, inequality and debt with industrial development. The discussion on South Africa emphasised local value addition for critical minerals, the cost of capital and debt, reducing investment risk through feasibility studies, and connecting T20 research with the B20 (Business20, the G20 engagement group for the business community) and industry. Taken together, these discussions showed a continuity of policy knowledge, with issues raised by one presidency taken up by its successors.

Session 7 discussed how G5EC can build on and connect the achievements of existing networks, including G20 and T20 policy dialogue and the networks that universities, research institutions and firms have each built. Several proposals were made on how to connect research outcomes with practice, on organisational management, on the secretariat and on relations with industry, but no specific institutional design was settled. The session closed with a shared commitment to developing the initiative jointly among the five countries.

Figure 2. Group Photo on 16 October 2026: Mr. TANAKA Kazushige, Director-General of Trade Policy Bureau, METI and participants



2.4. 19 October: Perspectives of the Four Country Representatives at the Nexus Japan–GS Forum

Building on the two-day Strategic Workshop, the Nexus Japan–GS Forum on 19 October offered an opportunity to discuss Japanese industry, business development and collaboration among government, financial and research institutions more broadly. In the final session (*Closing Session: Building the Global Five Epistemic Caucus: A Common Knowledge Platform for Policy and Business Co-Creation in the Global South*), representatives of CSIS (Indonesia), RIS (India), IPEA (Brazil) and SAIIA (South Africa) spoke about their countries' G20 presidency experience and the future potential of G5EC. This session concluded a separate public dialogue and was distinct from Session 7 of the Strategic Workshop.

The CSIS (Indonesia) representative identified inclusive digitalisation, energy transition, accessible climate finance and green industrial development as a legacy shared by the four presidencies, and called for moving from general commitments to concrete and mutually consistent projects. The representative stressed the importance of cooperation that links participants' strengths, responsibilities and benefits into a coherent whole.

The RIS (India) representative noted that G5EC can start from the knowledge accumulated over the past four years and the needs that each country has already identified. The representative described using the CKP to identify sectors and projects, and the potential to extend Japan-India collaboration into joint projects in third countries, such as in Africa. Making use of DAKSHIN and other existing networks to turn research outcomes into business opportunities was emphasised.

The IPEA (Brazil) representative said that the long-standing cooperation between Japan and Brazil in agriculture, industry and technology should be linked to measurable development outcomes involving research, finance, business and government. Concrete examples illustrated the limits of introducing finished technologies without an understanding of local livelihoods, institutions and communities, and the importance of co-creation in which projects are designed together with local actors. Research institutions are also expected to evaluate and verify project outcomes in addition to generating new knowledge.

The SAIIA (South Africa) representative highlighted the capacity to scale innovations that originate in Africa, connections with industrial practice and regional development challenges. Describing G5EC as an epistemic community, the representative stressed the importance of a three-way relationship that carries research-based evidence through to policy and industrial implementation. Cooperation at regional, bilateral, trilateral and international levels, and engagement with international institutions grounded in knowledge, were also proposed.

The four representatives treated the differences in their countries' industrial, institutional, market and social experience as the starting point for co-creation. Their remarks put forward proposals and

issues for further discussion, and do not represent a final agreement on G5EC's governance structure, individual projects or allocation of funds.

Figure 3. Group Photo of the Speakers at the Closing Session on 19 October 2026



2.5. Overall Outcomes of the Tokyo Meetings and Issues for the Next Section

Taken together, the outcomes of the two meetings held over three days can be summarised in three points. First, both the sectoral research discussions and the statements of the four country representatives demonstrated concretely the value of linking the experience accumulated through the four consecutive Global South G20 presidencies with joint research and business cooperation with Japan. Second, in every sector, feasibility was found to depend more on the local conditions that make technology work, namely institutions and standards, finance, the people and businesses that carry projects forward, and demand, than on whether the technology itself is available. Third, a cross-cutting task emerged: moving research outcomes beyond policy recommendations into a two-way exchange with the practice of firms, investors and local communities.

G5EC can therefore be understood as the forum in which the five countries give concrete form to a platform, the CKP, that deepens existing research networks and public-private cooperation while carrying out a continuous sequence of functions: (1) discovering opportunities for cooperation, investment and business (Discovery); (2) transforming them into implementation by bringing together institutions, standards, finance and human resources (Transformation); and (3) accumulating results and lessons and expanding them to other regions and countries (Expansion). This report uses these three functions as an analytical framework for organising the issues addressed in Tokyo; they were not adopted at the meetings as a finished institutional arrangement.

Realising this direction in a sustained way requires, in addition to the exchange of knowledge among researchers, a mechanism that connects the knowledge of countries that have followed different development paths among the people who carry out research, policy and industry, and that generates new knowledge and practice from their interaction. The next section builds on the discussions at the Tokyo Meetings to examine, in theoretical and practical terms, the meaning of Epistemic Connectivity and the concept of the Common Knowledge Platform (CKP) that supports Discovery, Transformation and Expansion.

Sources: G5EC Strategic Workshop, Record of Discussion (15 and 16 October 2026, all seven sessions); Nexus Japan–GS Forum, G5EC Final Session — Thematic Record of Interventions (19 October 2026). This section is an overview analysis based on these two records and does not replace a verbatim record.

3. Epistemic Connectivity and the Common Knowledge Platform (CKP)

3.1. Three Priority Areas and the Broadening of Discussion at the Tokyo Meetings

Consultations with each country in 2026 identified three priority areas: (1) joint engagement in international rule-making, (2) business collaboration including start-ups and (3) the sharing of growth and development strategies. These are the priority areas that the CKP addresses, and G5EC gives them concrete form through cooperation between Japan and four Global South countries. Each is an activity for developing, through joint work with Japan, the policy experience that the four Global South countries accumulated during their G20 presidencies.

At the G5EC Strategic Workshop on 15 and 16 October, all seven sessions examined cross-sectoral issues and opportunities for cooperation. On 15 October, the topics were process-level semiconductor value chains, the development of practical knowledge and human resources through AI, advanced human resource development by higher education institutions and joint education among universities, river basin development and the creation of secondary markets for investment. On 16 October, they were local processing of critical minerals, circular industries and the informal sector, mechanisms for taking fusion and space research through to commercialisation, and the consistency of supply chain ESG data. Participants compared the submitted research papers and proposals with each country's experience, identified obstacles to implementation and raised opportunities for cooperation relevant to all three priority areas.

The Nexus Japan–GS Forum on 19 October differed from the workshop in purpose and participants. It involved a broad dialogue including Japanese policy and industry stakeholders. In its final session, representatives of research institutions from the four countries each raised, from their own perspectives, the importance of linking the policy experience of past G20 presidencies with concrete projects, finding economic opportunities in existing knowledge, developing projects jointly with local actors and connecting research, policy and industry.

The discussions at both meetings revealed something that all three priority areas require: a way of mobilising knowledge that connects the knowledge of different countries, puts it into practice and carries it forward into the next round of cooperation. If the three priority areas define what to work on, this mobilisation of knowledge defines how to work on it. The following subsections first examine the conceptual foundation of this idea (Section 3.2) and then organise it into the three functions of the CKP (Section 3.3).

3.2. Debates on Knowledge Creation and Implementation: The Significance of Epistemic Connectivity

Alongside the question of how to use individual research findings, the Tokyo Meetings also discussed who produces knowledge, how different forms of knowledge connect, and what effects they have on policy and industrial activity. These discussions form an important part of the meetings for understanding Epistemic Connectivity.

In Session 2 of the Strategic Workshop on 15 October, the idea of epistemic justice was explicitly raised. Global South countries are more than recipients of knowledge produced elsewhere. Each country's history, culture, institutions and practical experience are sources of knowledge in their own right, and co-creation requires active participation in knowledge creation and mutual respect. This discussion was linked to joint research and human resource development among universities and to the joint development of institutions and technologies suited to local conditions.

Meanwhile, in the final session of the public forum on 19 October, SAIIA Chief Executive Elizabeth Sidiropoulos referred to the notion of an epistemic community and stressed the importance of treating the path from accumulating research-based knowledge to implementing it in policy and industry as a single continuum. Even where knowledge of the necessary solutions exists, the inability to implement them can be a major constraint. She pointed to the need for interaction among researchers, policymakers and business and industry.

The two discussions arose in different settings and addressed different questions. The former asks who produces knowledge and how different bodies of knowledge should respect one another; the latter asks how knowledge can be carried through to implementation. Adding a question raised repeatedly across the sessions, namely how research outcomes can be connected with finance and business activity, human resource development and local initiatives, brings into view the significance of Epistemic Connectivity, which underpins the CKP: connecting different forms of knowledge and experience while preserving their distinctive characteristics, and thereby generating new co-creation. This can also be described as 'emergence' in knowledge.

This idea rests on the principle of Path Diversity discussed in Section 1. Japan, Indonesia, India, Brazil and South Africa differ in their resources, industrial structures, technology, human resources, institutions, energy situations and market conditions. G5EC starts by identifying opportunities for

mutual complementarity within these differences. Accordingly, it gives priority to deepening existing relationships: the channels of policy dialogue (the G20, together with the T20 in which researchers participate and the B20 in which the business community participates) and the international partnerships that universities, research institutions and firms have each built.

Viewed through the discussions at the Tokyo Meetings, the process by which knowledge is created, connected, implemented and carried forward into the next round of cooperation has three points at which it tends to stall. First, knowledge scattered across countries remains unknown to others and lacks opportunities to connect. Second, existing knowledge fails to be implemented as policies or projects. Third, the knowledge and personal connections gained through a project are lost when the project ends. The three functions of the CKP described in the next subsection support the flow of knowledge at these three points.

3.3. The Movement of Knowledge within the CKP: Discovery, Transformation and Expansion

The three functions of the CKP describe the movement of knowledge within the CKP: how it connects, how it is reflected in policies and projects, and how it spreads to other countries and sectors. This report divides this movement into three phases, called Discovery, Transformation and Expansion. The three stalling points identified in the previous subsection are the points in each phase where the movement of knowledge tends to stop. Concerns relating to discovery and transformation also appeared in the sectoral discussions, and the need to extend the results of cooperation to further activities and regions was raised repeatedly. These three names were assigned by this report to organise the discussions at the meetings.

The first phase, Discovery, is where knowledge meets and connects. By linking technology, resources and human resources in one country with demand in another, it reveals opportunities for cooperation that would be hard to find alone. Examples include the process-level analysis of semiconductors, the processing of critical minerals and related industrial linkages, diverse opportunities to participate in fusion research, and international cooperation in river basin development, all discussed on 15 and 16 October. On 19 October, participants also raised the question of connecting existing knowledge with actual demand and applying past cooperation experience to new projects.

The second phase, Transformation, is where connected knowledge is reflected in policies and projects. This requires institutional conditions such as rules and standards, financial conditions, and the people and businesses to carry the work forward. In the discussion on innovative finance on 15 October, investment exits, exchange rate risk, information asymmetry and financial regulation were identified as challenges. The discussions on fusion and space business likewise pointed to the need to connect research with demonstration, certification, manufacturing and the formation of customers and markets. On 19 October, emphasis was placed on turning G20 policy commitments into concrete

projects, converting accumulated research into economic opportunities and bringing industry into the implementation process.

The third phase, Expansion, is where experience gained through implementation is stored as knowledge and spreads to other countries and sectors. Session 2 on 15 October discussed sustaining practical knowledge and personal networks after projects end, creating a cycle of practice, knowledge, human resource development and further practice. The need to carry forward the policy legacy of the four consecutive Global South G20 presidencies relates to the same issue. On 19 October, existing international research networks and opportunities for cooperation involving third countries were presented. Expansion requires adapting lessons drawn from both successes and failures to the conditions of each region. Knowledge that spreads in this way becomes the basis for new discoveries where it arrives. The three phases thus form a cycle that runs from Discovery through Transformation and Expansion and back to Discovery.

To summarise the relationship between the three priority areas and the three functions: the priority areas show what the CKP works on, and the functions show how knowledge moves in that work. G5EC is the forum in which these priority areas and this movement of knowledge are put into practice among the five countries. In business collaboration, for example, technologies and demand in different countries are connected to identify candidate projects (Discovery), financial and regulatory conditions are put in place to launch them as businesses (Transformation), and the experience is applied to subsequent projects and other countries (Expansion). Joint engagement in rule-making and the sharing of growth and development strategies require the same three movements. The three functions also apply to the individual forms of cooperation that took concrete shape at the Tokyo Meetings, such as local processing of critical minerals and joint education among universities.

3.4. Giving Concrete Form to the Common Knowledge Platform and Future Joint Work

The CKP is conceived as a platform for cooperation that holds papers and data and, above all, connects those who create knowledge (universities and research institutions), those who use it (policymakers, firms and financial institutions) and the places where it is implemented (local communities), so that Discovery, Transformation and Expansion occur in continuous succession. Experience generated by new projects is retained as knowledge, and that knowledge leads to the next round of cooperation. The significance of the CKP lies in creating this cycle.

The specific design of the CKP within G5EC, including the scope of information to be shared, participants, governance, links with finance and business, and the allocation of intellectual property and results, was not settled at the October meetings. The diverse views expressed in the discussions are issues for the research institutions of the five countries and other partners to examine jointly; they have yet to become points of agreement among all participants.

The Strategic Workshop on 15 and 16 October demonstrated concrete new opportunities for cooperation spanning the three priority areas. The public forum on 19 October opened these up to cooperation with a wide range of industry and policy stakeholders, and the representatives of the four countries each set out directions for G5EC's development from their own perspectives. The task ahead for G5EC is to translate Epistemic Connectivity, grounded in the idea of Path Diversity, into concrete activities and accumulated knowledge under shared ownership.

Chapter 2: Advancing Technology and Innovation to Strengthen Competitiveness in Japan and the Global South

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1. What Japan Aims to Achieve through "A New Kind of Technology-Driven Nation and Strengthening Competitiveness"

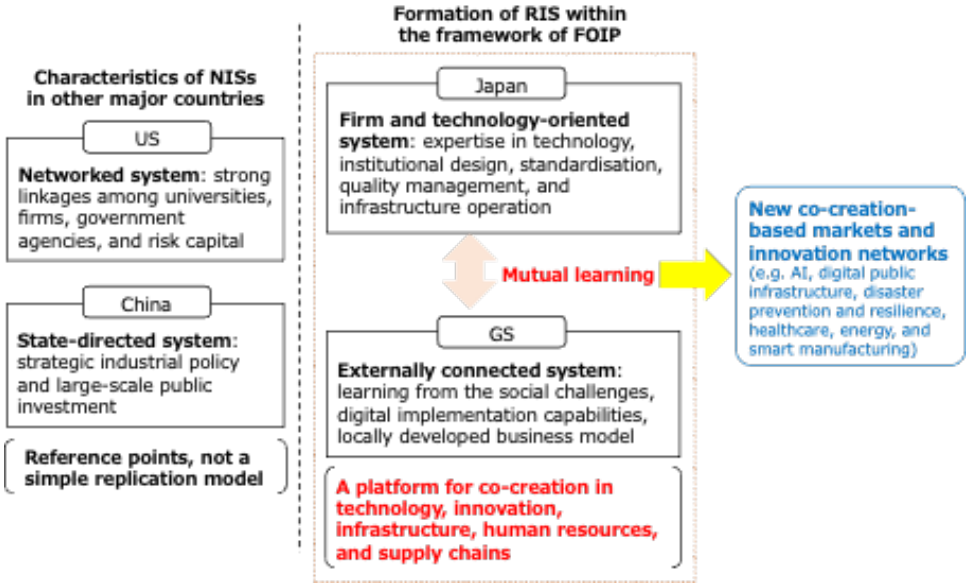
Technological change is accelerating globally across a wide range of fields, including artificial intelligence (AI), particularly generative AI, semiconductors, quantum technologies, biotechnology, healthcare, and space. Increasingly interconnected with AI, these technologies are forming the foundations of new industries. AI, for example, requires advanced semiconductors capable of rapidly processing vast amounts of data, while quantum technologies may further enhance computing capabilities. In biotechnology, healthcare, and space, AI is also becoming a key enabler of faster research and development (R&D) and social implementation. Moreover, AI is beginning to function as a general-purpose technology (GPT) that reshapes corporate decision-making, organisational structures, and business models. This transformation of economic, industrial, and social systems centred on AI can be described as AI Transformation (AX). The foundation of AX depends not only on AI models and applications but also on an integrated technological and infrastructure base encompassing semiconductors, computing resources, data centres, cloud services, telecommunications networks, electricity supply, and cybersecurity.

Against this backdrop, "A New Kind of Technology-Driven Nation and Strengthening Competitiveness" is a cross-cutting issue common to the 17 strategic fields identified by the Council for Japan's Growth Strategy. It is a fundamental policy challenge underpinning public-private investment, international expansion, human resource development, industry-academia cooperation, international standardisation, and demand creation. AX is expected to reshape industrial structures, the international division of labour, inter-firm collaboration, corporate organisations, business models, employment, and human capital formation. Japan's ambition to realise a new kind of technology-driven nation must therefore go beyond supporting R&D. It must simultaneously strengthen industrial competitiveness, enhance economic security, and address social challenges through the deployment of new technologies. This requires both the public and private sectors to combine strategic investments that enhance resilience against potential crises with growth investment. At the national level, sustained investment in the technologies underpinning AX is indispensable. At the corporate level, firms need to redirect accumulated financial resources towards domestic growth sectors, intangible assets, human capital, R&D, and start-ups, while accelerating business portfolio restructuring and risk-taking.

Japan retains strengths in corporate R&D, patents, and the capacity to improve and implement technologies at manufacturing sites. In particular, it continues to have a comparative advantage in process-oriented technology implementation in areas such as manufacturing, advanced materials, robotics, and infrastructure operation. At the same time, amid intensifying global R&D competition, Japan faces challenges in producing high-impact research, developing doctoral-level talent, creating start-ups, and scaling businesses in AI and software. Japan therefore needs to reinforce the research base of industry, academia, and government while strengthening the pathways from research outcomes to practical application and market creation. Key measures include strengthening public research institutions, promoting competitive markets, creating demand through government procurement, pursuing regulatory and institutional reforms, and advancing standardisation.

From a global perspective, a key challenge is to give concrete form to the Free and Open Indo-Pacific (FOIP) not only as a framework for values-based diplomacy and security cooperation but also as a platform for co-creation in technology, innovation, infrastructure, human resources, and supply chains. Under FOIP, the Global South (GS) should be positioned not simply as a production base, consumer market, or recipient of assistance, but as a co-creation partner. Japan can contribute expertise in technology, institutional design, standardisation, quality management, and infrastructure operation, while also learning from the social challenges, digital implementation capabilities, locally developed business models, and large young populations of GS countries. Through such mutual learning, Japan and GS countries can develop new co-creation-based markets and innovation networks in areas such as AI, digital public infrastructure, disaster prevention and resilience, healthcare, energy, and smart manufacturing. The United States (US) and Chinese National Innovation Systems (NISs) provide important reference points—respectively, a networked system characterised by strong linkages among universities, firms, government agencies, and risk capital, and a more state-directed system characterised by strategic industrial policy and large-scale public investment—but neither should be regarded as a model for simple replication by Japan and GS countries. Figure 1 illustrates the concept of a "regional innovation system" (RIS) linking the NISs of Japan and GS countries.

Figure 1. The Concept of a Regional Innovation System



Source: Author

This chapter examines technology and innovation issues in Japan, the US, and selected GS countries—Brazil, India, Indonesia, and South Africa. Section 2 discusses NISs and how they vary across countries and stages of development. Section 3 reviews key innovation-related indicators. Section 4 examines institutional foundations for innovation, focusing on patent systems and competition policy. Section 5 analyses the principal actors and policy instruments that generate innovation, including firms, universities, public research institutions, and government procurement and public demand. Section 6 concludes with policy recommendations for Japan and GS countries.

2. Innovation Systems

Innovation systems differ across countries. Japan's innovation system was widely praised in the 1980s for its contribution to the country's rapid economic development (Freeman 1987). An NIS refers to a network of public- and private-sector institutions, organisations, activities, and interactions that facilitate the creation, importation, improvement, and diffusion of new technologies (Freeman 1995). Developed by Freeman (1987, 1995), Lundvall (1992), Nelson (1993), and others, the NIS concept provides a framework for understanding how interactions among governments, firms, universities, public research institutions, financial systems, labour markets, and education systems shape innovation outcomes.

Private-sector R&D has played an important role in innovation in both Japan and the US. In the US, however, federal research funding, universities, defence and space agencies, government procurement, and venture capital became closely interconnected, creating an NIS oriented towards new industry formation. Collaboration among industry, academia, and government has been particularly extensive

across a wide range of industries. Since the late 1950s, research funding and government procurement by organisations such as the Defence Advanced Research Projects Agency (DARPA), the National Aeronautics and Space Administration, and the National Institutes of Health (NIH) have been linked with university research and private-sector technology development. These interactions are widely regarded as having contributed to the development of defence, space, aerospace, semiconductors, computers, and biopharmaceuticals.

By contrast, Japan's NIS was characterised by government-led industrial policy, particularly under the Ministry of International Trade and Industry (MITI); extensive in-house R&D by large firms; firm-based training and long-term employment; joint development, quality control, and continuous improvement through keiretsu-based inter-firm relationships; and an indirect financial system centred on main banks. Given Japan's limited domestic natural resources, its NIS evolved around export-oriented manufacturing, enabling domestic firms to become competitive in global markets. This distinctive system became a target of criticism during the US–Japan Structural Impediments Initiative (1989–1990), while also serving as a model for the catch-up strategies of economies such as South Korea and Taiwan. However, Japanese firms subsequently fell behind in the information and communications technology (ICT) revolution that accelerated around 2000, exposing limitations in the Japanese NIS.

Today, a transformation of industrial and social systems—namely, AX—is underway. Like earlier ICT, AI is expected to diffuse as a GPT: a foundational technology that can be applied across broad areas of the economy and society rather than being confined to a single use, fundamentally transforming both everyday life and industrial activity (Bresnahan and Trajtenberg 1995). GPTs are commonly characterised by pervasiveness, ongoing improvement, and innovation spawning. Generative AI increasingly satisfies these conditions and is likely to spread as a cross-industry foundational technology. Empirical evidence shows that generative AI can raise productivity in tasks such as customer support, programming, and document preparation (Brynjolfsson, Li, and Raymond 2023). However, sustained economy-wide productivity gains from AI require complementary investment in business processes, organisational structures, skills, data infrastructure, security, and governance.

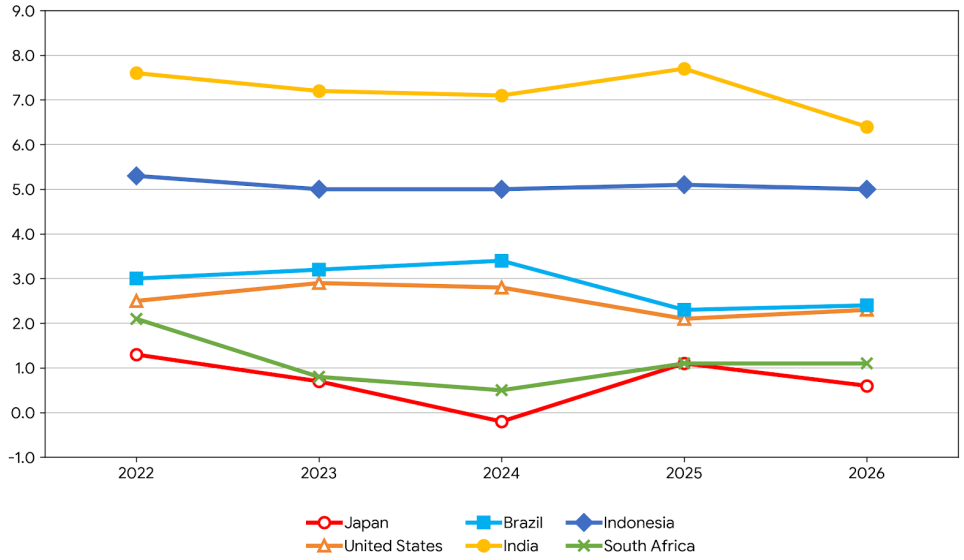
The US has maintained its position as the world's leading economy partly by developing and applying GPTs, including AI, and translating them into innovation. China has also rapidly strengthened its capabilities in AI, data, and digital industries. Against this background, Japan and countries in the GS face the strategic question of whether their existing NISs remain adequate. Japan's current industrial policies, particularly those centred on semiconductors, can be understood as mission-oriented policies combining R&D, capital investment, supply-chain resilience, and demand creation (Mazzucato 2013, 2021). To support the transition towards AX, Japan needs to strengthen open innovation, including collaboration among industry, academia, and government, while redesigning complementary assets such as data infrastructure, labour mobility, and start-up linkages. At the same time, Japan should preserve and further develop its traditional strength in adapting technologies to specific workplaces and industries—for example, by deploying AI in manufacturing.

The development experiences of Asian developing countries suggest that national development depends not on imitating or reproducing the innovation systems of other countries, but on the capacity to create new areas of growth through knowledge spillovers and learning (Lundvall et al. 2006). For countries in the GS, the key challenge is therefore not to reproduce the US, Japanese, or Chinese NIS as a complete package, but to build an "externally connected NIS" suited to their own industrial structures, human capital, and institutional capabilities. Such a system should establish linkages with foreign firms, public research institutions, universities, diaspora communities, international organisations, and private investors. This requires strengthening absorptive capacity—the ability to recognise the value of external knowledge, assimilate it, and apply it (Cohen and Levinthal 1990)—within firms, universities, and government agencies. The central challenge is to connect the rapidly evolving NISs of advanced economies and the innovations they generate with domestic development priorities. More specifically, externally connected NISs linking Japan and countries in the GS could evolve into a RIS that builds on their complementary strengths and promotes reciprocal innovation.

3. Innovation-Related Data

The US has maintained relatively resilient real GDP growth (Figure 2), while Japan has continued to experience sluggish growth. Estimates by the Cabinet Office and the Bank of Japan place Japan's potential growth rate at around 0.5%, highlighting the need to raise it through productivity growth and innovation. Among GS countries, Brazil has maintained relatively solid growth, supported by natural resources and agriculture; India by services, IT, and domestic demand; and Indonesia by resource-related industries and consumer demand. By contrast, South Africa's economy has remained weak, reflecting constraints on electricity supply and logistics, high unemployment, and sluggish investment.

Figure 2. Real GDP Growth Rates (2022–2026, %)



Note: Figures for 2025 and 2026 include IMF estimates and projections. Data for India are presented on a fiscal-year basis.

Source: IMF, World Economic Outlook, April 2026; IMF, World Economic Outlook Update, July 2026.

In terms of labour productivity (Table 1), the US recorded solid growth of 5.3% between 2020 and 2024 despite already having a high productivity level. Investment in digital technologies and intangible assets, together with strong business dynamism, may have contributed to this performance. Japan, by contrast, lags behind the US in both productivity levels and growth, recording an increase of 3.7% over the same period. Delayed digitalisation and limited labour mobility may be contributing factors. Among GS countries, India and Indonesia recorded relatively high productivity growth of 15.5% and 12.9%, respectively. However, these increases reflect multiple factors, including industrial upgrading, manufacturing catch-up, and the development of resource-related industries, and therefore cannot be directly attributed to AX. Brazil recorded weak productivity growth of −1.1% despite its competitiveness in agriculture and resource-related industries, partly because of the large share of low-productivity services. South Africa experienced a decline of −3.9%, reflecting the structural constraints discussed above. The productivity gap between the US and both Japan and GS countries may therefore widen further as AX progresses.

Table 1. Labour Productivity per Worker (2020–2024, 2021 PPP International Dollars)

Country	2020	2021	2022	2023	2024
Japan	81,349	83,620	83,826	84,723	84,354
United States	145,800	149,655	148,654	150,436	153,544
Brazil	41,893	41,905	40,323	41,148	41,441
India	21,152	22,095	22,615	23,680	24,430
Indonesia	25,884	27,058	27,581	28,184	29,217
South Africa	50,732	54,304	52,340	49,596	48,752

Source: World Bank, *World Development Indicators*.

R&D expenditure as a share of GDP (Table 2) is substantially higher in Japan and the US than in the GS countries examined here. The US maintains a high R&D-to-GDP ratio and ranks among the world's largest R&D spenders in absolute terms (Figure 3). Japan likewise maintains a high ratio, although it faces challenges in the international impact of its research. Brazil has a relatively high R&D-to-GDP ratio among GS countries, but the ratio has stagnated in recent years. While Brazil has strengths in aerospace, agricultural research, and resource- and energy-related fields, the expansion of R&D investment in these areas remains limited. In India, R&D investment has increased alongside economic growth, but the rapid expansion of digital and service industries has not translated proportionately into higher domestic R&D investment. Indonesia has benefited from investment in resource processing, infrastructure, and manufacturing, but its R&D-to-GDP ratio remains low and investment in basic research and advanced technologies is still limited. South Africa has experienced stagnation in both productivity and R&D investment.

Table 2. R&D-to-GDP Ratio (2020–2024, %)

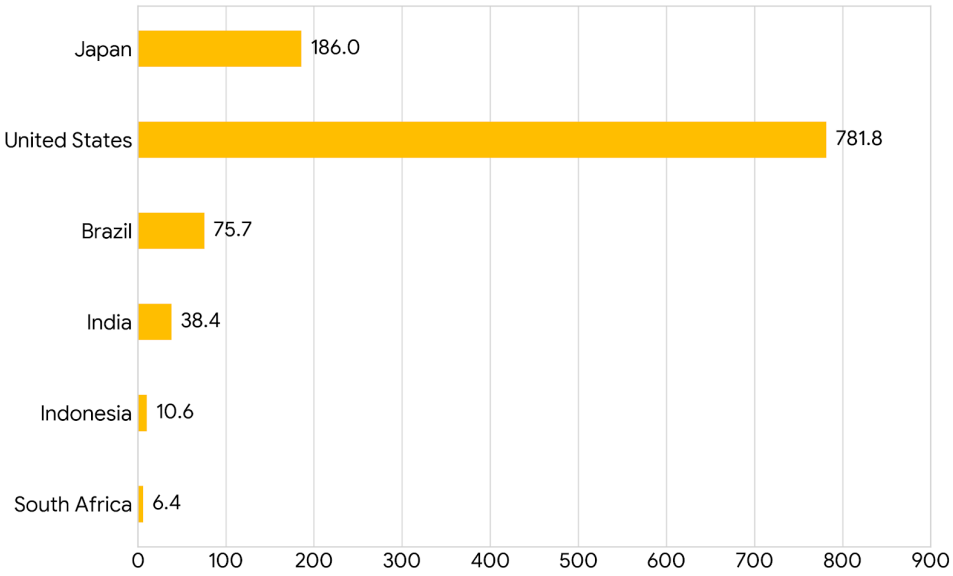
Country	2020	2021	2022	2023	2024
Japan	3.27	3.27	3.40	3.44	3.62
United States	3.41	3.46	3.48	3.42	3.44
Brazil	1.22	1.13	1.19	N.A.	N.A.
India	0.65	N.A.	N.A.	N.A.	N.A.
Indonesia	0.28	N.A.	N.A.	N.A.	N.A.
South Africa	0.60	0.62	0.61	N.A.	N.A.

Note 1: N.A. indicates that data are not available for the corresponding year.

Note 2: Figures for Japan and the United States for 2024 are OECD estimates.

Source: OECD, Main Science and Technology Indicators; World Bank, World Development Indicators.

Figure 3. R&D Expenditure by Country, 2024 (USD billion, constant 2015 PPP)



Source: WIPO estimates based on the Global Innovation Index Database and data from Eurostat, OECD, RICYT, and UNESCO UIS.

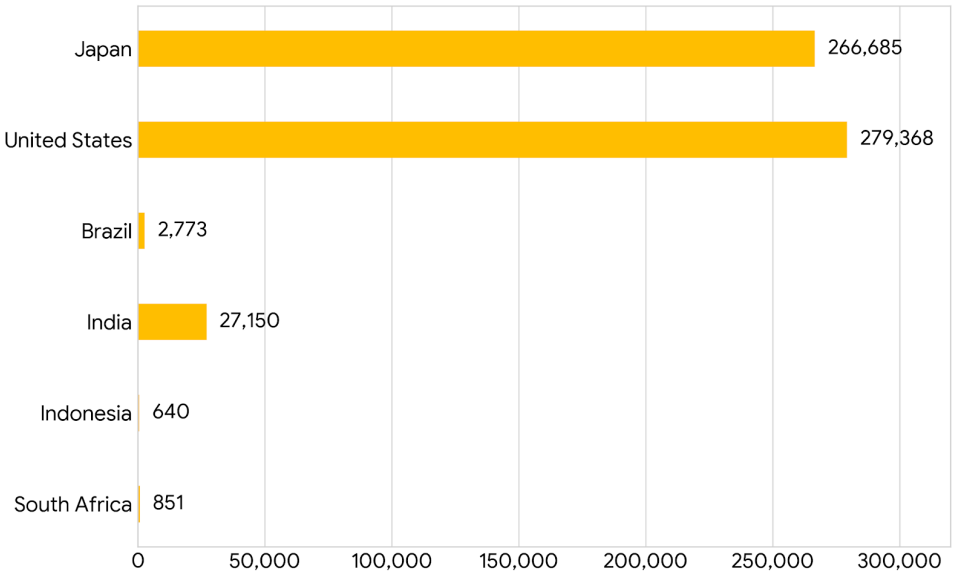
4. Institutions for Innovation

4.1. The Patent System

The patent system encourages R&D investment by granting inventors exclusive rights for a limited period in exchange for disclosure of their inventions. It also facilitates the accumulation and use of technological information. However, excessively broad or strong patent rights may impede follow-on innovation and market entry. An appropriate balance is therefore needed among the scope and duration of protection, the quality of patent examination, and the effectiveness of enforcement. This is particularly important for small and medium-sized enterprises (SMEs). If infringement is difficult to prove or damages are prohibitively costly through litigation, inventions may be inadequately protected, weakening incentives to innovate.

The US accounts for one of the world's largest numbers of patent applications and grants (Figure 4). From the late 1990s through the early 2000s, US firms built strong patent portfolios in areas such as software, business methods, biotechnology, and pharmaceuticals, using intellectual property to secure competitive advantages, support defensive strategies, and influence technological standards. Since the 2010s, however, stricter patent eligibility requirements have placed limits on some software and business-method patents. Nevertheless, the US retains one of the world's strongest and most influential intellectual property protection systems, supporting its large economy and innovation market. It also records the world's largest surplus in international transactions involving intellectual property.

Figure 4. Patent Grants by Country of Applicant Origin (2024)>



Source: World Intellectual Property Organization, WIPO Statistics Database.

Japan also records one of the world's largest surpluses in charges for the use of intellectual property, second only to the US. These revenues derive not only from patents but also from technology licensing fees from overseas manufacturing subsidiaries, trademarks, copyrights, software, and other forms of intellectual property. Japan has particular strengths in patenting and accumulated technological capabilities in manufacturing sectors such as transport equipment, electrical machinery, and advanced materials. From the late 1990s, following the US shift towards a pro-patent policy, Japan strengthened the creation, protection, and utilisation of intellectual property as part of its national strategy and sought to restore industrial competitiveness by commercialising research outcomes from universities and research institutions. In recent years, however, Japan has lagged behind the US and China in both the volume and impact of patenting in rapidly expanding digital fields such as AI and software.

India has steadily increased its number of patents, suggesting growing R&D capabilities in areas such as digital technologies and pharmaceuticals. By contrast, the numbers remain relatively limited in Brazil, Indonesia, and South Africa, indicating challenges in developing high-value-added technologies that can compete in global markets, generating innovation, and building the capacity to file patents internationally.

In the AI era, a key policy question is the extent to which software and algorithms should be protected. Countries need to clarify the scope of protection for AI-related inventions while ensuring that excessive exclusivity does not impede follow-on innovation. For Japan in particular, standard-essential patents and international standardisation are closely linked to technological leadership and competitiveness in telecommunications, semiconductors, AI, the Internet of Things, and smart manufacturing. Patent policy should therefore be integrated with standardisation strategies and

licensing negotiations. In GS countries, stronger patent protection may constrain technological learning, knowledge spillovers, and market entry by start-ups. Each country therefore needs to strike an appropriate balance, according to its stage of industrial development, among timely and high-quality patent examination, an appropriate scope of protection, effective enforcement, and the diffusion of technology.

4.2. Competition Policy

In the classical literature on innovation, Schumpeter argued that economic development arises through "new combinations", such as new products, production methods, sources of supply, and forms of organisation, which transform existing industrial structures (Schumpeter 1934). This process was later described as "creative destruction". Start-ups and other new entrants can play a particularly important role by introducing new ideas, technologies, and products, thereby placing pressure on incumbent firms and industries to adapt and creating opportunities for economic growth and structural change. Schumpeter later also argued that large firms and monopolistic enterprises with substantial financial resources and organisational capabilities could undertake large-scale R&D and drive innovation (Schumpeter 1942).

Regarding the relationship between competition and innovation, Arrow's replacement effect (Arrow 1962) suggests that monopolistic firms have relatively weak incentives to introduce new technologies because they already earn monopoly profits from existing technologies, reducing the incremental gains from replacing them. Firms in competitive markets, by contrast, may have stronger incentives to invest in R&D because innovation can enable them to escape competition and earn higher profits. However, the relationship between competition and innovation may be inverted-U-shaped rather than linear (Aghion et al. 2005). Where firms are technologically close, greater competition can stimulate innovation as they seek to escape competitive pressure. By contrast, when competition becomes too intense, particularly where technological gaps between firms are large, the investment incentives of lagging firms may weaken—the so-called Schumpeterian effect.

Competition policy should therefore prevent abuses of market power and anti-competitive barriers to entry while allowing firms a reasonable prospect of recouping their R&D investments. This requires an institutional framework that promotes innovation through market entry, start-up creation, collaborative R&D, and other forms of competition and cooperation. In the AI era, competition policy must also address the risk that a small number of firms may vertically integrate and control complementary assets—including data, computing resources, cloud infrastructure, app stores, advertising platforms, and foundation models. Such control could raise barriers to entry for start-ups and other new entrants and reduce the diversity of innovation.

In Japan and the US, major competition-policy concerns include the market power of large technology companies, killer acquisitions, and the exclusive control of data, AI infrastructure, and other critical assets. In GS countries, the challenges vary with the stage of economic development. Alongside

concerns over market dominance by foreign digital platforms, these countries may face high market concentration among domestic incumbents and significant barriers to entry for SMEs and start-ups. Competition policy in GS countries should therefore go beyond restraining monopolistic practices that inhibit innovation. It should also balance market entry and capability building by domestic firms, collaboration with foreign firms, consumer protection, and technology diffusion.

5. Actors and Policies that Generate Innovation

5.1. The Business Sector

In any country, private firms are central actors in the NIS. Large firms primarily undertake R&D investment, commercialisation and mass production, and international expansion, while start-ups and venture firms explore new technologies and markets, enter high-risk fields, complement innovation by large firms, and create employment. Science-based university spin-offs, particularly deep-tech start-ups, are also expected to commercialise university research and patents rapidly and drive breakthrough innovation. Because such firms typically require long development periods and substantial funding, venture capital alone is often insufficient. Government support, public procurement, and collaborative R&D with large firms are therefore important. Established firms also need to seek sources of innovation beyond their organisational boundaries, including from start-ups, and accelerate open innovation (Chesbrough 2003).

In practice, entrepreneurial activity in Japan has remained relatively weak compared with countries such as the US. Contributing factors include traditional features of Japanese corporate organisation and finance, such as low labour mobility associated with long-term employment, long-standing business relationships, and a financing structure centred on main banks. Other constraints include an insufficient supply of risk capital and limited mobility between universities and firms. Conventional debt financing is particularly ill-suited to R&D-intensive start-ups that lack collateral and stable cash flows. Japan therefore needs a broader range of financing channels—including venture capital, angel investment, corporate venture capital, growth-oriented capital markets, and government-backed risk capital—supported by an appropriate institutional framework.

In the US, the Small Business Innovation Research (SBIR) Program supports R&D-intensive small businesses that contribute to industrial dynamism. Federal agencies with extramural R&D budgets above specified thresholds are required to allocate a portion of those budgets to R&D support for small businesses. Agencies such as the Department of Defense, the Department of Energy, and the NIH provide funding for early-stage R&D and have supported the growth of technology-oriented start-ups. Evidence suggests that firms receiving SBIR support are more likely to grow subsequently and to obtain venture capital financing, partly through a signalling effect (Lerner 1999). Japan introduced its own SBIR programme in 1999, and reforms since 2021 have sought to provide more continuous support

from early-stage R&D to government procurement and civilian applications. Compared with the US SBIR Program, however, Japan's system still faces challenges in linking R&D support with government procurement and private risk capital.

Cross-country assessments of entrepreneurship frequently use the Total Early-Stage Entrepreneurial Activity (TEA) rate (Table 3) and the National Entrepreneurship Context Index (NECI) (Table 4), both compiled by the Global Entrepreneurship Monitor. TEA provides a broad measure of entrepreneurial activity within a country or region, although it may include necessity-driven entrepreneurship and informal self-employment. NECI, by contrast, measures the quality and strength of the entrepreneurial ecosystem, including government policies and access to finance.

Table 3. Total Early-Stage Entrepreneurial Activity (TEA) (2020–2024, %)

Country	2020	2021	2022	2023	2024
Japan	N.A.	5.4	5.0	4.6	5.5
United States	15.4	16.5	19.0	15.0	19.0
Brazil	13.4	21.0	19.9	20.3	21.3
India	5.3	14.4	11.5	13.5	14.2
Indonesia	9.6	N.A.	8.5	7.9	8.6
South Africa	N.A.	17.5	8.5	11.4	10.5

Note 1: N.A. indicates that data are not available for the corresponding year.

Note 2: TEA represents the percentage of the population aged 18–64 who are either actively involved in starting a business or are owner-managers of a business that is less than 42 months old.

Source: Global Entrepreneurship Monitor.

Table 4. National Entrepreneurship Context Index (NECI) (2020–2024)

Country	2020	2021	2022	2023	2024
Japan	4.0	4.0	4.3	4.6	4.5
United States	5.1	4.9	5.1	5.2	5.3
Brazil	4.4	4.0	4.2	4.1	4.3
India	5.0	5.0	5.8	6.6	6.1
Indonesia	5.4	N.A.	4.9	4.7	4.8
South Africa	N.A.	3.8	3.6	3.9	3.9

Note 1: N.A. indicates that data are not available for the corresponding year.

Note 2: NECI is a composite index scored on a 10-point scale based on expert assessments of 13 dimensions of the entrepreneurial environment, including support systems, infrastructure, and regulatory conditions. A score of 5.0 or above is generally regarded as indicating an adequate entrepreneurial environment.

Source: Global Entrepreneurship Monitor.

Japan's NECI has gradually improved, supported in part by government initiatives such as the Five-Year Plan for Startup Development. However, its TEA rate remains substantially below those of the US and the GS countries examined here, indicating relatively limited entrepreneurial activity. Notably, the US maintains a high TEA rate despite being an advanced economy, reflecting a dynamic entrepreneurial environment. One challenge for Japan is that R&D and patents remain concentrated in large firms, while the knowledge, human resources, and technologies accumulated in universities and large corporations are not sufficiently translated into start-up creation. This may reflect weaknesses not only in legal and physical infrastructure but also in the broader entrepreneurial ecosystem, including risk capital, labour mobility, and entrepreneurship education.

In India, both TEA and NECI have improved, supported by government digital and start-up policies such as Startup India, as well as digital public infrastructure, a large pool of IT talent, and an expanding domestic market. The rising number of US patent grants to Indian innovators also suggests growing technological capabilities, particularly in digital technologies and pharmaceuticals. Brazil and South Africa have relatively high TEA rates but low NECI scores, indicating constraints in areas such as institutions, finance, education, and market access. Indonesia has shown relatively little change in either TEA or NECI. Greater support is therefore needed to foster growth-oriented start-ups in the formal sector, particularly by improving access to finance, simplifying regulatory procedures, and strengthening university–entrepreneur linkages.

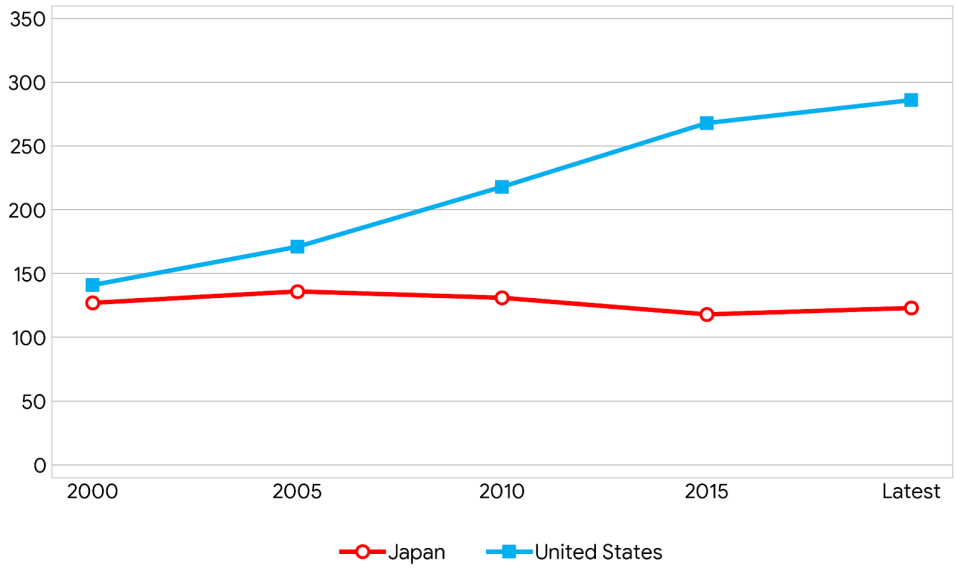
5.2. Universities: Science and Technology Talent, Knowledge Production, and Transfer

Higher education institutions (hereafter referred to collectively as "universities") play a central role in innovation by developing science and technology talent, generating new knowledge through basic and applied research, and transferring it to firms, public research institutions, and start-ups. Through human capital formation and technological progress, universities contribute to economic growth and productivity. In an increasingly knowledge-based economy, doctoral-level expertise is particularly important for innovation in areas such as deep tech, new product development, and business models (OECD 2023).

In Japan, the expansion of graduate education initially increased the supply of doctoral graduates. However, private-sector demand for PhD holders and improvements in their career prospects have not kept pace, reducing the attractiveness of doctoral study. The number of doctoral graduates per million population (Figure 5) in Japan peaked around the mid-2000s and has since stagnated, widening the gap with the US, where the number has continued to rise. A stagnant supply of doctoral talent may weaken the university research base, the availability of highly skilled personnel, firms' R&D capabilities, and start-up creation. Comparable statistics on doctoral graduates are difficult to obtain for GS countries, so Table 5 instead presents doctoral enrolment per million population. Brazil's doctoral enrolment has increased steadily over the past decade, with the absolute number now exceeding that of Japan. India has experienced more moderate growth in per-capita terms, partly reflecting the growth of its young

population. South Africa remains below Japan but has maintained a relatively stable level. Indonesia is still at an early stage in developing doctoral-level human resources, but doctoral enrolment has increased.

Figure 5. Doctoral Graduates per Million Population (2000–Latest)



Note: The latest available data are for 2022 for Japan and 2020 for the United States. The figure for Japan is based on the fiscal year.

Source: NISTEP, Japanese Science and Technology Indicators.

Table 5. Doctoral Enrolment per Million Population (2015–Latest)>

Country	2015	2020	Latest
Japan	582	632	641
United States	1,231	1,013	1,048
Brazil	506	599	635
India	89	146	164
Indonesia	99	N.A.	215
South Africa	351	396	416

Note 1: N.A. indicates that data are not available for the corresponding year.

Note 2: The latest available data are for 2022 for the United States; 2023 for Japan, India, Indonesia, and South Africa; and 2024 for Brazil.

Source: UNESCO Institute for Statistics, Enrolment in Tertiary Education, ISCED 8 Programmes, Both Sexes (Number); IMF, World Economic Outlook Database; author's calculations.

Cross-border mobility of science and technology personnel is closely associated with innovation (Stuen, Mobarak, and Maskus 2012; Franzoni, Scellato, and Stephan 2014). Several mechanisms have

been identified: (1) international selection and human capital formation among highly skilled workers, (2) cross-border knowledge spillovers, (3) the formation of international research networks, and (4) greater academic entrepreneurship. OECD analyses suggest that internationally mobile researchers tend to perform better in terms of co-authorship networks, citation impact, and international research visibility (OECD 2021). Compared with the US, Japan has a relatively high share of researchers with no international mobility and attracts relatively few foreign researchers (Table 6). Key priorities for Japan therefore include sending young researchers and doctoral talent abroad, attracting foreign researchers, supporting returning researchers, and strengthening international research networks. In the semiconductor sector, for example, cross-border technology transfer, research and business collaboration, technology licensing, and knowledge spillovers through interactions with suppliers and customers are also important (Goldberg et al. 2024).

Table 6. Science and Technology Personnel by Mobility Status (2024)

Country	Outflows	Returnees	Non-mobile Researchers	Foreign Researchers
Japan	4,795 (2.4%)	1,438 (0.7%)	187,284 (95.3%)	3,036 (1.5%)
United States	32,796 (3.6%)	8,018 (0.9%)	838,962 (91.7%)	34,798 (3.8%)
Brazil	4,514 (3.0%)	1,542 (1.0%)	141,544 (95.1%)	1,270 (0.9%)
India	10,567 (3.2%)	3,050 (0.9%)	318,230 (95.1%)	2,756 (0.8%)
Indonesia	1,643 (2.1%)	740 (1.0%)	74,112 (95.7%)	911 (1.2%)
South Africa	2,328 (9.0%)	478 (1.8%)	21,803 (83.9%)	1,374 (5.3%)

Note: "Outflows" refers to researchers who previously worked in the country concerned but are most recently affiliated with an institution abroad. "Returnees" refers to researchers who were previously affiliated with institutions abroad and are most recently affiliated with an institution in the country concerned. "Non-mobile researchers" are those for whom no change in the main country of affiliation is identified. "Foreign researchers" refers to researchers who moved into the country from abroad and are most recently affiliated with an institution in that country.
Source: OECD, Science, Technology and Industry Scoreboard.

For GS countries, it is similarly important to send science and technology personnel to universities, research institutions, and firms abroad, including in Japan, and to participate in international knowledge networks through joint research, degree programmes, and industry collaboration. As the experience of countries such as China demonstrates, mechanisms are also needed to connect the knowledge and networks acquired abroad with domestic universities, firms, public research institutions, and start-ups when researchers return.

The main concern regarding Japan's knowledge production is not simply the number of publications, but its declining position in highly cited research as global research output expands (Table 7). Analyses

by the National Institute of Science and Technology Policy (NISTEP) and others show that universities account for a large share of Japan's research output. A weakening of the university research base, particularly at national universities, could therefore undermine Japan's capacity for knowledge production. The number of highly cited papers produced by the US has also shown limited growth, although it remains among the world leaders. Notably, India has increased both its overall research output and its number of highly cited papers, supported by growth in researchers, universities and research institutions, and fields such as engineering, information technology (IT), and pharmaceuticals. Brazil's number of top 10% most-cited papers has declined, while South Africa remains at a relatively low level. Indonesia shows considerable year-to-year variation but has remained broadly stable.

Table 7. Top 10% Most-Cited Scientific Publications (2020–2024)

Country	2020	2021	2022	2023	2024
Japan	6,646	6,216	6,033	6,072	5,780
United States	69,494	70,047	64,677	63,751	58,894
Brazil	3,909	3,844	3,096	2,798	2,745
India	13,045	16,079	14,969	17,051	19,306
Indonesia	2,808	3,231	1,788	2,453	2,888
South Africa	1,303	1,283	1,223	1,088	1,223

Note 1: Figures are adjusted using fractional counting, whereby credit for a publication is divided equally among contributing countries or institutions.

Source: OECD, Science, Technology and Industry Scoreboard.

To translate research and technological development into innovation, firms need to strengthen their absorptive capacity—the ability to recognise the value of external knowledge, assimilate it, and apply it (Cohen and Levinthal 1990). Universities and public research institutions likewise need to connect knowledge with practical implementation through collaboration with firms and overseas research institutions. For GS countries in particular, knowledge acquired through international research networks should be channelled back into domestic universities, public research institutions, and start-ups, and used to support policy development.

5.3. Public Research Institutions

Public research institutions conduct R&D related to government missions in areas such as national defence, disaster prevention, infrastructure, public health, energy, and the environment. They also bridge basic research at universities and commercialisation by firms, while providing standardisation, testing and certification, R&D on generic industrial technologies, and technical support for SMEs.

In Japan, the National Institute of Advanced Industrial Science and Technology (AIST) was established in 2001 through the reorganisation of research institutes formerly under the Agency of Industrial

Science and Technology. AIST supports technological upgrading by firms and the practical application of industrial technologies through R&D. Japan's public research institutions have also supported long-term R&D on generic industrial technologies that individual firms may find difficult to undertake independently, while facilitating technology transfer through multi-firm research associations and large-scale R&D projects. In addition, public industrial research institutes established by local governments, known as Kosetsushi, are a distinctive feature of Japan's regional industrial policy. They provide local SMEs with testing and analysis, technical consultation, collaborative research, and human resource development, serving as accessible sources of technical support for firms with limited direct access to universities and national research institutions.

A distinctive US public research agency is DARPA, under the Department of Defence. DARPA was established in 1958 in response to the Soviet Union's launch of the world's first artificial satellite and supports advanced, potentially transformative R&D related to national security. Rather than operating a large in-house research laboratory, DARPA recruits highly capable programme managers (PMs) and provides substantial funding to external organisations, including universities, private firms, and start-ups. PMs define technological challenges and organise external research teams, thereby linking military and national-security needs with cutting-edge R&D. DARPA-supported research has contributed to technologies such as ARPANET, a precursor to the Internet, stealth technology, and speech recognition. Related technological advances also contributed to the civilian application of GPS. The DARPA model of high-risk, high-impact R&D has been extended to energy technologies through ARPA-E within the U.S. Department of Energy.

GS countries also have major public research institutions supporting industrial and technological development. In Brazil, the Institute for Technological Research of the State of São Paulo helps firms and the public sector address technological challenges in areas such as materials, infrastructure, metrology, and technical services. Fiocruz undertakes the R&D and production of vaccines and biopharmaceuticals and supports the development of the health industry. In India, the Council of Scientific and Industrial Research oversees a large network of national laboratories conducting research on industrial and societal challenges in fields including chemicals, pharmaceuticals, biotechnology, mining, aerospace, energy, and IT. In Indonesia, the National Research and Innovation Agency (BRIN) was established by integrating existing research organisations. BRIN consolidates previously dispersed public research functions and coordinates R&D related to national development priorities, including resource processing, digital technologies, energy, food, and health. In South Africa, the Council for Scientific and Industrial Research, one of Africa's leading public R&D institutions, conducts research to support industrial upgrading and address societal challenges in areas such as mineral resources, manufacturing, ICT, the environment, disaster risk reduction, and health.

As these examples illustrate, public research institutions bridge basic research at universities and commercialisation by firms through applied research, demonstration, and technology transfer. In GS countries, where private-sector R&D and university research capacity may be limited, these institu-

tions can play a central role in absorbing, adapting, localising, and diffusing technologies from abroad. However, inward-looking research organisations are less likely to translate research outcomes into industrial or social applications. Effective governance should therefore promote interaction with firms, universities, government agencies, and other stakeholders and orient public research institutions towards practical implementation.

5.4. Government Procurement and Public Demand

Governments can stimulate demand for innovation by setting advanced performance and quality requirements and using instruments such as public procurement, joint development with industry, levies on service charges, and subsidies. In particular, government procurement can directly stimulate innovation by supporting emerging technologies and creating new markets. Such measures are often referred to as demand-side innovation policies because they give firms greater certainty about future markets and revenue opportunities if innovation succeeds. Unlike R&D subsidies, procurement can also serve as an industrial policy instrument by providing firms with concrete market demand (Geroski 1990).

In the context of AX, governments can create initial demand and provide testing and demonstration environments in areas such as AI, semiconductors, computing resources, data centres, cloud services, energy, and cybersecurity. By acting as a lead user, the public sector can reduce uncertainty for firms investing in technological development. The effectiveness of such policies, however, depends on appropriate technical specifications, avoiding excessive protection of particular firms, and maintaining a competitive procurement environment.

Examples of large-scale public demand and government involvement in Japan include the Tokaido Shinkansen, subsequent Shinkansen projects, the Chuo Shinkansen maglev project, and the development of telecommunications infrastructure. In these cases, the government, public-sector entities, and private firms played different roles in creating large-scale demand, thereby promoting technological development, standardisation, quality control, and mass production in related industries. However, procurement practices that emphasise the lowest price, impose strict prior-experience requirements, or rely on rigid technical specifications can make it difficult for start-ups to enter public procurement markets. To support R&D-intensive start-ups and deep-tech firms, Japan should make greater use of its SBIR system, combined with demonstration projects, pilot procurement, and outcome-based contracts.

Defence procurement played an important role in the development of the U.S. innovation system during the Cold War. It supported the creation of knowledge across scientific and engineering fields, helped establish technologies that were later adapted for civilian applications, and created demand by making the government an early and lead user of new technologies (Mowery 2010). In the US, links among defence R&D, universities and firms, government procurement, and private markets created pathways for military technologies to spill over into civilian applications. In Japan, by contrast, the relatively small defence market, restrictions on defence exports, low profitability for participating

firms, and weak linkages between defence and civilian technologies have reduced the attractiveness of defence procurement as a market for technological development.

The WTO Agreement on Government Procurement (GPA) is a plurilateral agreement that opens government procurement markets among its parties. It covers specified procuring entities, goods and services, and contracts defined thresholds, while requiring non-discriminatory and transparent procurement procedures for suppliers from participating economies. Participation in the GPA is concentrated among advanced economies. Brazil, India, Indonesia, and South Africa are not parties, although Brazil, India, and Indonesia have observer status in the WTO Committee on Government Procurement. Non-GPA countries generally have greater policy space to use government procurement as an industrial policy instrument, for example through preferences for domestic firms and SMEs and measures to promote domestic industrial development and technology transfer. However, overly closed procurement markets or excessive protection of particular firms can raise costs, weaken competition, encourage corruption and inefficiency, lock in existing technologies, and discourage foreign firms from entering the market. GS countries therefore need institutional frameworks that balance domestic industrial development, international competition, transparency, and value for money.

6. Summary and Recommendations

This paper has examined the technology and innovation policies needed by Japan and countries in the GS amid the ongoing transformation of economic, industrial, and social systems driven by AI. Japan seeks to realise "A New Kind of Technology-driven Nation and Strengthening Competitiveness," while GS countries aim to strengthen their position in the global economy.

There is a risk that the innovation gap in AI-related fields between the US and both Japan and GS countries will widen further. Japan and GS countries have distinctive NISs, and simply imitating the NIS of the US or other countries is neither necessary nor necessarily desirable. Japan needs to adapt its NIS to AX, while GS countries need to align NISs suited to their own stages of development and policy objectives. Patent systems and competition policy provide important institutional foundations for innovation. In Japan, a key challenge is to prevent excessive control by dominant firms over critical assets in AI-related fields. In GS countries, additional challenges include balancing capability building by domestic firms, market entry by start-ups, technological collaboration with foreign firms, and consumer protection. Private firms remain central actors in innovation, but Japan urgently needs to revitalise its technology start-up sector, while GS countries need to foster growth-oriented start-ups in the formal sector. Stronger linkages among industry, academia, and government are also essential. Priorities include improving research productivity and researcher mobility at universities, linking R&D at public research institutions with private-sector implementation, and stimulating demand for innovation through government procurement.

Based on the discussion above, Japan's main challenges and policy recommendations can be summarised as follows.

- **Transition toward an NIS adapted to AX**: Japan should build on its strengths in the practical implementation of technologies in manufacturing, advanced materials, robotics, infrastructure operation, and quality management, while developing AI, semiconductors, data infrastructure, computing resources, telecommunications, electricity supply, digital transformation in public administration, and cybersecurity in an integrated manner. To achieve this, Japan should strengthen mission-oriented policies that combine R&D support, government procurement, regulatory reform, standardisation, and data sharing. In particular, Japan's SBIR system should evolve beyond support for early-stage R&D into a procurement framework in which national and local governments and public institutions act as initial customers in areas such as defence, disaster prevention, healthcare, and infrastructure.
- **Strengthening startups and the knowledge-production base**: Science-based and deep-tech start-ups require staged financing that supports them from proof of concept and prototyping through pilot-scale demonstration, scaling up to mass production, overseas certification, and initial sales. Japan should also expand support for young and doctoral researchers, international research collaboration and researcher mobility, and the standardisation of intellectual property and collaborative-research agreements at universities and public research institutions. These measures should strengthen internationally competitive knowledge production while improving the links between research outcomes, firms, startups, and public demand.
- **Building technology co-creation partnerships with the GS**: Japan should position GS countries not merely as production bases, consumer markets, or recipients of assistance, but as partners in technology co-creation. In line with the industrial development priorities of individual GS countries, Japan should promote joint research and demonstration projects, personnel exchanges, standardisation, and start-up collaboration. Potential areas include agricultural technology, biotechnology, aerospace, and green technologies in Brazil; AI, IT talent, pharmaceuticals, and digital public infrastructure in India; smart manufacturing, resource processing, and renewable energy in Indonesia; and mineral resources and telecommunications in South Africa. FOIP should be given concrete form as a co-creation platform linking technology, human resources, digital public infrastructure, and supply chains. It should also help connect the NISs of Japan and GS countries and support the development of RIS.

The main challenges and recommendations for GS countries can be summarised as follows.

- **Building an externally connected NIS**: GS countries should not seek to replicate the US, Japanese, or Chinese NIS as a complete model. Instead, they should build externally connected NISs suited to their own stages of development, industrial structures, human capital, and institutional capabilities. This requires stronger links with foreign firms, universities, public research institutions, diaspora communities, and private investors, together with mechanisms for transferring the knowledge and

technologies acquired through these connections into domestic firms, start-ups, and other relevant organisations.

- **Strengthening absorptive capacity at multiple levels**: At the firm level, countries need to strengthen technical training, quality management, capabilities related to standards and certification, and the ability to utilise data. Universities and public research institutions should enhance human resource development and collaboration among industry, academia, and government in fields such as AI, data science, engineering, biotechnology, and energy. At the government level, institutional capacity should be strengthened in areas such as intellectual property, competition policy, government procurement, and data governance.
- **Ensuring transparency, competition, and value for money in government procurement**: Government procurement can provide initial demand for domestic firms and start-ups and serve as an effective instrument for industrial development. However, excessive protection of domestic firms can raise costs, weaken competitive pressure, and lead to technological lock-in. GS countries therefore need procurement systems that combine performance-based specifications, phased procurement, third-party evaluation, and joint demonstration projects with foreign firms, including Japanese companies. Such systems can promote technological learning while preserving market competition and value for money.

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Part Ⅱ.

Sectoral Studies and Policy Recommendations

A. Technology, Industry, and Human Resource Development

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Chapter 3: International Strategy for the Semiconductor Industry Supply Chain

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This paper summarises the semiconductor supply chain analysis component of a policy framework for Japan's international relations with the Global South Big Four (Indonesia, India, Brazil, and South Africa). It redefines the semiconductor industry as a common ten-stage linear framework running from "Materials" to "Collection/Recycling," and uses this common axis to compare the four countries horizontally, clarifying each country's strengths and weaknesses and the stage-by-stage potential for engagement by Japanese industry.

The analysis reveals that the four countries occupy distinct positions along the semiconductor supply chain. India has the most systematically developed industrial base, including entry into front-end processes (wafer fabrication), while South Africa has the thinnest base in both specialised legislation and statistical infrastructure. A common pattern across the four countries is that each holds certain strengths in downstream stages (electronic devices, final products, sales/distribution), while upstream manufacturing processes (front-end, board & unit assembly) and the downstream circular-economy stage (collection/recycling) are uniformly weak — a pattern consistent with their respective stages of industrial development.

This structure carries a dual significance for Japan. First, the fact that there is substantial room for new entry into upstream manufacturing processes across all four countries suggests concrete business opportunities for Japanese companies that remain competitive in equipment and materials. Second, the fact that the circular-economy stage (collection/recycling) is undeveloped in all four countries means there exists a relatively uncontested area of cooperation where Japan's strengths — such as urban mining recycling and EPR (Extended Producer Responsibility) system design — can be leveraged.

Building on this analysis, this paper proposes, country by country, the stages in which Japanese industry should newly engage, and puts forward "support for statistical and classification system development" as a new axis of cooperation, alongside technology transfer, to address the structural challenge of "data gaps." It also discusses, in light of the engagement patterns of the three major powers — the United States, the EU, and China — the importance of adopting different strategic approaches towards countries where China has already established strong engagement versus countries where an engagement gap remains.

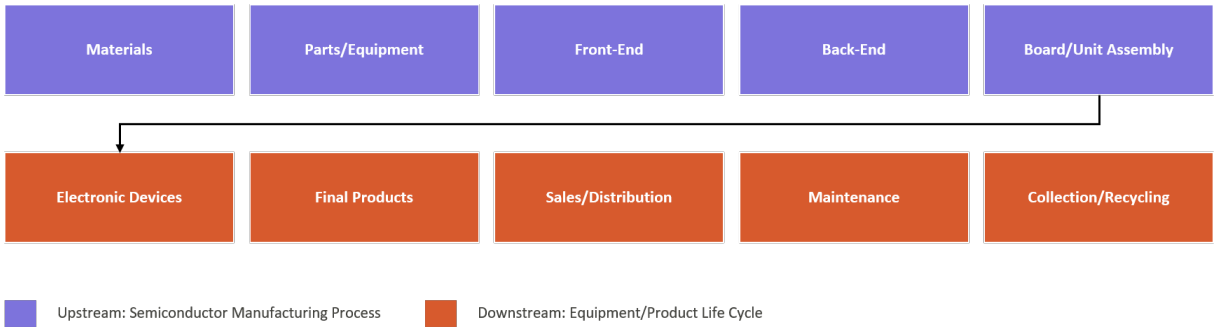
1. Purpose of This Paper and the Common Framework

Semiconductors are a foundational technology for modern industry and security, and while they are a focal point of U.S.–China rivalry, they are also a key lever for economic development in Global South countries. Although Japan has retreated from the front line of leading-edge logic semiconductor mass production since the 2000s, it is now pursuing the domestic production of 2nm-generation chips through government-backed support for Rapidus, and has set growth targets of ¥15 trillion in semiconductor industry sales by 2030 and ¥40 trillion by 2040. At the same time, it retains world-class competitiveness in intermediate goods such as materials, manufacturing equipment, and components. The starting question of this paper is how Japan should build its relationship with the Global South on the strength of this foundation.

The semiconductor industry can be understood as a linear supply chain in which physical goods flow in one direction, from materials to the collection and recycling of end-of-life products. Building on this characteristic, this paper defines the semiconductor supply chain as a common ten-stage framework and establishes an analytical axis that compares the four target countries (Indonesia, India, Brazil, and South Africa) against the same yardstick. Rather than a deep dive into a single country, the value of comparison through a common framework lies in three points: (1) it organises information so that it can be cross-referenced across countries; (2) it turns gaps themselves into usable information; and (3) it can be applied to designing menus of cooperation.

It should be noted that, while this framework depicts each stage as an independent process, in practice many supply chains are vertically integrated across multiple stages within a single company or facility. The stage divisions used in this paper are a convenient analytical simplification and do not necessarily correspond to the organisational boundaries of actual corporate activity.

Figure 1. Common Semiconductor Supply Chain Framework (10 Stages)



Source: Author

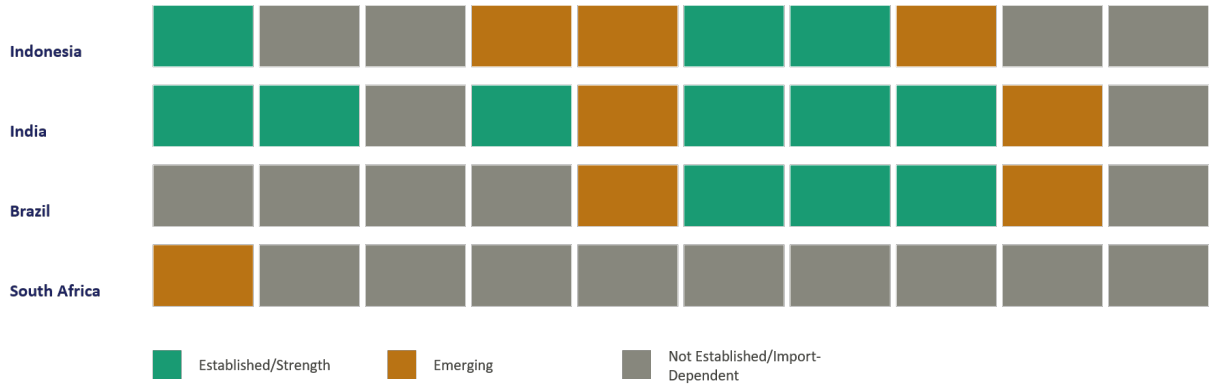
The upstream stages (①–⑤, purple) represent the semiconductor manufacturing process itself, while the downstream stages (⑥–⑩, orange) represent the life cycle of the devices and products in which

the finished semiconductors are embedded. A further feature is the circular structure in which stage ⑩ (Collection/Recycling) flows back into stage ① (Materials).

2. Industrial Structure of the Global South Big Four and Their Positions in the Supply Chain

Coding each country's strengths and weaknesses under the ten-stage framework into three categories — "Established/Strength" (green), "Emerging" (orange), and "Not Established/Import-Dependent" (grey) — reveals a contrasting structure. Visually, India is the only country with three or more stages coded "Emerging" or better among the upstream stages (①–⑤); all four countries fill the downstream stages (⑥–⑧) with green to orange; and all four countries remain at orange or grey for stage ⑨ (Maintenance) and stage ⑩ (Collection/Recycling). In particular, the fact that all four countries are "Not Established/Import-Dependent" at stage ⑩ (Collection/Recycling) shows that building circular-economy and EPR systems is a shared policy challenge across all four countries.

Figure 2. Positions of the Four Countries in the Semiconductor Supply Chain (Green = Established/Strength, Orange = Emerging, Grey = Not Established/Import-Dependent)



Source: Author

2.1. Indonesia: Materials Potential and a Focus on Downstream Assembly

Indonesia has potential as a materials supplier, holding substantial silica reserves, while its industrial structure leans downstream, with strengths in "back-end processes (assembly, testing, and packaging — OSAT)" and "final assembly of electronic devices." Semiconductor manufacturing requires silica sand, and Indonesia is estimated to hold reserves of roughly 340 million tons, which the government has positioned as a core national strategic asset. Indonesia's share of global semiconductor revenue, however, remains small, at 0.24%, though it is growing. Front-end processes (wafer fabrication) do not yet exist; in February 2026, the state investment fund Danantara partnered with Arm to launch a chip-design training programme for up to 15,000 engineers, indicating that upstream entry is being pursued starting from human-resource development. On the policy side, building on the 2018 comprehensive

industrial-upgrading roadmap "Making Indonesia 4.0," the Ministry of Industry formulated a national semiconductor industry roadmap built on four pillars — materials, design, front-end, and back-end — and in December 2025 published the "Silica Downstreaming Roadmap 2025–2045," focused specifically on upgrading silica sand.

2.2. India: The Thickest Industrial Base Among the Four Countries and Entry into Front-End Processes

India has the most substantial industrial base among the four countries. Under ISM (India Semiconductor Mission, launched in 2021 with an incentive outlay of ₹76,000 crore (roughly 760 billion rupees)), the country has attracted front-end (fab) investment, with large-scale projects by Tata Electronics, Micron, and others now taking concrete shape. India can be coded "Established/Strength" in six of the ten stages — materials, parts/equipment, back-end, electronic devices, final products, and sales/distribution — and has seen continuous policy deepening since the India–Japan CEPA (Comprehensive Economic Partnership Agreement) took effect in 2011. Following the launch of ISM in 2021, the 2026 announcement of ISM 2.0 (India Semiconductor Mission 2.0) in the Union Budget 2026–27 further underscores a policy consistency and continuity that stands out relative to the other three countries. On the talent side, a workforce base anchored by major IT services companies (discussed later) functions as a supply source for semiconductor design and verification engineers.

2.3. Brazil: A Structure Centred on Electronics Assembly in the Manaus Free Trade Zone

Brazil's industrial structure is highly specialised in electronics assembly centred on the Manaus Free Trade Zone (ZFM). As shown by the composition ratios (Section 3), the electronic devices segment accounts for more than 90% of total industrial scale, while upstream manufacturing processes remain almost entirely undeveloped. Brazil's scheme, PADIS (Programa de Apoio ao Desenvolvimento Tecnológico da Indústria de Semicondutores e Displays; established in 2007), is the oldest among the four countries, and there is also room to build on existing automotive-industry relationships with Toyota, Honda, Nissan, and others, and policy renewal has advanced in recent years with the 2024 revision of the PADIS law and the 2026 institutionalisation of Brasil Semicon.

2.4. South Africa: The Thinnest Base Among the Four and a Data Gap

Aside from materials (mining), which is at an emerging stage, South Africa remains not established or under-documented across nearly every stage, making it the thinnest industrial base among the four countries. Because no dedicated semiconductor industrial policy or statistical system exists, addressing the "data gap" discussed in Section 5 is especially important for this country. Since mid-2026, moves towards a broader industrial policy have only just begun, exemplified by the Industrial Development Strategy 2026 (IDS 2026), published by the Department of Trade, Industry and Competition (the dtic) in June 2026, which makes digitalisation one of its three pillars and lists electronics among high-technology industries but does not explicitly target semiconductors.

3. Composition Ratios Across the Ten Stages: Where Is Value Added Concentrated?

Visualising each country's industrial scale as a composition ratio across the ten stages shows that the concentration of value added differs greatly from country to country.

Table 1. Industrial Scale of the Four Countries: Stage with the Largest Composition Ratio

Country	Stage with Largest Share	Share	Characteristics
Indonesia	Sales/Distribution	76.7%	Followed by Electronic Devices (16.5%) and Back-End (6.8%); concentrated in the downstream distribution stage
India	Sales/Distribution	71.3%	Followed by Electronic Devices (21.4%); composition data can be confirmed across six stages, the most diversified structure among the four countries
Brazil	Electronic Devices	92.5%	Extreme concentration in electronics assembly centred on the Manaus Free Trade Zone
South Africa	Materials (Mining)	Limited data	Of the ten stages, composition data could be confirmed for only one — Materials

This skew in composition ratios suggests which stages each country's industrial policy should prioritise going forward. A structure like Brazil's, which is extremely dependent on a single stage (electronic devices), carries significant risk if that stage loses competitiveness, making diversification a policy challenge.

4. Quantifying Industrial Scale and Comparing GDP

There is a wide range in the macroeconomic scale of the four countries. India is the world's sixth-largest economy according to the IMF World Economic Outlook (April 2026; unchanged in the October 2026 edition), having been overtaken by Japan and the United Kingdom, while South Africa ranks around 40th globally (though first in Africa).

Table 2. Macroeconomic Scale of Each Country (2026, IMF Nominal GDP; WEO April 2026)

Country	Nominal GDP (2026)	World Rank	GDP per Capita
Indonesia	US$1.5399 trillion	17th	US$5,362
India	US$4.1532 trillion	6th	US$2,813
Brazil	US$2.6359 trillion	10th	US$12,313
South Africa	US$480 billion	~40th	US$7,503

Looking at the ratio to GDP of representative semiconductor-related segments, South Africa's mining sector as a whole stands out at 5.4%, though it should be noted that this ratio derives from materials (mineral resources) rather than semiconductors themselves. Brazil's Manaus electronics industry accounts for 1.6% of GDP, India's semiconductor consumption market for 1.3%, and Indonesia's semiconductor market for only 0.33%. Because the granularity and scope of statistics differ across countries, these figures should be used not for simple side-by-side comparison but to read the characteristics of each country's industrial structure.

5. Typology of Data Gaps and Support for Statistical and Classification System Development

Tallying the number of stages, by country, for which named companies could be confirmed shows that India and Brazil could be confirmed in six of the ten stages, while Indonesia reached five and South Africa only one (materials), with named companies in its other stages difficult to confirm (Table 4). This difference is not simply a matter of "insufficient information" but can be organised into two structurally distinct types: Type A countries (Indonesia and Brazil), where statistical systems exist but are not disaggregated to the firm level, and Type B countries (South Africa), which lack a dedicated industrial classification system altogether.

This typology suggests that "support for statistical and classification system development" can serve as an effective new axis of cooperation from Japan to the Global South, alongside technology transfer and investment promotion. Drawing on precedents of statistical-development support by international organisations (the World Bank, UNIDO, and others), a menu of cooperation led by the Japan International Cooperation Agency (JICA) and the Ministry of Economy, Trade and Industry (METI) — such as training statistical personnel and jointly developing industrial classification codes — would be especially valuable for Type B countries like South Africa. For the Type A countries, Indonesia and Brazil, support for disaggregating and digitising existing statistics down to the firm level would be effective.

6. Potential for Engagement by Japanese Industry: Stage-by-Stage Proposals

Existing business relationships are concentrated in resources and automobiles, leaving substantial room for new engagement in semiconductors themselves. In particular, concrete examples of Japanese companies entering the core manufacturing stages — front-end, back-end, and board/unit assembly — are scarce. The promising stages of engagement, organised by country, are as follows.

Table 3. Potential for Engagement by Japanese Industry (Example Proposals by Country and Stage)

Country	Promising Stages	Outline of Proposal
Indonesia	Front-End, Board/Unit Assembly, Collection/ Recycling	Establishing maintenance bases for equipment trading companies, technology transfer for PCB assembly, cooperation on urban mining recycling
India	Front-End, Back-End, Collection/Recycling	Joint development of advanced human-resource training programmes, joint-venture investment in OSAT facilities, provision of e-waste processing technology
Brazil	Materials, Parts/Equipment, Front-End	Joint development of rare-earth refining, building an equipment maintenance network, attracting front-end investment to Manaus
South Africa	Statistical Development, Materials, Parts/Equipment	Support for developing an industrial classification system, cooperation on critical-minerals supply chains, establishing new equipment trading bases

Source: Author

Three overall observations emerge from these stage-by-stage proposals: (1) all four countries share a common structure in which existing relationships are concentrated in resources and automobiles, requiring new development for engagement in semiconductors themselves; (2) there is substantial room for new development in the core manufacturing stages — front-end, back-end, and board/unit assembly; and (3) proposals that use Japan's technology and human-resource-development infrastructure to complement each country's weaknesses under the ten-stage framework (emerging or not-established stages) are likely to be effective. Engagement by Japanese industry is best pursued by leveraging existing intergovernmental cooperation frameworks — FTAs/EPAs and JICA/ODA (Official Development Assistance) — while tailoring the approach to each country's type of data gap.

6.1. Overview of Leading Companies by Stage

Examining the leading companies by stage in each country reveals a different cast of players — resource majors, foreign-affiliated assembly companies, and local IT companies.

Table 4. Representative Leading Companies by Country (Selected, by Stage)

Country	Stage	Representative Companies
Indonesia	Back-End, Electronic Devices	Amkor Technology (OSAT); Panasonic, LG (electronics assembly)
India	Front-End, IT Talent Base	Tata Electronics, Micron, CG Power (front-end investment); TCS, Infosys, Wipro (design/verification talent)
Brazil	Materials, Electronic Devices	Vale (iron ore, nickel); Samsung, LG, Foxconn (Manaus electronics assembly)
South Africa	Materials	Resource majors such as Valterra Platinum (formerly Anglo American Platinum; renamed in May 2025) (platinum-group metals); named companies in other stages are difficult to confirm

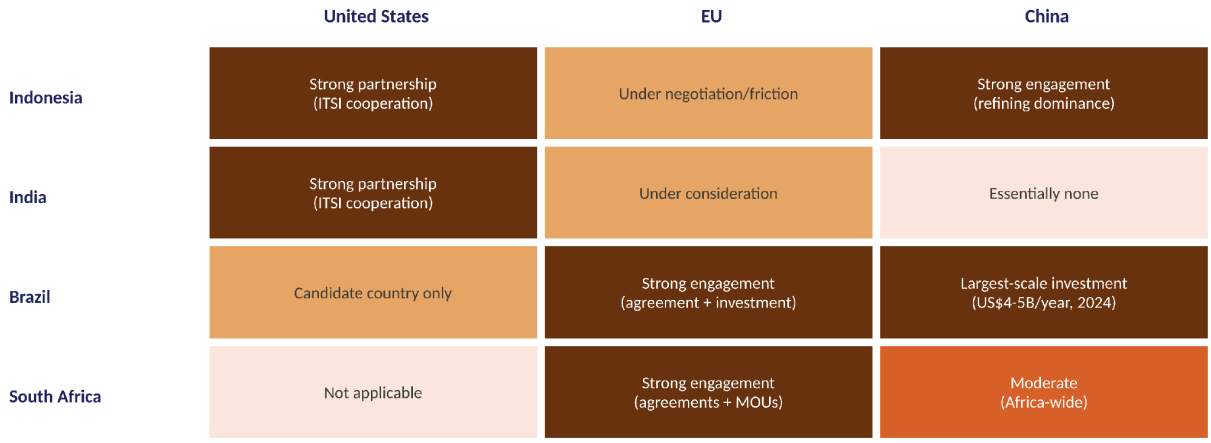
This list reaffirms that, outside the materials stage, the ability to identify named companies in South Africa is severely limited, corroborating the "data gap" discussed in Section 5.

7. National Semiconductor Policies and Engagement Trends of the United States, the EU, and China

Arranging the four countries' major semiconductor-related policies chronologically shows that Brazil's PADIS (2007) is the oldest scheme, and that India has seen continuous policy deepening since the India–Japan CEPA took effect in 2011. South Africa still has no policy that explicitly targets semiconductors: the Industrial Development Strategy 2026 (IDS 2026), approved by Cabinet in June 2026, prioritises digitalisation and lists electronics among high-technology industries, but does not single out semiconductors.

Organising the engagement levels of the three major powers (the United States, the EU, and China) by country highlights China's outsized presence. Indonesia has a "strong engagement (refining dominance)" relationship with China, and Brazil has received investment from China on the order of US$4–5 billion a year (as of 2024), among the largest of its kind. By contrast, U.S. engagement with South Africa is essentially nonexistent ("not applicable" in Figure 3).

Figure 3. Engagement Levels of the United States, the EU, and China with the Four Countries (Darker Shading = Stronger Engagement)



Source: Author

This structure offers Japan strategic implications that differ by country: in countries where China has already established strong engagement (Indonesia, Brazil), a differentiated cooperation model is needed, whereas in countries with an engagement gap, such as South Africa, first-mover advantage is more readily available. The United States is deepening cooperation with Indonesia and India through ITSI (the International Technology Security and Innovation Fund) while its engagement with South Africa remains limited; the EU, meanwhile, is pursuing agreement- and MOU-based engagement with all four countries.

8. METI Subsidies and Human Resource Development Support Measures

Examining the track record of METI's Global South subsidy programme shows that a certain number of awards can already be confirmed in connection with Indonesia, India, and Brazil, while no awarded projects related to South Africa could be confirmed at the time of writing. This is consistent with the "data gap" in South Africa discussed in Section 5, and suggests that existing subsidy schemes may not be sufficiently utilised there.

As Japan-originated human-resource-development support measures, AOTS (the Association for Overseas Technical Cooperation and Sustainable Partnerships, formerly HIDA), the overseas expansion of the KOSEN (Japanese technical college) education model, and JICA technical cooperation already exist as a certain level of infrastructure. In terms of priorities across the four countries, expanding utilisation in Indonesia and India, where AOTS bases already exist, offers the fastest results; Brazil faces the urgent structural constraint that no AOTS base exists there at all; and South Africa presents a different challenge — the absence of an industrial classification system makes it difficult even to identify the target talent pool.

9. Summary of Policy Recommendations

- **Stage-by-stage engagement strategy based on the common framework**: Use the ten-stage framework as a "common language" to plan engagement by stage according to each country's strengths and weaknesses, prioritising new development in the core manufacturing stages — front-end, back-end, and board/unit assembly — where examples of Japanese companies entering are scarce.
- **Statistical and classification system development support as a new axis of cooperation**: In addition to technology transfer and investment promotion, prioritise statistical-development support for countries such as South Africa that lack an industrial classification system altogether, and support the digitisation and firm-level disaggregation of existing statistics for countries such as Indonesia and Brazil where statistical development is still underway.
- **Attention to the circular-economy stage (collection/recycling)**: The collection/recycling stage, a shared weakness across all four countries, represents a new cooperation opportunity linked to the development of EPR systems, and has strong affinity with fields where Japan holds strengths, such as urban mining recycling technology.
- **Differentiation in light of China's engagement structure**: In countries where China has already established strong engagement (Indonesia, Brazil), Japan should differentiate on technological strength and reliability rather than competing on scale, while in countries with an engagement gap, such as South Africa, it should pursue first-mover advantage.
- **Leveraging intergovernmental cooperation frameworks**: Implement the stage-by-stage proposals as concrete projects, building on existing FTA/EPA and JICA/ODA schemes and METI's Global South subsidy programme. For South Africa in particular, since there is little track record of utilising existing schemes, public-institution-led formation of new projects will be important.

10. Nature of Sources and Reference Information

The original document on which this summary is based (the main volume of the semiconductor industry supply chain analysis) draws on primary sources, including official statistics and industrial policy documents of each national government, the IMF World Economic Outlook, Worldometer, published data from industry associations and research firms (SEMI, Statista, and others), and press releases from companies operating in each country. Detailed bibliographic information (authors, publishing organisations, URLs, access dates) is organised by country and section in Chapter 9, "List of Sources," of the main volume. For South Africa in particular, because no dedicated industrial statistics exist, the analysis relies on indirect estimates drawn from mining statistics and published materials from African continental development bodies (such as the African Continental Free Trade Area (AfCFTA)).

11. Topics for Future Consideration

- For Type A countries (Indonesia, Brazil), the progress of institutional change in statistical development should be continuously monitored.
- For South Africa, an independent examination within the broader framework of resource diplomacy and critical minerals policy, rather than the semiconductor supply chain alone, would likely be effective.
- The actual classification systems behind each country's industrial classification codes (Indonesia's KBLI, Brazil's CNAE, South Africa's SIC, and others) should be examined in detail to identify concrete focal points for statistical-development support.
- Because South Africa's Industrial Development Strategy 2026 (IDS 2026) was approved by Cabinet in June 2026 and has only just entered implementation, its implementation, including whether electronics and semiconductors are taken up as priority value chains, should be followed continuously.
- The expansion of the U.S. ITSI Fund into Brazil and South Africa, the timing of the EU–Mercosur FTA's entry into force, and China's future investment trends in the Indo-Pacific region should be continuously monitored.

12. Conclusion

The analysis and recommendations above provide a starting point for Japan to progressively deepen its relationship with the Global South Big Four in the semiconductor field, under the basic approach —proposed in this paper, and not an official government policy—of "pursuing qualitative differentiation suited to each country's industrial structure and data gaps, rather than competing with the United States and China on scale." Cross-country comparison through a common framework serves as a "common language" for visualising each country's strengths and weaknesses; designing actual cooperation projects will require consideration tailored to each country's specific context — existing business relationships, the type of data gap, and barriers to implementation.

Chapter 4: International Strategy for the AI Industry Value Chain

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This paper summarises the AI industry value chain analysis component that complements the semiconductor supply chain analysis (Part 1). Unlike the semiconductor industry's "linear ten-stage supply chain," this paper redefines the AI industry as a seven-layer framework consisting of "four stacked layers + one diffusion layer + two cross-cutting functional layers," and uses this common axis to compare the Global South Big Four (Indonesia, India, Brazil, and South Africa).

The core argument of this paper is that, while generative AI and physical AI are major trends, the structural limitations of each have become clear, and that — given that Japan's AI industry currently holds no clear advantage — Japan should pursue a new approach to AI strategy. Because generative AI and physical AI cannot convert tacit knowledge into training data and face an absolute shortage of such data, "Neurosymbolic AI," which sits above both as an integrating layer built on their foundations, offers a technology domain in which Japan can more readily establish a first-mover advantage, precisely because the field is still in its infancy. The market for this integrated structure is estimated at approximately US$96.6 billion in 2035, roughly ten times the stand-alone projection of US$9.3 billion, and the physical AI hardware market itself could expand by up to 2.8 times.

As a concrete implementation example of this integrated structure, this paper presents a technology — built on the Digital Triplet concept advanced by Professor Yasushi Umeda of the University of Tokyo — that formalises experts' tacit knowledge into practical knowledge through a two-layer structure consisting of a "World Model (neural, grounding layer)" and "PD3 (symbolic, exploration layer)." The author proposes this Japan-originated practical-knowledge AI as one candidate for a national strategy (disclosure: the author is CEO of LEXER RESEARCH Inc., which provides a PD3-based engineering-support service) and, on the basis of these technical insights, presents concrete strategies for the Global South Big Four.

1. Purpose of This Paper: The Structural Difference Between Semiconductors and AI

The semiconductor supply chain could be understood as a linear, ten-stage chain in which physical goods flow in one direction, from the extraction of materials to the collection and recycling of products. It is a structure with clear physical causality, in which downstream companies process materials manufactured by upstream companies, the resulting products are ultimately consumed, and used products flow back from downstream to upstream.

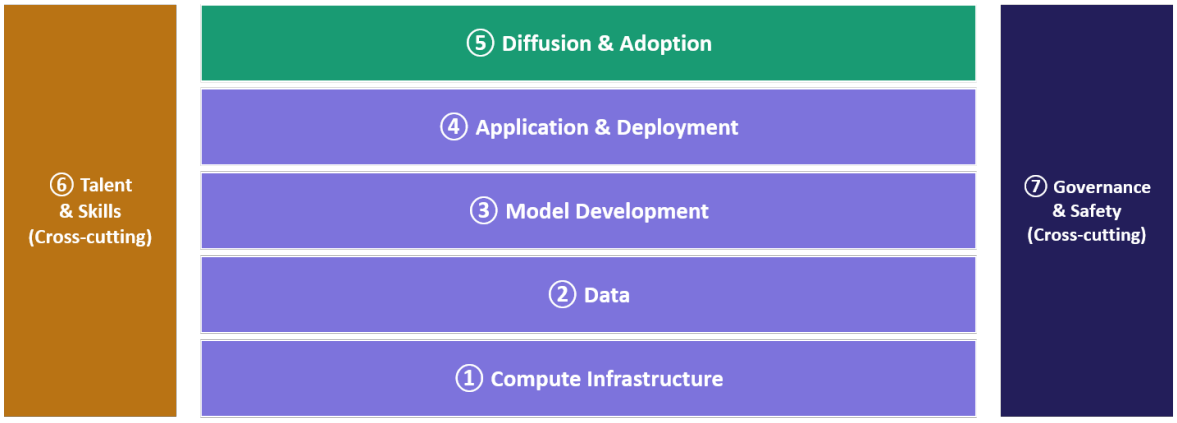
AI, by contrast, has a "stack structure (layered architecture)" in which intangible assets — compute resources, data, and models — accumulate, rather than physical goods moving. There is a vertical dependency in which data sits atop compute infrastructure, models are built atop data, and applications are implemented atop models; at the same time, those applications "diffuse" horizontally into diverse industries such as healthcare, education, agriculture, and public administration — a diffusive character that semiconductors do not have. In addition, AI talent development and the assurance of governance and safety do not belong to any single stage but exist as "cross-cutting functions" spanning every layer.

A further distinctive feature is that, whereas in semiconductors "collection/recycling" was a physical return flow from downstream to upstream, in AI the data and feedback generated at the usage stage are fed back into the "data" layer and the "model development" layer and used for the continuous improvement of models — a non-physical but analogous feedback structure. It should also be noted that AI's "compute infrastructure" layer connects directly to the AI semiconductors (GPUs and the like) and data centres covered in Part 1; the two parts are not independent but are connected through the common foundation of compute infrastructure. In other words, this paper is an analysis that extends Part 1, and is intended to provide an integrated understanding of the two as a structure in which the "supply network of intelligence" that is AI is stacked atop the "supply network of hardware" that is semiconductors.

2. A Common Framework for the AI Value Chain

In place of the semiconductor industry's "linear ten-stage supply chain," this paper defines AI as a seven-layer framework consisting of "four stacked layers (① Compute Infrastructure, ② Data, ③ Model Development, ④ Application & Deployment) + one diffusion layer (⑤ Diffusion & Adoption) + two cross-cutting functional layers (⑥ Talent & Skills, ⑦ Governance & Safety)."

Figure 1. Common AI Value Chain Framework (7 Layers)



Layered structure + cross-cutting functions (intangible assets accumulate upward; usage data feeds back downward)

Source: Author

Organising the AI-substitutability of work along two axes — "degree of structuring" and "dependence on practical knowledge" — based on this framework shows that routine, structured work is concentrated in the domain that is "easily replaced" by generative AI, while judgements based on frontline practical knowledge remain in a domain that is "difficult to replace" with existing AI technology. This "difficult to replace" domain is precisely the main battleground of Neurosymbolic AI, discussed from Section 4 onward in this paper.

2.1. Comparison of Five Fields: Existing AI and AI Yet to Develop

Comparing five fields — generative AI, physical AI, Neurosymbolic AI, quantum AI, and other AI (conventional/specialised) — along a technology axis running from statistical pattern recognition towards causal reasoning and real-world grounding, Neurosymbolic AI emerges as a third technological current positioned beyond the limitations faced by generative AI and physical AI. Market-size estimates vary widely by field: as of 2026, estimates for generative AI (US$29.6–161.0 billion) and physical AI (US$1.5–110.8 billion) differ so greatly in scope definition among research firms that the range spans up to a factor of 74. Neurosymbolic AI, as of 2026, is still an emerging market for which this kind of estimate has not yet even been established — and this is precisely the first-mover opportunity for Japan.

A note on quantum computing technology: quantum AI is a field in which Japan already has a comparatively robust policy foundation. The FY2025 supplementary budget allocated ¥100.4 billion to the industrialisation of quantum computing, meaning quantum technology benefits from policy support backed by concrete budget measures. That said, generative AI and physical AI are not without a national strategy of their own: the 2nd AI Basic Plan, formulated in July 2026, positions physical AI as a priority area, and Japan's growth strategy sets a target of achieving more than a 30% global share in AI robots. The six-year policy-formation process for quantum technology policy (the 2020 strategy ⟶ 2025 ecosystem building) can also serve as a reference model for the Neurosymbolic AI national strategy discussed later. It should be noted, however, that quantum AI itself is primarily a compute-infrastructure technology that improves the performance of existing AI — for example, through memory-efficiency gains in large language models — and is a different technological axis from the "differentiation at the reasoning layer" that is the focus of this paper.

3. National AI Strategies of the Global South Big Four

Comparing the national AI strategies of the four countries reveals a pattern similar to that seen in the semiconductor paper (Part 1): India has the most systematised strategy and budget, while South Africa has no dedicated strategy and remains dependent on regional frameworks.

Table 1. Comparison of National AI Strategies Across the Four Countries

Country	Strategy Name	Budget Scale	Characteristics
Indonesia	Stranas KA 2020–2045	No clear budget figure confirmed	5 priority areas (healthcare, public administration, education, food security, smart cities)
India	IndiaAI Mission	Approx. ¥150 billion	7 pillars (compute infrastructure, foundation models, data, applications, talent, startups, Safe AI)
Brazil	PBIA 2024–2028	Approx. ¥460 billion over 4 years	5 strategic pillars (compute infrastructure, talent, government AI, productive-sector AI, ethics and safety)
South Africa	No dedicated strategy	Not applicable	April 2026 draft policy withdrawn the same month; positioned within the African Union (AU) continental AI strategy framework

Looking at the relationship between AI market size and GDP reveals a pattern partly similar to that in semiconductors. In semiconductors, India stood out in both absolute value and share of GDP, and among the countries for which AI market figures are available on a comparable basis, India again ranks highest in the AI market, at approximately 0.44% of GDP. Indonesia's AI market, by contrast, remains small relative to its economy, at approximately 0.2–0.3% of 2026 GDP, even though its workplace AI adoption rate of 92% (Layer ⑤ of the framework) is the highest of the four. Indonesia's strength therefore lies in diffusion and adoption rather than in market scale or in compute infrastructure or model development (Layers ① and ③). South Africa, described as having "the thinnest base" in semiconductors, shows a certain presence in AI in terms of its data-centre market and company count — 726 AI-related companies, the most on the African continent — an interesting case where its position differs between the two fields.

Table 2. Relationship Between AI Market Size and GDP Across the Four Countries

Country	AI Market Size Indicator	Relationship to GDP
Indonesia	Approx. US$3–4 billion (2026, Statista-based estimate); US$10.88 billion (2030 forecast); 92% adoption rate	Approx. 0.2–0.3% of 2026 GDP
India	Approx. US$18.08 billion (2026); CAGR 38.1%	Approx. 0.44% of 2026 GDP
Brazil	US$2.85 billion (2025)	Approx. 0.11% of 2026 GDP
South Africa	726 AI-related companies (most in Africa)	Approx. 0.53% of 2026 GDP (data-centre market basis)

Note: Ratios are calculated against 2026 GDP. The South African figure is based on the data-centre market and is not directly comparable with the AI-market figures for the other three countries; the Brazilian figure uses 2025 market data.

Extending the typology of data gaps from Part 1 to an AI version, South Africa shows a new type not seen in Part 1: "policy vacuum, on-the-ground vibrancy." Its national AI strategy has been withdrawn and remains undecided, even as its number of AI-related companies is the largest on the African continent — a distinctive structure in which policy and on-the-ground reality have diverged.

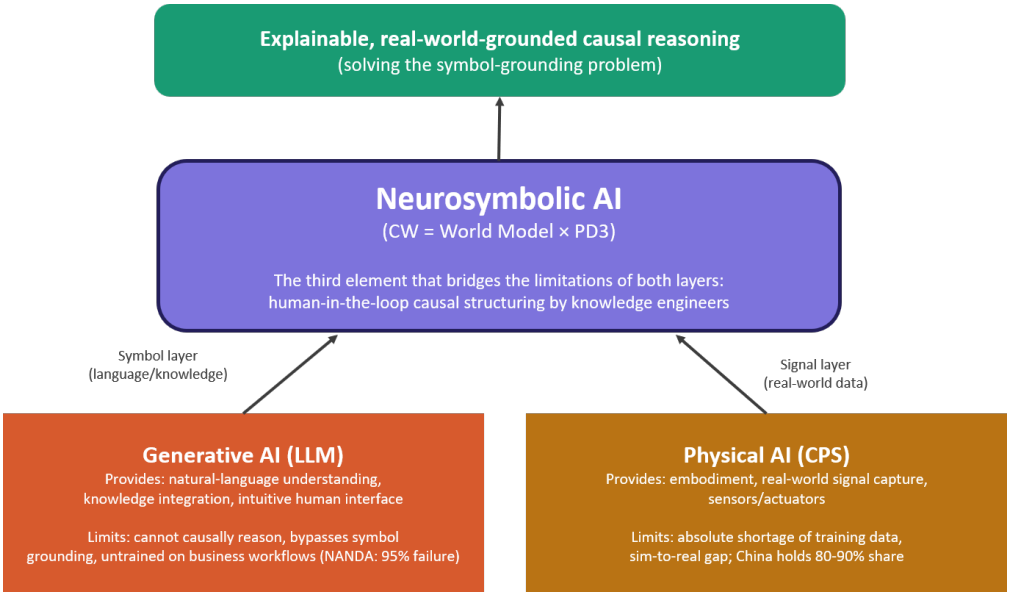
4. Neurosymbolic AI: The Integrated Structure of Generative AI and Physical AI

Generative AI (LLMs) and physical AI (cyber-physical systems (CPS)/robotics) each face different kinds of limitations. Generative AI offers high value through natural-language understanding and the integration of large-scale knowledge, but faces limitations in that (1) it cannot perform systematic diagnosis based on causal reasoning, (2) it merely "works around" rather than "solves" the symbol-grounding problem, and (3) as the MIT NANDA survey shows, 95% of pilots fail to achieve measurable revenue impact. Physical AI offers a value that generative AI lacks — real-world interaction through embodiment — but faces limitations in that (1) available training data amount to only a fraction of a per cent of the required volume, (2) there is a simulation-to-real gap, and (3) China dominates 80–90% of the finished-product market (humanoid robots; Omdia, 2025), placing other countries at a significant competitive disadvantage.

What matters is that the limitations of these two technologies are mutually complementary. The "grounding in real-world signals" that generative AI lacks is precisely the value that physical AI provides, and the "systematic causal reasoning and verbalisation of knowledge" that physical AI lacks is precisely the value that generative AI provides. However, simply combining the two does not solve the symbol-grounding problem, nor does it mean that causal reasoning can be achieved. Here, a "third

element" that bridges the two technologies is required — human-in-the-loop causal structuring that draws on engineers' expert knowledge and practical knowledge.

Figure 2. The Integrated Structure of Neurosymbolic AI, Built on Generative AI and Physical AI



Source: Author

4.1. China's Robotics Dominance and the Difficulty for Japan

China's presence in physical AI and robotics is striking. Chinese companies account for 80–90% of global shipments in the humanoid robot market (Omdia, 2025 shipment data: the three largest vendors — all Chinese — alone account for roughly 80% of about 13,000 units), and China accounts for 54% of new industrial robot installations worldwide (IFR, World Robotics 2025; 2024 data). Chinese local governments have committed more than 70 billion yuan (approx. US$9.7 billion) to newly launched state-backed funds for humanoid robotics and embodied intelligence (TMTPost, April 2025), and China was granted 7,705 humanoid-robot patents over the past five years, about five times the 1,561 granted in the United States (Morgan Stanley, Robot Almanac Vol. 3, December 2025). Japan, by contrast, holds a position as an "indispensable component supplier" — Harmonic Drive's precision reduction gears, for example, are used in nearly all high-performance robots worldwide — but, in the author's view, a strategy relying on this position alone carries three difficulties that cannot be overlooked. First, it is fundamentally a defensive strategy, premised on ceding to finished-product manufacturers a large share of the value added in the finished-product market — brand, platform, and control over data collection. Second, in solar panels, batteries, and EVs, production has become concentrated across the supply chain, from finished products to key components — China accounts for more than 80% of every key manufacturing stage of solar PV (IEA, Special Report on Solar PV Global Supply Chains, 2022), Chinese companies hold around 80% of battery-related manufacturing capacity, and about

70% of electric cars sold worldwide are manufactured in China (IEA, What Next for the Global Car Industry, 2025) — and a similar concentration could, in principle, extend to robot components. Third, a component-supplier strategy alone is not a sufficient answer for Japan's overall AI sovereignty.

This integrated structure points to a concrete path forward for Japan's physical AI strategy problem. Japanese companies' business strategy to date has been survival as a "component supplier" of modules and units, seeking to enhance their functions and performance by incorporating physical AI. A physical AI strategy based on AI-enabled hardware, however, is grounded in the hardware layer — a layer that vertically integrated competitors could, in the future, come to replace. If, by contrast, Japan can differentiate itself by solving the diverse problems that arise in the real world at the "reasoning layer" of Neurosymbolic AI, positioned above physical AI, this capability can add value to any physical AI system, regardless of the hardware's origin. If Japan can establish an advantage at this reasoning layer, then even if overseas manufacturers come to dominate the finished robot market, Japan can secure a position supplying "the intelligence needed to operate any country's robots safely and explainably."

This integrated structure is also significant from the standpoint of market size. Normalising market-size estimates to a common base year (2035), the Neurosymbolic AI market — US$9.3 billion when calculated as a stand-alone market — reaches approximately US$96.6 billion, roughly ten times the stand-alone figure, by absorbing a certain share as an "enabling layer" from generative AI (narrowly defined, approximately US$797.6 billion) and physical AI (narrowly defined, approximately US$62.7 billion). Furthermore, because Neurosymbolic AI eases the data constraints on physical AI, the physical AI hardware market itself could expand by up to 2.8 times, from US$1.2589 trillion under a constrained scenario (31% CAGR) to US$3.5514 trillion under an accelerated scenario (47% CAGR).

5. Reference Case: An Implementation Example of Neurosymbolic AI

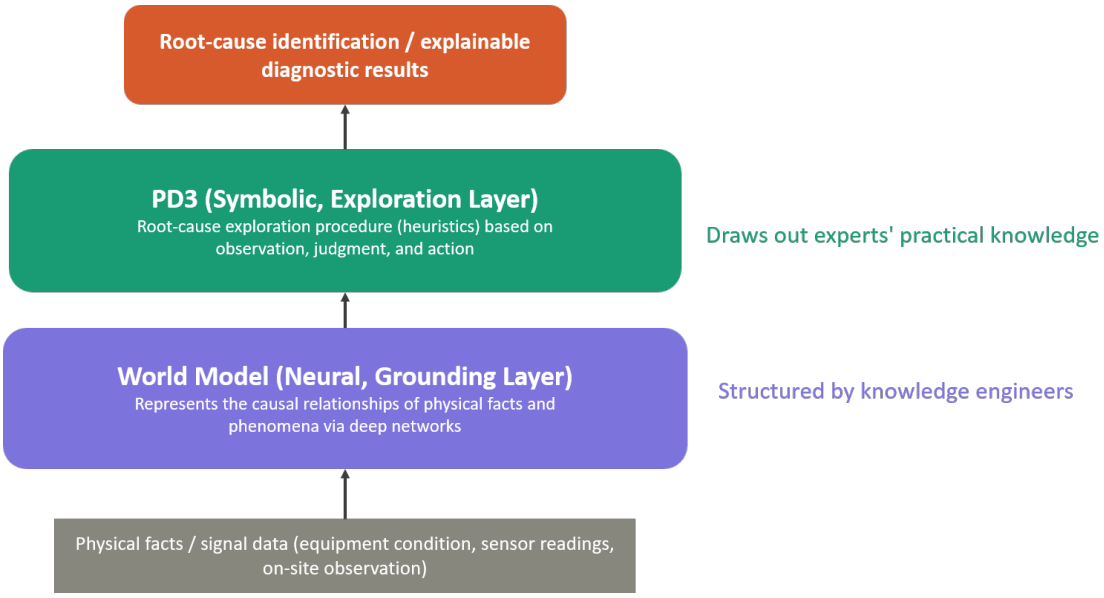
A concrete implementation example of this "new AI technology" is the Digital Triplet concept advanced by Professor Yasushi Umeda of the University of Tokyo. It operates through teams that pair knowledge engineers with experts across diverse manufacturing domains — TPM (Total Productive Maintenance), life-cycle design, production-system design, digital twins, and others. Knowledge engineers draw out experts' processes of "observation, judgement, and action," and play the role of structuring, verifying, disseminating, and teaching this knowledge using a proprietary description format (PD3: Problem-response Process Database), with the aim of making experts' tacit knowledge transparent as "practical knowledge."

The crisis in Japanese manufacturing that Digital Triplet seeks to address is severe. According to the 2025 White Paper on Manufacturing, 65.9% of manufacturing companies reported "not enough people to teach," and 49.7% reported that "people quit even after being trained"; over the past twenty years, the manufacturing workforce has shrunk by 1.57 million. Digital Triplet positions this failure of skills

transfer as "a structural industry-wide challenge that cannot be solved by the efforts of individual companies alone," and is designed to address three problems caused by tacit knowledge: (1) dependence on specific individuals, (2) risk of loss, and (3) failure to be transmitted or verified.

Within individual organisations, Digital Triplet is implemented through a three-layer architecture: (1) a Practical Knowledge Sharing layer (the engineering World Model, expert-knowledge database, and PD3), (2) a Practical Knowledge Interaction layer, and (3) a CPS (operations) layer (digital twins and field data). The two-layer structure this paper uses for inferential purposes — the "World Model (neural, grounding layer)" and "PD3 (symbolic, exploration layer)" — corresponds to the upper two layers of this three-layer architecture.

Figure 3. The Two-Layer Structure of the Neurosymbolic Model: The World Model (Grounding Layer) and PD3 (Exploration Layer)



Source: Author

This operating model and the problem underlying Neurosymbolic AI are not merely analogous; both are grounded in a shared lineage in the history of AI research — the "Knowledge Acquisition Bottleneck." The challenge faced by expert systems in the 1970s–80s — that experts find it inherently difficult to verbalise their own expertise — remains a central challenge in Neurosymbolic AI research today, and a 2025 academic study (arXiv 2504.11200) proposes, as a promising research direction, "giving experts a 'structure' to follow when making their knowledge explicit." The PD3 description format used in Digital Triplet can be positioned as a case that has put this "structure" into practical operation.

6. Proposed Strategies for the Four Global South Countries

The national AI strategies of all four target countries explicitly list the development of domestic talent as a pillar. Neurosymbolic AI technology, rather than simply providing a finished capability or piece of hardware, is offered as a "place of learning" where local engineers learn, think, and judge using experts' practical knowledge as a guide. This "simultaneous advancement of talent and technology" aligns directly with each country's national policy and is the greatest point of differentiation from technology offerings by other countries or companies.

Table 3. Proposed Strategies for the Four Global South Countries

Country	Deployment Type	Core Strategy	Time Frame
Indonesia	Immediately deployable	Elevate existing academic partnerships to the commercialisation stage	Short term (1–2 years)
India	Integrated deployment	Connect the talent base with the compute infrastructure base	Medium term (2–3 years)
Brazil	Phased development	Phased expansion using the automotive industry as a beachhead	Long term (3–5 years)
South Africa	Distinctive direct deployment	Direct approach to the private sector (726 companies)	Short term, in parallel

Source: Author

This integrated structure also shows that Japan can potentially surpass physical-AI frontrunners such as China through a different approach, rather than competing on the same ground — mass production and cost reduction of finished robots. The key is the manufacturing knowledge Japanese industry has accumulated — skilled workers' tacit knowledge, kaizen activities, and quality and maintenance know-how — a resource that already exists within Japan and can be converted into usable knowledge and put to work at a cost of a few hundredths to a few thousandths that of hardware development (on the order of hundreds of billions to a trillion yen).

7. Summary of Policy Recommendations

- **Formulating a Neurosymbolic AI national strategy**: Using the six-year policy-formation process of quantum technology policy as a reference model, incorporate a strategy document, numerical targets, base-building, and Global South connections from the outset.
- **Expanding use of METI's Global South subsidy programme**: Establish a dedicated feasibility-study funding track for knowledge engineering, and roll out the university-partnership model horizontally.

- **Shifting physical AI strategy towards the reasoning layer**: Develop beyond the defensive strategy, pursued at the level of individual companies, of being a component supplier, towards differentiation at the reasoning layer that is agnostic to hardware origin.
- **A low-cost industrial policy of turning manufacturing knowledge into usable knowledge**: For Japan, which lags the U.S. and China in financial firepower, position this as a realistic policy tool that delivers maximum effect within a limited budget.
- **Executing a phased international deployment model**: Establish a leading case in Indonesia, then sequentially transfer the resulting insights to India, Brazil, and South Africa.

8. Topics for Future Consideration

- As of the time of writing, market estimates for Neurosymbolic AI rely on a single 2035 projection from Astute Analytica; the accumulation of estimates from other research firms should be continuously monitored.
- The technology for converting practical knowledge into usable knowledge is, like Neurosymbolic AI technology as a whole, still at an exploratory stage, and remains a research topic requiring further technology-development support to advance.
- The trajectory of South Africa's distinctive "policy vacuum, on-the-ground vibrancy" structure — including the resubmission and possible enactment of the Draft National AI Policy 2026 — should be followed continuously.
- The technical relationship between quantum AI and Neurosymbolic AI (the potential for quantum computing to serve as compute infrastructure for neurosymbolic reasoning) is not fully explored in this paper and remains a topic for future consideration.
- The potential for horizontal expansion to countries and regions beyond the Global South Big Four (other Southeast Asian and African countries, for example), using the analytical framework common to Part 1 and Part 2, also warrants continued investigation.

9. Conclusion

This paper consistently applies, to the AI field, the basic approach — proposed by the author, and not an official government policy — established in Part 1 (the semiconductor paper) of "differentiating on quality rather than competing on scale," and presents a phased, learning-oriented international deployment model that adapts strengths Japan already possesses — manufacturing-style process knowledge, talent-development infrastructure, and already-implemented new AI models — to the industrial structure and institutional maturity of each of the Global South Big Four.

Chapter 5: Developing Integrative Professionals for a Shared Epistemic Platform: A Proposal for an "International Organisation-Affiliated Think Tank Graduate University" Linking Knowledge, Talent, and Practice

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Preface

This policy paper presents four proposals for establishing a Shared Epistemic Platform to support co-creation between Japan and the Global South. In addition, a policy addendum provides a complementary proposal on the strategic development of Professional Higher Education Institutions.

1. Background and Problem Statement: Challenges in Advancing Co-Creation between Japan and the Global South

In recent years, the foundations of national and regional competitiveness have shifted from models primarily based on natural resources and capital to those driven by knowledge and human talent. This direction is broadly consistent with the discussion in the OECD's Future of Education and Skills 2030 project regarding the growing importance of competencies and human capabilities in future societies (OECD n.d.). At the same time, advances in digital technologies and the expansion of international exchange have increased the importance of knowledge creation and knowledge sharing. UNESCO has similarly emphasised the need for a new social contract for education based on knowledge sharing and collaborative learning (UNESCO 2021).

This transformation is equally relevant to countries of the Global South. Rapid population growth, urbanisation, growing infrastructure demands, and climate-related challenges have created both significant development needs and new opportunities. Under these circumstances, the ability to connect knowledge, technology, institutions, and human resources across national boundaries has become increasingly important. For Japan as well, engagement with the Global South is evolving beyond conventional frameworks of aid and technology transfer towards a relationship characterised by mutual learning, co-creation, and shared value generation. This direction is also consistent with UNESCO's emphasis on collaboration and mutual learning as foundations for addressing shared challenges (UNESCO 2021).

Discussions conducted through this initiative have identified opportunities for collaboration between Japan and the Global South in a wide range of fields, including finance, deep technology, watershed management, urban development, and energy. A common observation emerging from these discussions is that complex social challenges cannot be adequately addressed through technology or financial resources alone. This perspective is consistent with the World Economic Forum's recognition that increasingly complex societal challenges require capabilities that extend beyond narrow technical expertise (World Economic Forum n.d.). Effective solutions require diverse stakeholders to collaborate, generate knowledge, learn through practice, and apply those lessons to future initiatives.

However, many existing efforts remain project-based. Knowledge, experience, and human networks generated through individual projects are often insufficiently accumulated and may be lost as organisations and personnel change. Moreover, lessons learned in one context are not always transferred effectively to others, resulting in repeated experimentation and missed opportunities for collective learning.

To build a sustainable framework for co-creation between Japan and the Global South, success should not be measured solely by the outcomes of individual projects. Greater attention must be given to the continuous accumulation of knowledge, experience, talent, and networks generated through practice, and to mechanisms that transform these assets into new forms of value creation. This paper therefore begins from the premise that a Shared Epistemic Platform is needed as a foundational mechanism for sustaining and expanding co-creation between Japan and the Global South.

2. Defining the Shared Epistemic Platform: A Cycle of Implementation, Knowledge Creation, Human Resource Development, and Re-implementation

In this paper, a Shared Epistemic Platform refers not merely to a mechanism for information sharing or knowledge exchange. Rather, it is a social platform through which knowledge, experience, networks, and human resources generated through co-creation between Japan and the Global South can be continuously accumulated and transformed into new forms of value creation.

Traditionally, many international cooperation initiatives and joint projects have been designed to address specific challenges. While such projects often generate valuable knowledge and professional networks, these outcomes are not always systematically organised or accumulated and may dissipate once individual projects come to an end. In many cases, lessons learned in one region are not effectively transferred to others, resulting in repeated experimentation and duplicated efforts.

However, when the discussions conducted through this initiative on finance, deep technology, watershed management, urban development, and energy are viewed collectively, a common characteristic

emerges. Although these fields differ substantially, all represent efforts to solve social challenges and create new value through collaboration among diverse stakeholders.

For example, the establishment of investment funds and startup support programmes in finance, the social implementation of deep technologies, multi-stakeholder cooperation in watershed management, community-based value creation in urban development, and efforts to balance decarbonisation with economic growth in the energy sector may appear unrelated. Yet all require the integration of multiple elements, including technology, institutions, finance, human resources, and local communities.

The value generated through these activities extends beyond the direct outcomes of individual projects. More importantly, they generate knowledge, experience, human resources, and networks. By systematically accumulating, sharing, and applying these assets to future initiatives, it becomes possible to generate value beyond the scope of individual projects.

This paper therefore conceptualises the Shared Epistemic Platform as a cycle consisting of four interrelated stages: implementation, knowledge creation, human resource development, and re-implementation.

First, practical initiatives are undertaken to address social challenges and create new value (implementation). The knowledge and experience generated through these activities are then organised and systematised into reusable forms (knowledge creation). That knowledge is subsequently utilised to develop the next generation of professionals (human resource development). Finally, those professionals apply their capabilities to new challenges in different regions and sectors, generating new forms of practice (re-implementation).

As this cycle continues, knowledge, human resources, and networks can be reproduced across generations and geographical boundaries. The essence of a Shared Epistemic Platform therefore lies not in preserving knowledge itself, but in creating a mechanism through which knowledge and human resources can be continuously generated and renewed.

The objective of this proposal is not simply to accumulate successful projects. Rather, it seeks to establish a cycle in which practical experiences arising from co-creation between Japan and the Global South are transformed into knowledge, used to develop human resources, and subsequently applied to new initiatives. In this sense, a Shared Epistemic Platform should be understood not merely as an information infrastructure but as a social platform for sustained innovation and co-creation.

3. Integrative Professionals: A New Professional Model for a Shared Epistemic Platform

As discussed in Section 2, a Shared Epistemic Platform is expected to function as a platform that sustains a continuous cycle of implementation, knowledge creation, human resource development, and re-implementation. However, such a cycle does not emerge automatically through institutions or systems alone. It requires individuals who can connect diverse stakeholders across disciplines, organisations, countries, and sectors, and guide them towards the creation of new value.

This paper defines such individuals as Integrative Professionals. Integrative Professionals are individuals who bridge previously fragmented domains of knowledge, organisations, and institutions, such as research and social implementation, government and industry, Japan and the Global South, and technology and public policy, thereby enabling both knowledge creation and practical implementation.

The challenges facing contemporary societies have become increasingly complex and cannot be adequately addressed through expertise in a single field alone. This trend is also consistent with the future workforce profile presented by the World Economic Forum (n.d.). Watershed management, for example, requires the integration of disaster prevention, water resources, urban planning, agriculture, and environmental conservation. Urban development similarly demands coordination among transportation, housing, education, industry, and community development. Likewise, energy transitions and the social implementation of deep technologies require not only technological expertise but also an understanding of policy, finance, industrial development, and human resource development.

Addressing such challenges requires more than highly specialised experts. Equally important are individuals who can connect experts and organisations, articulate a shared direction, and facilitate the implementation of solutions. Integrative Professionals do not replace specialists; rather, they function as hubs that connect diverse forms of expertise and transform them into new forms of value.

This paper proposes three core competencies for Integrative Professionals:

(1) Strategic Leadership

The ability to formulate visions for addressing social challenges and future opportunities, and to communicate those visions to diverse stakeholders. Rather than merely managing projects, Integrative Professionals provide long-term direction and promote co-creation among participating actors.

(2) Coordination Capability

The ability to connect stakeholders with different areas of expertise, organisational interests, and cultural backgrounds and to build collaborative relationships among them. In collaboration with the Global South, the ability to establish trust across different national, institutional, and cultural contexts is particularly important.

(3) Implementation Capability

The ability to translate ideas and knowledge into concrete policies, programmes, and projects. Integrative Professionals are expected to mobilise diverse resources and generate tangible outcomes in response to social challenges.

These three competencies are not independent of one another. Their value emerges through integration. By providing direction through strategic leadership, connecting stakeholders through coordination capability, and generating results through implementation capability, Integrative Professionals enable a Shared Epistemic Platform to operate as a sustained cycle.

Accordingly, Integrative Professionals should not be understood simply as specialists or managers. Rather, they are the central actors who bridge knowledge creation and social implementation, and who advance co-creation between Japan and the Global South through the continuous development and application of shared knowledge.

4. An International Organisation-Affiliated Think Tank Graduate University: The Educational and Research Pillar of a Shared Epistemic Platform

4.1. Rationale for Establishing an International Organisation-Affiliated Think Tank Graduate University

Section 2 defined the Shared Epistemic Platform as a mechanism that sustains a continuous cycle of implementation, knowledge creation, human resource development, and re-implementation. Section 3 identified Integrative Professionals as the key actors who enable this cycle.

However, a Shared Epistemic Platform cannot be sustained by individuals alone. A durable institutional foundation is needed to accumulate knowledge generated through practice, develop it through research, transfer it through education, and apply it to new forms of implementation.

Most universities today focus primarily on education and academic research, while think tanks concentrate on policy analysis and recommendations. Yet institutions capable of systematically transforming practical knowledge into educational, research, and policy assets remain limited. Likewise, although international organisations provide frameworks for international cooperation, relatively few possess sustained human resource development functions.

To establish and strengthen a Shared Epistemic Platform, an institution is needed that can simultaneously:

- generate knowledge from practice;

- systematise knowledge through research;
- develop human resources;
- provide policy recommendations; and
- build international networks.

This paper therefore proposes the establishment of an International Organisation-Affiliated Think Tank Graduate University as the educational and research pillar of the Shared Epistemic Platform.

The purpose of this concept is not simply to create a new university. Rather, it aims to provide an institutional framework through which knowledge and experience generated through co-creation between Japan and the Global South can be continuously accumulated, translated into educational and policy resources, and applied to future initiatives.

One reason for proposing a graduate-level institution is that educational programmes create long-term human networks that can serve as strategic assets for the Shared Epistemic Platform. A period of collective learning, research, and practical engagement among participants from diverse backgrounds can foster enduring relationships and mutual trust. Through alumni networks that extend across governments, businesses, international organisations, universities, and civil society organisations, the institution itself can function as a long-term hub of international collaboration.

Graduates should therefore be viewed not merely as degree holders, but as members of a continuing network that supports and expands the Shared Epistemic Platform.

The proposed institution is envisioned as a graduate-level university without an undergraduate programme. The aim is not to provide foundational academic education, but to develop Integrative Professionals capable of connecting knowledge with social implementation across organisational and disciplinary boundaries. Participants are expected to enter the programme with prior expertise and practical experience acquired through work in government, industry, international organisations, research institutions, or civil society organisations.

4.2. Distinctive Features of the International Organisation-Affiliated Think Tank Graduate University

The International Organisation-Affiliated Think Tank Graduate University is not intended to replicate existing research universities on a smaller scale.

While research universities traditionally emphasise academic research and the training of scholars, the proposed institution places greater emphasis on connecting academic and practical knowledge and translating that knowledge into policies, programmes, and institutional innovations. It should therefore be regarded as a higher education and research institution with a distinct mission and evaluation framework.

One relevant precedent is the RAND School of Public Policy, which seeks to connect academic knowledge with practical policy engagement. Students develop the capacity to apply academic knowledge to real-world policy challenges through direct engagement with policy research and clients (RAND School of Public Policy n.d.). The proposed institution draws inspiration from this approach.

At the same time, the International Organisation-Affiliated Think Tank Graduate University differs in a fundamental respect. Its purpose is not simply to add educational functions to an existing think tank. Instead, it seeks to institutionalise a cycle in which practical knowledge generated through co-creation projects between Japan and the Global South is transformed into organised knowledge, incorporated into education and research, and subsequently applied through new forms of social implementation.

Nor is the concept of a professional graduate institution linked to an international organisation without precedent. Japan hosts the United Nations University (UNU), an international graduate institution within the United Nations system. While both institutions are international in character, their missions differ.

Whereas UNU addresses a broad range of global issues, including peacebuilding and sustainable development, the proposed International Organisation-Affiliated Think Tank Graduate University would focus on fields in which Japan and the Global South can pursue practical co-creation, including finance, deep technology, watershed management, urban development, and energy. Countries of the Global South would not merely serve as research subjects or field sites, but as equal partners in building and operating the Shared Epistemic Platform.

Another important reference is the College of Europe, which has educated generations of diplomats, European Union officials, and professionals involved in European integration (College of Europe n.d.). Similarly, the China Europe International Business School (CEIBS), jointly established by the Chinese government and the European Commission in 1994, demonstrates how international higher education institutions can contribute to long-term capacity building and international cooperation.[*1]

While Japan successfully attracted the headquarters of the United Nations University, it has played a more limited role in establishing and co-governing international graduate institutions of its own. In retrospect, one may imagine a hypothetical "Japan Europe International Business School (JEIBS)", jointly established by Japan and the European Commission before the creation of CEIBS. Such an institution could have served as a platform for cultivating internationally oriented leaders and strengthening Japan's role in the internationalisation of higher education. Although no such institution emerged, the concept illustrates the strategic significance of building internationally co-governed educational institutions. The proposed International Organisation-Affiliated Think Tank Graduate University seeks to fulfil a similar role for a new era of collaboration between Japan and the Global South.

From an operational perspective, a consultative mechanism should be established among participating countries and partner institutions. The proposed institution may adopt a multi-campus structure across

participating countries, enabling students to study at multiple locations during their programme and gain first-hand international experience. Such an arrangement would strengthen both educational collaboration and the development of long-term transnational networks.

4.3. Functions of the International Organisation-Affiliated Think Tank Graduate University

In pursuing this mission, the university should actively draw upon the academic knowledge, human resources, and institutional networks accumulated by existing universities, research institutes, think tanks, and international organisations. It should expand its educational and research functions through collaboration with these institutions while adopting flexible forms of cooperation, including joint education, collaborative research, and personnel exchange. Given the diversity of educational systems and socio-economic conditions across participating countries, partner institutions should be actively involved not only in programme delivery but also in setting research priorities and applying knowledge generated through collaborative activities. To this end, the university is expected to fulfil five core functions.

Education

To continuously develop Integrative Professionals through educational programmes that maintain a balance between rigorous academic instruction and practice-oriented learning, including PBL, fieldwork, and engagement with real-world challenges. The university should actively explore double-degree and joint-degree programmes with public policy schools and other graduate programmes at leading research universities in participating countries. Through collaboration with research universities, it should seek to generate synergies between academic excellence and practical problem-solving, thereby strengthening both the theoretical and applied dimensions of Integrative Professional development.

Research

To organise, advance, and disseminate knowledge generated through practical initiatives in fields such as watershed management, urban development, energy transition, industrial development, and other areas of co-creation between Japan and the Global South. The university should actively promote joint research programmes and researcher exchanges with think tanks across participating countries. At the same time, it should encourage think tank researchers to engage more actively in academic research and scholarly communities. Through greater interaction between universities, think tanks, policy institutions, and practitioners, the institution should contribute to diversifying both the actors and research agendas that have traditionally shaped the social sciences, thereby fostering new forms of knowledge creation and academic inquiry.

Policy Recommendation

To connect research outcomes with policy processes through collaboration with governments, think tanks, international organisations, and other relevant actors, thereby supporting institutional design and practical implementation in Japan and the Global South.

International Collaborative Research

To serve as a hub for international knowledge networks through collaboration among universities, research institutions, think tanks, businesses, and public organisations in Japan, the Global South, and other regions. The university should actively promote joint research projects and academic exchange programmes with institutions such as the Institute of Developing Economies, Japan External Trade Organization (IDE-JETRO) and other relevant partners. It may also explore the establishment of an international peer-reviewed journal grounded in perspectives and experiences emerging from the Global South, drawing lessons from existing publication platforms developed by such organisations. Such initiatives would expand opportunities for diverse actors to disseminate research findings, strengthen international collaborative research, and contribute to the development of a more globally inclusive knowledge ecosystem. Over time, the journal may seek broader international recognition through indexing services such as Scopus and similar academic databases.

Knowledge Management and Archiving

To accumulate, manage, and systematise knowledge and experience generated through individual projects so that they can be transferred across generations and regions.

Through these functions, the International Organisation-Affiliated Think Tank Graduate University is expected to serve as the educational and research pillar of the Shared Epistemic Platform. The essential objective is not to conduct education, research, and policy activities separately, but to connect them in a manner that continuously circulates knowledge and human resources.

4.4. Concluding Remarks

As collaboration between Japan and the Global South expands, the Shared Epistemic Platform itself may eventually evolve into a broader international framework for cooperation. In such a context, the International Organisation-Affiliated Think Tank Graduate University can be expected to function as the educational and research pillar of that evolving framework.

Accordingly, the proposed institution should be understood not simply as a higher education institution. It is envisioned as a foundational mechanism that sustains the continuous cycle of implementation, knowledge creation, human resource development, and re-implementation by transforming practical experiences into knowledge, cultivating human resources, and linking both to policy and social implementation.

5. An Educational Model for Developing Integrative Professionals: Adopting Competency-Based Education

As discussed in Section 3, Integrative Professionals require three core competencies: strategic leadership, coordination capability, and implementation capability. These competencies cannot be acquired through classroom-based knowledge acquisition alone. Rather, they are developed through experience

in addressing real-world challenges, collaborating with diverse stakeholders, making decisions, and implementing solutions in practice.

For this reason, this paper adopts Competency-Based Education (CBE) as the principal educational approach for developing Integrative Professionals. CBE focuses not simply on the acquisition of knowledge, but on the development of the capabilities required to generate meaningful outcomes in society and organisations. While traditional education often emphasises what students know, CBE places greater emphasis on what they are able to do.

However, CBE should not be interpreted as disregarding theoretical knowledge or academic research. Integrative Professionals must be grounded in rigorous disciplinary knowledge and be capable of analysing practical challenges through academic and theoretical perspectives, while translating the resulting insights into policies, programmes, and institutional innovations. Accordingly, academic foundations should be strengthened through collaboration with existing universities and research institutions. At the same time, practice-oriented approaches such as PBL, fieldwork, and policy engagement should be used to promote a continuous interaction between theory and practice.

Individuals responsible for sustaining a Shared Epistemic Platform require not only specialised expertise but also the ability to create value across disciplinary, organisational, and cultural boundaries. Educational programmes must therefore be designed around collaboration and practical engagement rather than remaining confined within a single academic field.

This paper identifies the following forms of professional learning as core components of Integrative Professional development.

Project-Based Learning (PBL)
Learners work on real-world projects and collaborate with individuals from diverse professional backgrounds to address practical challenges. Through this process, they develop both implementation capability and coordination capability.

International Collaborative Research
Joint research programmes involving universities, think tanks, and research institutions in Japan and the Global South provide opportunities to experience knowledge creation, cross-cultural collaboration, and interdisciplinary problem-solving. Such programmes can also strengthen connections between academic research and practical implementation.

Policy Proposal Projects
Students engage not only in problem analysis but also in the design of concrete policies and institutional solutions. These activities help cultivate strategic leadership.

Industry-Government-Academia Collaboration Projects
Collaboration among businesses, governments, universities, and local communities provides opportunities to experience stakeholder coordination, consensus-building, and practical problem-solving.

Fieldwork

Direct engagement with real-world challenges, including those in the Global South, enables students to learn from local knowledge and practical experience while deepening their understanding of social implementation.

These educational components should not be treated as isolated activities. Rather, they should be integrated into a continuous learning cycle in which participants identify challenges in the field, conduct research and analysis, develop policy or project proposals, and test those ideas through implementation.

Learning outcomes should be evaluated from multiple perspectives, including the quality and rigour of academic analysis, project achievements, demonstrated leadership, collaborative performance, and contributions to social implementation.

In this regard, the CBE model practised by the Advanced Institute of Industrial Technology (AIIT) provides a useful reference. By combining PBL with competency assessment, AIIT has established a practical model for developing advanced practice-oriented professionals. The approach proposed in this paper builds upon and extends such experiences.

The objective of Integrative Professional development is not simply to train specialists. It is to develop individuals who can transform knowledge into social value, connect diverse stakeholders, and generate new forms of practice. The essence of education for Integrative Professionals therefore lies not in the transmission of knowledge itself, but in the development of the practical capabilities required to sustain a Shared Epistemic Platform.

6. Policy Recommendations: Four Proposals for Building a Shared Epistemic Platform

This paper proposes an institutional framework for advancing sustainable co-creation between Japan and the Global South.

Discussions conducted through this initiative have identified opportunities for collaboration in a wide range of fields, including finance, deep technology, watershed management, urban development, and energy. However, when such activities are treated solely as individual projects, knowledge, experience, and human resources are not sufficiently accumulated, limiting their long-term impact.

To develop an enduring and mutually beneficial relationship between Japan and the Global South, a mechanism is needed through which knowledge and human resources can be continuously reproduced beyond the lifespan of individual projects. To this end, this paper presents the following four recommendations.

Recommendation 1: Establish a Shared Epistemic Platform as a Continuous Cycle of Implementation, Knowledge Creation, Human Resource Development, and Re-implementation

The Shared Epistemic Platform should not be understood merely as a venue for information sharing. Rather, it should function as a platform that continuously generates, accumulates, and mobilises knowledge, experience, networks, and human resources emerging from co-creation between Japan and the Global South.

Its objective is not simply to disseminate project outcomes, but to transfer those outcomes across generations and regions and transform them into new forms of value creation.

Recommendation 2: Develop Integrative Professionals as the Core Actors of the Shared Epistemic Platform

A Shared Epistemic Platform can function effectively only when supported by individuals capable of connecting diverse stakeholders and fields of expertise.

This paper defines such individuals as Integrative Professionals.

Integrative Professionals are expected to possess three core competencies:

- Strategic Leadership
- Coordination Capability
- Implementation Capability

They should serve as key actors who bridge knowledge creation and social implementation while facilitating collaboration across organisational, disciplinary, and national boundaries.

Recommendation 3: Establish an International Organisation-Affiliated Think Tank Graduate University as the Educational and Research Pillar of the Shared Epistemic Platform

To ensure the continuous development of Integrative Professionals and the systematic accumulation of practical knowledge, an International Organisation-Affiliated Think Tank Graduate University should be established as the educational and research pillar of the Shared Epistemic Platform.

The institution should not be regarded merely as a graduate university. Rather, it should function as a centre for knowledge creation integrating:

- Human Resource Development
- Research
- Policy Recommendation
- International Collaborative Research
- Industry-Government-Academia Collaboration

As the Shared Epistemic Platform evolves, the International Organisation-Affiliated Think Tank Graduate University is expected to serve as one of its core institutional components. It should be developed

neither as a smaller version of an existing research university nor as an educational extension of a think tank, but as a world-class institution dedicated to both academic excellence and excellence in social implementation.

The international alumni network formed through the institution should also be regarded as a strategic human resource base supporting the long-term development of the Shared Epistemic Platform.

Recommendation 4: Adopt CBE as the Standard Educational Model for Developing Integrative Professionals

Conventional educational approaches centred primarily on knowledge acquisition are not sufficient for developing Integrative Professionals.

Accordingly, CBE should be adopted through such approaches as:

- Project-Based Learning (PBL)
- International Collaborative Research
- Policy Proposal Projects
- Industry-Government-Academia Collaboration Projects
- Fieldwork

These approaches should be used to develop the competencies required for Integrative Professionals through practice and direct engagement with real-world challenges.

Conclusion

The purpose of this proposal is to establish a framework through which Japan and the Global South can continuously generate and reproduce knowledge and human resources through co-creation, thereby strengthening a Shared Epistemic Platform.

The concepts presented in this paper, namely the Shared Epistemic Platform, Integrative Professionals, the International Organisation-Affiliated Think Tank Graduate University, and CBE, should not be regarded as independent proposals. Rather, together they constitute an integrated institutional framework centred on a continuous cycle of implementation, knowledge creation, human resource development, and re-implementation.

As co-creation between Japan and the Global South continues to deepen, success will depend not only on the achievements of individual projects but also on the ability to transform those achievements into enduring sources of knowledge, talent, and institutional capacity. This paper hopes to contribute to the development of such a foundation for future collaboration.

Policy Addendum

Recommendation 5: Strategic Development of Professional Higher Education Institutions for the Global South (Prepared by Mitsuhiro MAEDA)

Finally, this paper proposes the establishment of specialised Professional Higher Education Institutions as a means of supporting industrial transformation in countries of the Global South. As industrial societies evolve, the capabilities required of their workforce also change. To respond effectively to these changes, educational systems must be able to develop advanced practice-oriented professionals equipped with the knowledge, practical skills, and leadership required by emerging industries. The challenge is therefore not simply to expand higher education, but to establish educational institutions specifically designed to meet the needs of each stage of industrial development.

1. Japan's Experience in Establishing Professional Higher Education Institutions

Professional Higher Education Institutions are educational institutions established for the development of advanced practice-oriented professionals. Although universities are generally regarded as the primary form of higher education, Japan's experience demonstrates that alternative institutional models can also play an important role in responding to changing industrial needs.

Universities have long been regarded as valuable social assets. However, during periods of rapid industrial transformation, some countries have created specialised higher education institutions to accelerate the development of the professional talent required for modernisation and economic growth.

Japan provides an important example of this approach. Since the late nineteenth century, Japan has repeatedly established new forms of higher education institutions in response to changing economic and industrial demands.

The Faculty of Engineering, The University of Tokyo

In 1886, Japan established the College of Engineering within the Imperial University, later known as the Faculty of Engineering of the University of Tokyo.

At a time when higher education opportunities were limited, engineering education played a critical role in developing the technical talent required for national modernisation.

One distinctive feature of Japanese engineering education was the development of Laboratory-Based Education (LBE). Under this model, professors, researchers, graduate students, and senior undergraduate students work together within research laboratories, creating an environment in which education and practical research are closely integrated.

Colleges of Technology (KOSEN)

Following the Second World War, Japan faced an urgent need to rebuild its economy and strengthen its manufacturing sector. In response, the government established a new institutional category known as Colleges of Technology (KOSEN) in 1961.

KOSEN institutions admit students after lower secondary education and provide five-year programmes combining academic study with intensive practical and technical training.

Their primary objective has been to develop advanced industrial professionals capable of contributing directly to production, technological innovation, and industrial development.

The KOSEN model has attracted international interest and has been introduced, with local adaptations, in countries such as Mongolia, Thailand, and Vietnam.

Professional and Vocational Universities (PVUs)

In 2017, Japan introduced another institutional category, the Professional and Vocational University (PVU).

PVUs were established to provide practical and applied higher education for professions requiring advanced technical expertise. Educational programmes place a strong emphasis on internships, training, experiments, and industry engagement. A significant proportion of teaching staff are experienced practitioners from industry.

The objective of PVUs is to develop graduates who can move directly into professional practice while maintaining the academic standards expected of higher education institutions.

Professional Graduate Schools

Japan established the Professional Graduate School system in 2003 to address growing demand for highly qualified professionals capable of operating in increasingly complex and globalised environments.

These programmes focus on areas such as business administration, public policy, public health, intellectual property, accounting, and clinical psychology.

Unlike conventional academic graduate programmes, Professional Graduate Schools are specifically designed to prepare advanced practitioners through the integration of theory and professional practice.

Through these successive institutional innovations, Japan has repeatedly adapted its higher education system to meet the changing needs of industrial and social development. This experience suggests that the establishment of specialised Professional Higher Education Institutions can serve as an effective policy option for countries seeking to develop the advanced practice-oriented professionals required for future economic transformation.

2. Advanced Practice-Oriented Professionals and Competencies

Why is the development of advanced practice-oriented professionals through Professional Higher Education Institutions important during periods of industrial transformation?

The answer lies in the role such individuals play in society and industry. Advanced practice-oriented professionals are expected not only to possess specialised knowledge acquired through higher education, but also to demonstrate practical technical skills and the leadership necessary to guide others in real-world settings.

In other words, advanced practice-oriented professionals combine three essential elements:

- Advanced Knowledge
- Practical Skills
- Leadership

Individuals who possess these capabilities contribute not only through their own professional performance but also by improving the performance of the teams and organisations around them.

Specialised educational institutions can be an effective policy option for cultivating such talent.

First, the knowledge required by industry changes rapidly. Educational programmes must therefore continuously adapt to evolving industrial needs. This requires close collaboration with industry and the ability to revise curricula in response to technological and economic change.

Second, practical skills are essential. Higher education institutions often emphasise theoretical knowledge, yet advanced practice-oriented professionals must also be capable of applying knowledge in real-world settings. Practice-oriented professional education provides opportunities to develop such capabilities through hands-on learning and direct engagement with professional activities.

Third, leadership is increasingly important. Advanced practice-oriented professionals are expected not only to perform specialised tasks but also to guide teams, coordinate stakeholders, and contribute to organisational development. These capabilities must be intentionally cultivated through educational experiences and practical engagement.

For these reasons, establishing Professional Higher Education Institutions can be an effective strategy for developing the human resources required during periods of industrial transformation.

The changing competency requirements of the digital sector provide a useful example.

Research conducted at the Advanced Institute of Industrial Technology (AIIT) has shown that the competencies expected of advanced digital professionals have evolved significantly over time.

During the early period of computerisation, technical operation and programming skills were the primary requirements. As digital systems became more complex, demand shifted towards system development, project management, and specialised technical expertise.

Subsequently, the expansion of digital services and globalisation increased demand for capabilities related to systems integration, service management, and cybersecurity.

More recently, the era of Digital Transformation (DX) has created demand for new categories of professionals, including business architects, digital coordinators, and operation architects. In addition to advanced technical expertise in areas such as AI, IoT, big data, and blockchain, these professionals are expected to possess broader competencies including agile management, data science, design thinking, and leadership.

Even within a single field, competency requirements can change significantly over time. This highlights the need for educational institutions capable of responding flexibly to evolving industrial and societal demands.

Accordingly, the establishment of new forms of Professional Higher Education Institutions should be regarded as a viable policy option for countries seeking to develop the advanced practice-oriented professionals required for future economic and industrial development.

3. The Meta-Competencies of the Advanced Institute of Industrial Technology (AIIT)

The discussion thus far suggests that countries of the Global South may require not only advanced technical professionals capable of supporting industrial development, but also higher-level professionals who can guide organisations, coordinate stakeholders, and lead innovation.

When considering institutional models for developing such talent, the Advanced Institute of Industrial Technology (AIIT) in Japan provides a useful reference.

Established by the Tokyo Metropolitan Government in 2006, AIIT is a professional graduate school designed to develop advanced practice-oriented professionals. Unlike institutions primarily focused on academic research, AIIT places particular emphasis on the practical application of knowledge and the development of professional competencies.

A distinctive feature of AIIT is its adoption of Project-Based Learning (PBL) as a core educational method. While PBL is implemented in many higher education institutions around the world, AIIT integrates it comprehensively into its curriculum. Students are expected to complete substantial practical projects, and these projects serve as a central component of the degree programme.

This approach provides flexibility in responding to changing industrial and social needs. As competency requirements evolve, project themes and learning activities can be adapted accordingly, allowing educational programmes to remain closely aligned with developments in industry and society.

AIIT identifies three fundamental competencies (meta-competencies) as core educational objectives:

- Continuous Learning Capability
- Communication Capability
- Teamwork Capability

These competencies are intended to prepare graduates for leadership roles in professional and organisational settings. The focus extends beyond technical expertise to include the ability to work effectively with others, adapt to changing circumstances, and contribute to collective problem-solving.

The significance of this approach extends beyond Japan. As countries of the Global South continue to pursue industrialisation and economic transformation, demand will increase not only for highly skilled professionals but also for individuals capable of leading innovation and organisational development.

AIIT therefore offers a useful example of how a higher education institution can combine practical learning, competency development, and industry relevance within an integrated educational framework.

Japan has already incorporated elements of this approach into international cooperation initiatives. One notable example is the initiative to support higher professional human resource development in Central Asia, announced by Prime Minister Shinzo Abe in his policy speech at Nazarbayev University, Kazakhstan, on 27 October 2015. Under this initiative, the Government of Japan identified the AIIT educational model as an important reference for developing advanced industrial and professional talent in Central Asia. In February 2016, a delegation consisting of higher education ministers and university leaders from Central Asian countries visited Japan and participated in workshops at AIIT to learn about its educational approach. Since then, AIIT faculty members have continued to contribute to human resource development initiatives through seminars and workshops conducted in the region.

Experiences gained through such efforts suggest that the educational practices developed by AIIT, together with other Japanese models of professional higher education, may provide valuable references for countries seeking to establish systems for developing advanced practice-oriented professionals.

In this sense, AIIT should be understood not merely as a professional graduate school, but as a practical reference model for the development of advanced practice-oriented professionals in rapidly changing economic and industrial environments.

Note

*1. The establishment and development of CEIBS are discussed in detail by Otsuka (2008).

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Part Ⅱ.

Sectoral Studies and Policy Recommendations

B. Regional Development, Infrastructure, and Finance

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Chapter 6: Regional Economic Development Strategy Based on Basin Ecosystems: An Integrated Model for Growth, Investment, and Resilience through Basin OS

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Introduction

Sustainable regional development requires an integrated understanding of the natural environment and socioeconomic activity connected through the water cycle. Climate change, urbanisation, population growth, and industrial expansion are making the relationships among flood control, water use, agriculture, cities, industry, and the environment more complex. Optimising each sector separately can no longer address all of these challenges.

Figure 1. Overview of Basin OS



Source: Author

This paper reframes the basin ecosystem as a regional management system that supports livelihoods, industry, and investment. An understanding of local water, land, disaster risk, and ecosystem condi-

tions can guide industrial location and help increase productivity, investment, employment, and income. Making regional needs visible in water management, sensing, digital transformation (DX) in agriculture (hereafter agricultural DX), resource circulation, and natural capital assessment can open new markets for established businesses, start-ups, and university-developed technologies through demonstration and commercialisation.

We propose Basin OS (Basin Operating System), an integrated decision-support platform operating at basin scale. It connects information across sectors and compares future scenarios to inform policy and investment decisions. The Citarum River Basin in West Java, Indonesia, is the proposed demonstration area. Agricultural DX would be the first use case, with outcomes assessed in terms of income, productivity, water-use efficiency, and disaster risk before expanding to cities, industry, and water-quality management.

The objective is not to transfer a Japanese system, but to co-design a locally led approach that combines Japan's experience with each country's natural conditions, culture, institutions, knowledge, people, and technologies. Priorities, governance arrangements, data use, and benefit-sharing should be determined jointly with local governments, universities, businesses, farmers, and communities through the feasibility study. We seek a cycle in which employment and income increase, disaster risk and environmental pressures decline, and the value generated by growth is reinvested in the basin and its people.

1. Basin Ecosystems and Regional Economic Development

1.1. Rivers Form within Basin Ecosystems

Human settlements and economic activity have long developed alongside rivers. Rivers supply water for households and agriculture, create fertile land, and provide routes for people and goods. Cities, agriculture, industry, and trade have all developed in relation to water. Rivers themselves form within basins through interactions among rainfall, terrain, forests, farmland, groundwater, ecosystems, and human activity.

We use the term "basin ecosystem" for these interactions between nature and human activity. It encompasses forests, farmland, rivers, wetlands, and other natural environments, as well as cities, industry, agriculture, transport, energy, people, and investment. These elements influence one another through the water cycle. A basin ecosystem is therefore both an environment to be managed and a regional management system that supports livelihoods, industry, and investment.

1.2. Sectoral Management Has Supported Civilisational and Economic Development

As civilisations and economies developed, institutions and infrastructure were established for flood control, water use, irrigation, water supply and sewerage, urban development, industry, and environ-

mental conservation. Dams, levees, irrigation facilities, and water supply and sewerage systems expanded rapidly in the 20th century. They reduced flood damage, stabilised water supplies, and supported agricultural production, urbanisation, and industrialisation. Japan likewise developed its flood control, water management, cities, transport, and industrial infrastructure while repeatedly facing earthquakes, tsunamis, typhoons, heavy rainfall, floods, and landslides. Progress in these sectors has reduced disaster risk, stabilised livelihoods, and supported economic development.

1.3. Limits of Sectoral Management in the 21st Century

The conditions affecting river basins have changed substantially in the 21st century. Climate change is increasing uncertainty around floods, droughts, and water shortages. At the same time, population growth, urbanisation, and industrialisation are increasing demand for water, land, and infrastructure (IPCC 2023)[1]. Agriculture, cities, industry, and energy draw on the same water resources, while changes to forests and farmland affect the water cycle, disaster risk, and ecosystems. Optimising flood control, cities, agriculture, and industry separately may therefore fail to produce the best outcome for the region as a whole.

Responding to climate change and other uncertain conditions requires continuous review of the entire basin and the relationships among its sectors. This means building on the achievements of sectoral management while reconnecting the basin ecosystem as a whole.

1.4. Reframing the Basin Ecosystem as a Regional Management System

An integrated view of the basin ecosystem brings decisions about where to protect, farm, locate cities and industries, and invest into a single regional strategy grounded in water, land, disaster risk, and ecosystem conditions. Basin management is thus also regional economic policy: it supports industrial location, productivity, investment, employment, and income. The natural environment should be considered at basin scale, and economic activity as networks within and beyond the basin. Connecting these perspectives supports sustainable regional economic development.

1.5. Linking Disaster Risk Reduction and Environmental Protection to Regional Economic Development

Disaster risk reduction and environmental protection should not be viewed solely as additional costs of economic development. When disasters destroy roads, factories, homes, and farmland, they also destroy accumulated capital and productive capacity. Water shortages, deteriorating water quality, and ecosystem degradation constrain agriculture, industry, and urban activity. Investment in disaster risk reduction and the environment can improve safety while creating industries, jobs, and investment opportunities. The Sendai Framework for Disaster Risk Reduction 2015–2030 identifies investment in disaster risk reduction for resilience as a priority for action (UNDRR 2015)[2]. The proposed approach to regional management seeks to protect lives and the natural environment, develop industry, and

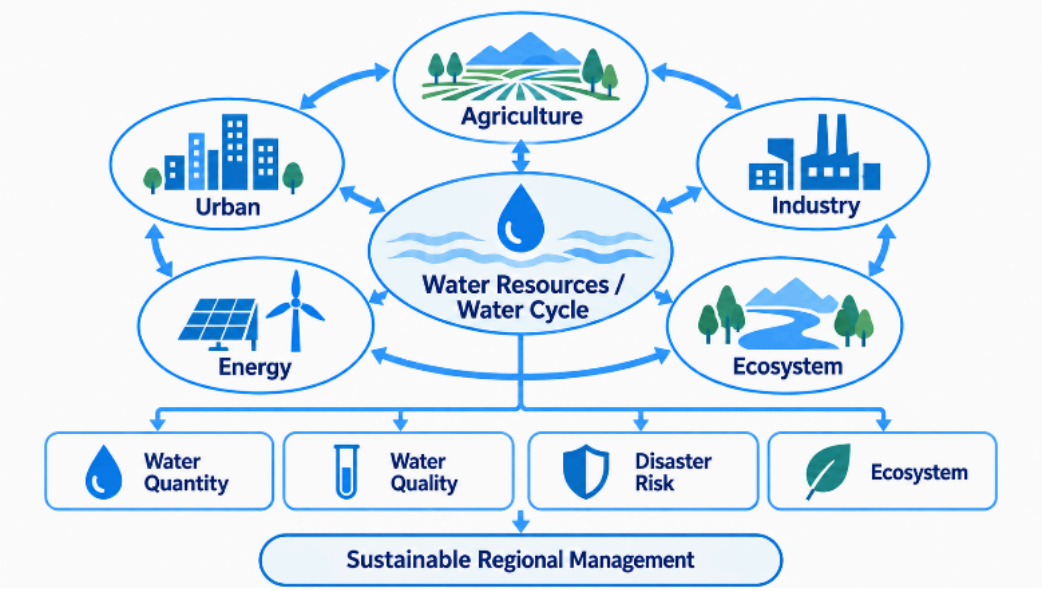
increase employment and income. It reinvests the value generated by growth in disaster risk reduction, the environment, and people.

2. Rebuilding Basin Management as a Foundation for Regional Management

2.1. Water Connects the Basin Ecosystem

Water is central to the basin ecosystem as a regional management system. Agriculture needs irrigation water, cities need domestic water, and industry needs water for production. Power generation also depends on the water cycle. Water connects forests, farmland, cities, and ecosystems from upstream to downstream, while competing uses draw on the same resource. Water management should therefore serve as a common foundation for regional management across agriculture, cities, industry, energy, and ecosystems. Basin management uses water as a lens to understand the condition and constraints of the entire basin ecosystem and strengthen the sustainability of the regional economy.

Figure 2. Water Management as Regional Management



Source: Author

2.2. Water Balance as a Condition for Economic Growth

Population growth, urbanisation, and industrial concentration increase water demand, while climate change alters rainfall, river flows, and groundwater recharge. Available supplies from rivers, reservoirs, groundwater, and reclaimed water must therefore be assessed against demand from agriculture, cities, industry, energy, and ecosystems.

Water-balance information helps determine which industries can be located where, and at what scale, to enable sustainable growth. Its purpose is to inform development decisions. Water management should therefore underpin industrial, urban, agricultural, and investment policy.

2.3. Assessing Water Quantity, Water Quality, Disaster Risk, and Ecosystems Together

Assessing water quantity alone is insufficient for regional management. Poor water quality reduces usable supplies, while floods, droughts, and other disaster risks constrain land use and investment. Ecosystems also require water. Basin management must therefore assess water quantity, water quality, disaster risk, and ecosystems together. This allows regional safety, environmental pressures, industrial location, productivity, and future growth potential to be compared within one regional management framework. Basin management uses water as a lens to reveal the constraints and opportunities of the entire basin ecosystem, extending beyond the resolution of individual water problems.

3. Basin OS: An Integrated Decision-Support Platform for Regional Management

3.1. From Urban OS to Basin OS

Cities increasingly use urban operating systems (Urban OS) to connect data on transport, disaster risk reduction, energy, and public services to support city operations and policy decisions. Urban OS connects data and services across sectors. The same approach can be extended to regional management at basin scale. Urban OS primarily addresses administrative areas and urban functions, whereas water cycles, floods, sediment flows, and ecosystems extend across administrative boundaries. Upstream forests and farmland, urban water use, industry, and downstream agriculture interact through a single river system. The Urban OS approach therefore needs to extend beyond administrative boundaries and be organised around the natural water cycle. We call this basin-scale decision-support platform Basin OS.

3.2. What Basin OS Connects

Basin OS connects more than river and water-management data. It brings together information on water, disasters, ecosystems, land use, cities, agriculture, industry, transport, energy, and investment to reveal the basin's condition, constraints, and opportunities. Where water is scarce, for example, decisions on urban growth, agricultural production, and industrial location should jointly consider future water demand, disaster risk, and ecosystem impacts. Basin OS does not require a single large new information system. It progressively connects existing data, systems, institutions, and knowledge through application programming interfaces (APIs) and similar tools. The scope of data sharing, decision rights, access, and safeguards should be agreed with data holders and affected stakeholders.

Its central task is to connect what already exists while building trust through transparent assumptions, accountable governance, and locally appropriate data arrangements.

3.3. Definition of Basin OS

We define Basin OS as follows:

Basin OS is an integrated decision-support platform that extends the Urban OS approach to the basin scale. With water management at its core, it connects information on the natural environment, land use, agriculture, industry, cities, disasters, and investment, and compares future scenarios to support regional economic policy and investment decisions.

Its distinctive feature is the connection between natural and socioeconomic systems. It jointly assesses water, disasters, and ecosystems that cross administrative boundaries and their relationships with cities, agriculture, industry, transport, investment, and other economic activities.

In the future, information connected through Basin OS could inform common regional management indicators based on the concepts of a balance sheet, profit and loss statement, and cash flow statement. These indicators would link stocks of natural capital and infrastructure with future burdens, regional value creation with maintenance costs, and investment with reinvestment. Together, they would help assess regional sustainability and policy and investment outcomes. Physical and risk indicators should complement monetary measures where natural capital, disaster risk, or other factors are difficult to value financially.

3.4. Basic Process

The basic Basin OS process is "Data → Scenario → Policy → Investment → Monitoring → Learning." First, data on water, land, disasters, ecosystems, cities, agriculture, and industry are connected to reveal current conditions, risks, and regional value. Alternative futures for population, climate, water demand, industrial structure, and land use are then compared. The results inform policy options and decisions on public and private investment and industrial location. After implementation, outcomes are monitored and fed back into the data and models. Basin OS thus supports an ongoing decision process rather than serving merely as a data platform or dashboard. Just as Urban OS supports city operations, Basin OS guides the sustainable management of the basin ecosystem as a regional system.

4. A Sustainable Regional Economic Development Model Based on Basin Ecosystems

4.1. Spatial Management: Development, Buffer, and Conservation

Uniform development or conservation across an entire basin is rarely appropriate. We distinguish three spatial roles. The Development Zone (Urban Zone) comprises areas with relatively low risk

and favourable water, transport, and infrastructure conditions, towards which cities and industry are directed. The Buffer Zone (Reserved Development Zone) accommodates flooding and other risks through uses such as farmland, wetlands, green space, and flood-retention areas. The Conservation Zone (Ecosystem Conservation Zone) protects water sources, forests, wetlands, and areas of particular importance for biodiversity. These roles form a regional management approach that is reviewed as risks, development needs, and ecosystem values change. They are not fixed land-use regulations.

4.2. Turning Natural Capital into Resilience and Regional Value

Forests, wetlands, farmland, and river corridors retain and recharge water, regulate floods, purify water, store carbon, and support biodiversity and landscapes. Nature-based Solutions (NbS) and Ecosystem-based Disaster Risk Reduction (Eco-DRR) use these functions to address societal challenges. Natural capital investment should be assessed for the damage it avoids, the living conditions and land and asset values it improves, and the stability it brings to industry, alongside its environmental benefits.

Figure 3. Three Zones and the Value Cycle



Source: Author

Biodiversity conservation should be coordinated with water cycles, land use, and development plans. Target 3 of the Kunming-Montreal Global Biodiversity Framework calls for effective conservation and management of at least 30% of terrestrial and inland water areas, and of marine and coastal areas, by 2030. This is not equivalent to conserving a uniform 30% of every basin (CBD 2022)[3].

4.3. A Value Cycle through LVC and PES

Upstream forest conservation benefits downstream cities, agriculture, and industry, but upstream communities often bear a disproportionate share of the costs. Combining Land Value Capture (LVC) with Payments for Ecosystem Services (PES) can address this imbalance. LVC captures part of the land

and asset value generated by public investment and urban development. PES and related mechanisms channel that value back to upstream forests, water sources, and ecosystems. This cycle of "Ecosystem Enhancement → Natural Capital → Risk Reduction → Economic Value → Reinvestment" is central to the economic model supported by Basin OS.

5. Policy and Investment Decisions through Scenario Comparison

Basin OS compares possible futures as well as revealing present conditions. Population, climate, water demand, industrial structure, and land use all change over time. For example, business-as-usual, growth-first, and balanced scenarios for 2035 and 2050 can be compared in terms of income, employment, productivity, water demand, disaster risk, natural capital, and public and private investment. This comparison also examines how limited water, land, and fiscal resources can be allocated among policies, areas, and industries to increase benefits for the whole region. The purpose is to show alternatives and their consequences so that a region can choose its own future. The comparison guides the selection of areas for investment, adaptive use, and conservation.

After implementation, key performance indicators (KPIs) assess economic, water, disaster risk, ecosystem, and social outcomes together. Growth that raises incomes while increasing water stress or disaster risk, for example, should not be judged sustainable. Feeding policy and investment outcomes back into the data makes Basin OS a continuously learning regional management platform rather than a fixed master plan.

6. Demonstration Model for the Citarum River Basin

6.1. Why the Citarum River Basin?

West Java, Indonesia, faces interconnected pressures from urbanisation, industrialisation, agriculture, water demand, flooding, water quality, and ecosystem change. The Citarum River Basin connects upstream forests and farmland, cities and industry in the Bandung Basin, the Saguling, Cirata, and Jatiluhur dams, and downstream agricultural and industrial areas through one river system.

Figure 4. Citarum Basin Demonstration Model



Source: Author

Note: Figure 4 is a schematic illustration of the demonstration model.

The Citarum River Basin supplies water to areas stretching from Bandung, Karawang, and Bekasi to Jakarta. According to the basin management agency, Balai Besar Wilayah Sungai Citarum (BBWS Citarum), irrigation networks supplied from the basin serve approximately 520,000 hectares of rice fields. Published figures from power producers put the combined installed generating capacity of the Saguling, Cirata, and Jatiluhur dams at approximately 1,900 MW (BBWS Citarum 2026; PLN Indonesia Power n.d.; PLN Nusantara Power n.d.; Perum Jasa Tirta II n.d.)[4]. The river is therefore critical economic infrastructure for West Java's water, food, electricity, cities, and industry.

6.2. Agricultural DX as the First Use Case

Agricultural DX is the proposed first use case. Water and weather data on rainfall, river flows, irrigation, water use, and flood risk would be connected with data on land, soils, crops, field conditions, and agricultural production. The objective is to improve agricultural policy and investment decisions by connecting water, land, weather, and agriculture at basin scale, rather than merely to develop an agricultural application.

The working hypotheses for 2035 are a doubling of farmers' income, a 20% increase in productivity, a 20% improvement in water-use efficiency, and a 30% reduction in disaster risk. These are hypotheses to be tested in a feasibility study (FS).

6.3. Expansion to Cities and Industry

The next stage would extend the approach to urban development, industrial location, and water-quality management. In textiles and dyeing, for example, connecting data on water intake, inputs,

production, wastewater, and water quality would allow water-use efficiency, wastewater treatment and reuse, and industrial location to be assessed together. Where lenders find evidence that improved environmental management reduces relevant risks, they may reflect those reductions in financing decisions, potentially including more favourable lending terms. For water-intensive industries, joint assessment of water resources, energy, transport, and disaster risk can improve location decisions. Renewable energy and energy management also need to be assessed at regional scale, including their relationship with water resources.

Making these regional challenges visible can create opportunities for companies and start-ups to demonstrate technologies and services in water treatment, sensing, data analysis, energy, and finance. Basin OS clarifies regional needs and connects technologies, businesses, and finance to develop commercially viable solutions, without selecting a particular technology in advance.

6.4. Joint Implementation with ITB

Institut Teknologi Bandung (ITB) is the proposed core institution for the local Knowledge Hub. ITB would build data and knowledge resources, conduct research, develop policy proposals and human capacity, and connect government, businesses, and communities. Japanese partners would contribute experience in water management, disaster risk reduction, cities, the environment, data, and commercialisation.

The approach would be developed jointly under local leadership, with local actors ultimately responsible for operation. It would progress from proof of concept (PoC) to demonstration, commercialisation, and self-sustaining operation, rather than import a finished Japanese system. Implementation should start with a limited use case selected jointly by Indonesian partners and expand only where evidence demonstrates local value, institutional feasibility, and commercial potential. The agricultural DX pilot should therefore be treated as a learning process through which local stakeholders can refine the objectives, governance, technologies, and indicators before wider application.

7. Governance and a Common Knowledge Hub for Basin OS

7.1. Data Governance

Basin OS does not require all government, university, and business data to be stored in one place. Data holders would generally retain their data and connect only what is needed for authorised purposes, subject to access rights and confidentiality. Public-private collaboration would cover public and business data as well as data from the Internet of Things (IoT), sensors, and satellites. Clear requirements for data quality, update frequency, provenance, access rights, and security are needed to support reliable policy and investment decisions. Artificial intelligence (AI) can assist analysis and scenario development, but its results require scrutiny of data limitations and assumptions, expert validation,

and human judgement. Universities, research institutions, and other Knowledge Hubs would provide neutral support for data standardisation, quality management, analysis, and coordination among stakeholders.

7.2. Integrator Professionals

Basin OS needs professionals who connect specialists in rivers, cities, agriculture, the environment, energy, data, and finance, enabling knowledge and practice to inform each other. We call them "integrator professionals." Integrator professionals need the ability to envision, connect, and implement: strategic leadership to shape the basin's future, coordination skills to bring stakeholders together, and practical skills to turn concepts into policies and projects. They need not be experts in every field. Their role is to identify the expertise required, connect universities, research institutions, government, businesses, financial institutions, and communities, and translate regional challenges into policies and projects.

Basin OS provides the decision-support platform, integrator professionals operate it, and Knowledge Hubs sustain the development of knowledge and people. Long-term operation requires a common knowledge hub through which knowledge, people, and practice continually inform one another.

8. Finance for Basin OS

Disaster risk reduction and environmental investments should be assessed in terms of social benefits, risks, and financial returns. The findings should inform the design of investable projects and appropriate public and private financing arrangements. Initially, official development assistance (ODA), public investment, multilateral development bank (MDB) funding, and climate finance can reduce risks associated with the FS, data development, capacity building, and institutional design. This prepares the conditions for private capital to participate.

As commercial viability becomes clearer, projects can draw on public-private partnerships (PPP), bank lending, project finance, and private investment. Identifying the mutual benefits of flood control, urban development, industrial location, water supply, agriculture, and ecosystem conservation allows related projects to be combined into investment packages.

LVC, PES, and related mechanisms described in Section 4.3 can return part of the value generated by development to upstream forests, water sources, and ecosystems. The resulting cycle is "Public Investment → Risk Reduction → Private Investment → Economic Growth → Value Capture → Reinvestment." Basin OS supports investment development by revealing risks, benefits, and value within the basin. It informs decisions on which funding to allocate to which projects at each stage; it does not itself provide finance.

9. Regional Economic Links beyond the Basin

The basin is a basic unit for managing water cycles, ecosystems, and disaster risk. People, goods, finance, energy, and information, however, move across basin boundaries. Natural systems should therefore be understood at basin scale, and economic systems as networks connecting basins. Each basin need not accommodate every urban, industrial, agricultural, and energy function. Basins can take complementary roles according to their resources and characteristics, and connect through transport, logistics, energy, and markets to form a wider regional economy.

In the Citarum Basin, transport and logistics connect agricultural and industrial production to markets, while power-generation sites and demand centres do not necessarily coincide. If urban and industrial growth brings water demand close to available capacity, coordination with neighbouring regions can complement land-use adjustments within the basin. Future comparisons of the water resources, agriculture, industry, cities, transport, and environmental conditions of the Citarum, Cimanuk, Cipunagara, and other basins could identify complementary roles and connections.

For example, basins focused on agriculture and food production, cities and industry, or water sources and natural capital could be linked through transport and logistics hubs. This would enable growth beyond the capacity of a single basin. Basin OS uses basins as the basic units of regional management and connects them into networks, supporting broader economic growth alongside environmental management rather than creating closed economies.

10. Co-Creation from Indonesia to the Global South

The Citarum initiative is not intended as a finished product or a uniform model for transfer to other countries. Natural conditions, industrial structures, institutions, cultures, knowledge systems, and development priorities vary by region. Methods and lessons developed in Indonesia would be shared as common knowledge, while each country would determine its own priorities, partners, governance, and implementation pathway. The candidate areas presented below are therefore illustrative starting points for dialogue, not predetermined projects.

10.1. India: Harohar River Basin / Rajgir Area in the Ganges System

The proposed candidate in India is the Rajgir area of Bihar. Rivers in the Nalanda area ultimately connect to the Ganges system. The theme is to strengthen rural and urban economies by combining traditional water management and digital technology. Nalanda University is the candidate Knowledge Hub. Its campus incorporates southern Bihar's traditional Ahar-Pyne water-management system, combining rainwater use, groundwater recharge, and wastewater reuse (Nalanda University n.d.)[5]. Connecting Nalanda's ancient tradition of knowledge exchange and traditional water management with IoT, satellite data, weather forecasts, and agricultural DX gives India a distinctive development theme: "Ancient Knowledge × Traditional Water Management × Digital Innovation."

10.2. Brazil: Rio Negro Basin / Manaus Area in the Amazon System

The proposed candidate in Brazil is Manaus in the State of Amazonas. The theme is to strengthen the regional economy through biodiversity and the bioeconomy. Conserving forests, water, and biodiversity can support higher-value industries in food, pharmaceuticals, cosmetics, tourism, and environmental services. Candidate Knowledge Hubs are the National Institute of Amazonian Research (Instituto Nacional de Pesquisas da Amazônia, INPA) and the Federal University of Amazonas (Universidade Federal do Amazonas, UFAM).

Connecting local knowledge of forests, rivers, and biological resources with science, data, and industrial policy gives Brazil the theme "Traditional Knowledge × Biodiversity × Science × Bioeconomy." The aim is to move from an economy that generates value by converting forests to other uses towards one in which maintaining forests and biodiversity creates income and industrial value.

10.3. South Africa: Johannesburg and the Vaal River Basin in the Orange River System / Crocodile River (West) Basin in the Limpopo River System

The proposed candidate in South Africa is Johannesburg in Gauteng. Johannesburg lies on the Witwatersrand drainage divide. To the north, the Crocodile River (West) connects to the Limpopo system. Northern Johannesburg and other areas also receive water transferred from the Vaal River system through Rand Water. South Africa's Department of Water and Sanitation reports that transfers from the Vaal support a substantial share of water use in the Crocodile River (West) basin (South African Department of Water and Sanitation n.d.)[6]. Johannesburg can thus be understood as a metropolitan area linking two major river systems through water use.

The theme is to restructure the urban and industrial economy by addressing water constraints and using the region's mining legacy. Candidate Knowledge Hubs are the University of the Witwatersrand (Wits University) and the University of Johannesburg (UJ). The region can build on the industrial capabilities developed through gold mining while creating opportunities for new industries in mine-water treatment, resource recovery, and environmental restoration, including efforts to address acid mine drainage. The proposed theme is "Mining Heritage × Water Technology × Circular Economy × Urban Regeneration." This theme envisages Johannesburg's transition from a city that produced gold to one that regenerates water and resources and creates new industries.

Table 1. Co-Creation Themes in Four Countries

Country	Target Area	Candidate Knowledge Hub	Regional Assets / Features	Co-Creation Theme
Indonesia	Citarum River Basin / Bandung	ITB	Water resources, agriculture, urban and industrial clusters, dams, ecosystems	Water × Agriculture × Cities / Industry
India	Harohar River Basin / Rajgir	Nalanda University	Traditional Ahar-Pyne water management, agriculture, long history of knowledge exchange	Ancient Knowledge × Traditional Water Management × Digital Innovation
Brazil	Rio Negro Basin / Manaus	INPA; UFAM	Forests, water, biodiversity, local knowledge, urban and industrial clusters	Traditional Knowledge × Biodiversity × Science × Bioeconomy
South Africa	Vaal / Crocodile River Basins / Johannesburg	Wits University; UJ	Water constraints, mining legacy, urban and industrial clusters, mine water, resource circulation	Mining Heritage × Water Technology × Circular Economy × Urban Regeneration

11. Policy Recommendations and Implementation Roadmap

11.1. Policy Recommendations

We propose six policy recommendations.

- **Recommendation 1:** Use water balance, disaster risk, and ecosystem value as common criteria for urban development, industrial location, agricultural policy, and public investment decisions.
- **Recommendation 2:** Develop Basin OS as a common foundation for policy and investment decisions, extending beyond the functions of a data platform.
- **Recommendation 3:** Assess the avoided damage, production stability, land and asset value, and employment generated by disaster risk reduction and natural capital investment, and incorporate these effects into policy and investment appraisal.
- **Recommendation 4:** Position locally anchored universities and research institutions as Knowledge Hubs within Special Epistemic Zones (SEZ), connecting government, businesses, financial institutions, farmers, and communities, and translating shared knowledge into feasibility studies, investable projects, and locally relevant business opportunities.

- **Recommendation 5:** Develop integrator professionals who can envision, connect, and implement, with the aim of self-sustaining operation under local leadership.
- **Recommendation 6:** Use public funding to reduce initial risks, mobilise PPP, private investment, LVC, and PES, and reinvest the value generated by growth in the basin.

11.2. Implementation Roadmap

Implementation would proceed in four phases.

Phase 1: Preparation and Demonstration Design (0–6 months). Confirm the target area, priority challenges, implementing organisations, data, and institutions, and establish a joint implementation framework.

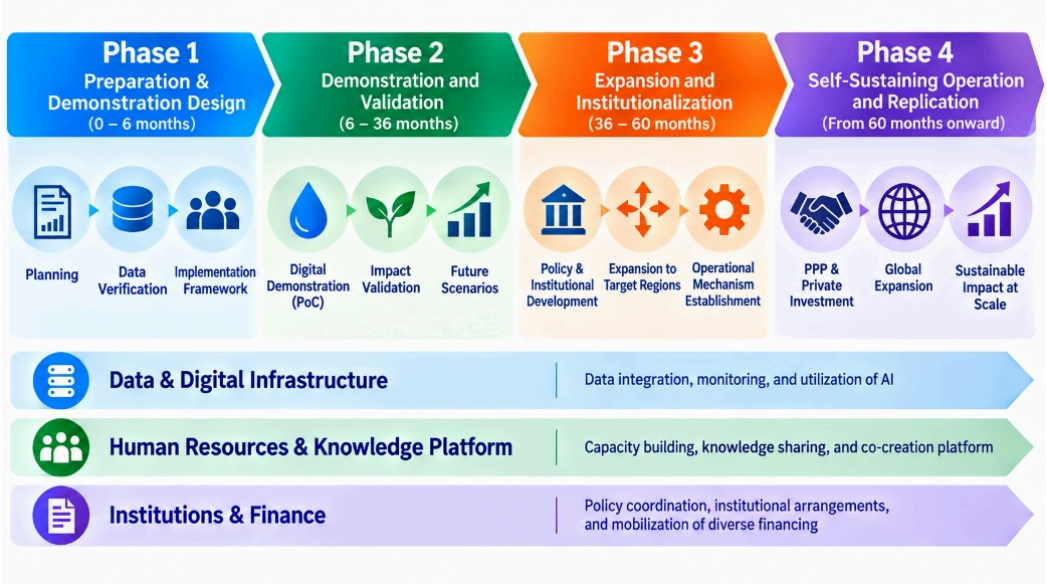
Phase 2: Demonstration and Validation (6–36 months). Connect existing data and fill gaps using IoT and other tools. Begin PoC with agricultural DX and related use cases, and develop future scenarios.

Phase 3: Expansion and Institutionalisation (36–60 months). Compare policy and investment scenarios, expand to agriculture, water, cities, land use, industry, and natural capital, and transfer operation to local personnel.

Phase 4: Self-Sustaining Operation and Replication (60 months onward). Mobilise PPP and private investment, embed data governance in routine practice, expand to neighbouring basins, and connect to the common knowledge hub across countries.

The ultimate goal of Basin OS is a region where protecting natural capital strengthens the economy, and economic growth enables further investment in disaster risk reduction, the environment, and people. Completion of a digital system is only a means to that end.

Figure 5. Implementation Roadmap



Source: Author

Japan should contribute its experience in water management, disaster risk reduction, urban planning, and infrastructure development in combination with each country's natural conditions, culture, institutions, people, and technologies. Indonesia, India, Brazil, and South Africa would each shape their own locally appropriate approach, drawing selectively on the Basin OS methodology. We aim to start with a jointly designed FS in the Citarum River Basin and proceed towards demonstration in stages. The resulting evidence, methods, and lessons would be shared through the Global Five Epistemic Caucus (G5EC), while participating countries and local partners would retain ownership of their development priorities, data, and implementation choices.

Basin OS is a methodology that enables regions to choose their own future and sustain growth on the foundation of water and ecosystems, rather than a finished system for unified basin management.

12. Basin OS as a Pilot Project for the SEZ Concept

12.1. The SEZ Concept

In this section, we consider the direction of new regional development strategies based on Basin OS. Here, SEZ refers to a Special Epistemic Zone (Recommendation 4), not a special economic zone. As defined in Section 3.3, Basin OS is an integrated decision-support platform that supports policy and investment decision-making by connecting information on water management, natural environment, land use, agriculture, industry, cities, disasters, and investment, and comparing future scenarios. It is built by gradually connecting existing systems through APIs and similar tools.

The policy recommendation in this paper is that, for promoting development strategies in local regions of the Global South, governmental administrative bodies (local offices of central government and local governments) should retain their administrative responsibilities, while universities/research institutions supporting the operation of the Basin OS should promote collaboration among industry, government, and academia as the core of a common knowledge hub. This would enable a promotion strategy based on superimposed governance through collaboration among administrative bodies, universities/research institutions, private companies, and local communities. This would contribute to disaster risk reduction and national resilience by supporting the understanding of disaster risks and decisions on disaster risk reduction investment.

In advanced countries including Japan, the planning and implementation of regional development strategies within the nation state have traditionally been handled by administrative organisations, such as local offices of the central government and local governments. In such countries, this approach has been generally effective, and throughout the 19th and 20th centuries, regions generally developed successfully. On the other hand, for 21st-century development strategies in local regions of the Global South, we believe that, rather than simply following the approaches of advanced countries, regions should adopt methods suited to the realities of 21st-century civilisation.

Regarding how to promote development strategies for local regions in the Global South that are suited to the realities of 21st-century civilisation, the Musashino Institute for Global Affairs (MIGA) proposed a new regional development strategy in its 2025 "Musashino Reflection," with SEZs serving as Knowledge Hubs. In this strategy, ambitious universities and research institutions in local regions of the Global South support the planning and implementation of the development strategy for the entire region through the provision of knowledge and support for coordination among stakeholders, on the premise that administrative organisations retain their administrative responsibilities. It is also one of the "leapfrog" development strategies that promote knowledge-intensive industries through DX ahead of manufacturing: SEZs such as universities and research institutions support the development of the whole region by providing knowledge through an interoperability platform in cyber-physical systems. This kind of development strategy is called the "New Brain Location Policy."

The historical background of the SEZ concept is as follows: MIGA compiled the MIGA Policy Package "Path Diversity" for "No One Left Behind," a policy proposal for the Global South, in November 2024. This policy paper was distributed at G20-related events held in Rio, including the Sherpa meetings. In fiscal year 2025, building on the concept of path diversity presented there, MIGA explored ways to promote development strategies in local areas of the Global South, which led to the internal development of the SEZ-type development strategy described above in May 2025. In light of Japan hosting the Ninth Tokyo International Conference on African Development (TICAD 9) in Yokohama in August 2025, a series of events was held under the theme of "Africa Year," and MIGA sought to promote this SEZ-type development strategy actively, especially to African states. As preparation for this, from May to June 2025, workshops on the SEZ-type development strategy were held with stakeholders at major

universities in Ethiopia and Kenya as well as at the African Union (AU) headquarters to gather feedback from the African side on this concept. Specifically, in Ethiopia, discussions and workshops were held with Addis Ababa Science and Technology University (May 28), Muna Jemal Redi, Minister's Advisor at the Ministry of Industry (May 29), Dire Dawa University (May 30), Jimma University (June 2), Adama Science and Technology University (ASTU) (June 3), Addis Ababa University (June 4), and Dr. Milkesa Jagema Tolera, Director General of the Manufacturing Industry Development Institute, Ministry of Industry (June 5). In Kenya, discussions and workshops were held with Jomo Kenyatta University of Agriculture and Technology (JKUAT) (June 9), Stanley Koske Sawe, Director at the Ministry of Industry (June 10), and Stephen Odua, Director at the Kenya Investment Authority (June 10). Additionally, at the AU headquarters, engagements were held with Prof. Saidou Madougou, Director of the Department for Education, Science, Technology & Innovation (June 4), Dr. Patrick Ndzana Olomo, Ag. Director of Department for Economic Development, Trade, Tourism, Industry and Minerals, Head Economic Policy & Sustainable Development (June 5), and Dr. Jean-Bertrand Azapmo, Principal Adviser to AU Commissioner for Economic Development, Trade, Tourism, Industry and Minerals & AU-G20 Sherpa (June 6).

The response was generally positive, with strong interest in this initiative from the African side. In particular, universities showed eagerness to act as SEZs themselves, taking on the role of a Knowledge Hub supporting regional development. Based on this response, in August 2025, the SEZ concept was introduced at Musashino University's International Seminar and the TICAD Side Event Seminar. Then in November 2025, MIGA participated in a G20 / Think 20 (T20)-related seminar held in Johannesburg to present the SEZ concept. Since then, the SEZ concept has continued to be widely introduced in seminars at universities in the Global South, including the Asia Professional Education Network (APEN) General Assembly Seminar (December 2025), ITB and Maranatha Christian University (December 2025), National University of Laos (March 2026), and Eastern Visayas State University (March 2026).

12.2. Basic Concepts of SEZ and Basin OS

An SEZ is a mechanism for optimising the activities of the many domains within a social system so as to maximise common value. We call this kind of system a Domains Optimising System (DOS). SEZs are one way to implement DOS.

Within social systems, numerous domains such as the education domain, the industrial domain, and the religious domain coexist in an overlapping manner. Each of these domains operates according to a different value system. For the education domain, the value is student empowerment; for the industrial domain, the value is profit maximisation; and for the religious domain, the value is the worship of God. DOS serves the function of providing knowledge to coordinate these domains, which are all governed by completely different values, so that the overall social system moves towards the realisation of common values, optimising the way each domain operates. It assumes that each domain primarily operates according to its own value but nudges each domain gradually towards the direction

of common values. For example, if the common value is different from the empowerment of students, profit maximisation, or worship of God, consensus-building among stakeholders would be supported so that the education domain acts 95% for student empowerment but 5% towards the attainment of the common value, the industrial domain acts 95% for profit maximisation but 5% towards the common value, and the religious domain acts 95% for worship of God but 5% towards the common value.

The idea of DOS—that a social system is composed of many domains and that each domain should be optimised to achieve an overarching common value—is not new. History offers numerous examples. For example, national development plans also provide a mechanism for coordinating policies across multiple domains. In Indonesia, the National Long-Term Development Plan (RPJPN) and the National Medium-Term Development Plan (RPJMN) are prepared under the National Development Planning System (SPPN), based on Law No. 25 of 2004 (Republic of Indonesia 2004)[7].

Compared with these, SEZ strategies have two distinctive characteristics. The first characteristic is that, as a methodology for optimising each domain, it takes the approach of linking digital data. In conventional coordination among domains, plans by administrative organisations and discussions among stakeholders have played important roles. In the SEZ strategy, by contrast, digital data hubs set up in SEZs such as universities or research institutions complement such coordination: AI is used to clarify how each domain could be optimised, and the results are shared electronically with each domain to support stakeholders' decisions. We call this methodology of the SEZ strategy the Cyber Domain Optimising System (C-DOS).

The second characteristic of the SEZ strategy concerns the areas targeted by regional development strategies, and it is here that the connection to Basin OS lies. The target regions for regional development strategies supported by SEZs are set by the concept of a basin, in coordination with existing administrative mechanisms.

Traditional regional development strategies by administrative organisations are carried out according to administrative boundaries. However, as discussed earlier in this paper, zoning based on administrative boundaries is not necessarily a sound basis for designing regional development strategies, and planning and implementing strategies for each administrative area may not be efficient. By contrast, the concept of a basin, which this paper advocates, can be considered an appropriate zoning method for thinking about regional development strategies in the Global South in the 21st century. As discussed in Section 1, forests, farmland, wetlands, cities, industrial areas, etc., are interconnected through the water cycle. A basin is a regional system where the natural environment and socioeconomic activities are connected through water.

It is therefore reasonable for universities/research institutions acting as SEZs, in collaboration with administrative organisations and other stakeholders, to set the basin as the basic unit for planning and implementing regional development strategies. Basins often cross multiple administrative areas and

sometimes only cover part of an administrative area. As a result, regional development strategies based on basins may diverge in many respects from those implemented along administrative boundaries.

The Subak water-management system in Bali, an example of traditional Asian wisdom, illustrates how administrative boundaries, which divide territory for ordinary administrative tasks, can coexist with water-management units based on irrigation systems, and how the two can coordinate their respective roles where their functions overlap. Subak was inscribed on the UNESCO World Heritage List in 2012 as part of "Cultural Landscape of Bali Province: The Subak System as a Manifestation of the Tri Hita Karana Philosophy." Two points are important. First, Subak is organised independently of administrative units such as the Banjar (sub-village) and Desa (village). Subak boundaries are based on irrigation systems supplied by the same diversion weir or main canal, rather than administrative areas, and do not necessarily coincide with an entire basin. Therefore, it is common for members of the same Banjar to belong to different Subaks. Second, even though Subak operates independently of administrative structures, it collectively manages irrigation water allocation and the maintenance of canals. Governance in traditional rural communities in Bali is thus superimposed: it is exercised both by administrative units such as the Banjar and Desa and by the Subak system.

This example suggests that it is at least logically possible to build a governance system in which two types of governance are superimposed, through coordination between ordinary administrative structures and the entities implementing basin-based governance. What we propose is the construction of such a superimposed governance system. In other words, in local regions of the Global South, national and local governments should take the lead in administrative tasks, including disaster risk reduction and economic development, while SEZs should serve as a basin-based common knowledge hub, supporting administrative policy-making and decision-making through the provision of knowledge and coordination support by universities/research institutions. This division of roles is also premised on the Sendai Framework principle that the State bears primary responsibility for disaster risk reduction (UNDRR 2015)[2].

12.3. Implementing Basin OS: Preparing a Collaborative Project with ITB

As described in Section 6, we are preparing a pilot project to build a Basin OS targeting the Citarum River Basin in West Java, with ITB as the core institution of the local common knowledge hub. We position this as a pilot project for SEZ-type development strategies in local regions of the Global South, aiming to proceed in stages from PoC to demonstration and commercialisation.

The historical background of this project with ITB is as follows: As mentioned earlier, MIGA consolidated its ideas on SEZs in the summer of 2025, and these were widely introduced to the Global South at TICAD-related events in August 2025 and G20-related events in November. Immediately afterward, in December 2025, a MIGA researcher visited ITB and reached a basic agreement with the university's vice rector on establishing SEZ functions at ITB in collaboration with MIGA. In 2026, based on this agreement, a number of collaborative research projects were undertaken, and as a venue to present

these results, MIGA co-hosted a Basin OS workshop in August 2026 with the Faculty of Civil and Environmental Engineering at ITB. Furthermore, following the agreement reached with the university rector in August 2026, the necessary preparations for building Basin OS are currently underway. The specific implementation arrangements and scope will be developed through discussions with stakeholders and a joint FS.

Through this collaborative project with ITB, we aim to develop and test an initial reference case for an SEZ-type regional development strategy. The purpose is not to establish a standard for the Global South, but to generate adaptable methods, evidence, and lessons that other regions may assess and combine with their own institutions, knowledge, and development priorities.

A major reason for choosing ITB is its unique position in West Java. As we saw earlier, the key to the SEZ-type development strategy lies in whether a superimposed governance system can be established in the region—one that involves governance by administrative organisations and the provision of knowledge and coordination support by universities/research institutions that set the target areas based on basins. Sustained implementation requires trust, clear responsibilities, and workable coordination between administrative organisations and the universities or research institutions serving as SEZs. Where institutional interests differ, the joint FS should provide a process for clarifying roles, identifying shared objectives, and resolving concerns before implementation is expanded. In this regard, the accumulated collaboration between ITB and the West Java Provincial Government and other partners can provide a basis for building trust between administrative organisations and universities/research institutions. Because of these particular circumstances, it is reasonable to expect that applying the Basin OS built in Bandung directly to other local regions of the Global South would lead to various problems. However, for the purpose of building an initial model case, it can be considered a promising environment.

In addition, MIGA researchers have regularly held seminars on the West Java Developmental Strategy in Bandung since the 2010s (most recently in March 2023), co-hosted by ITB, the West Java Provincial Government, and Japanese universities. Building on this cooperation, we aim to steadily advance the project described in this paper.

Notes

1. IPCC (2023). The report finds that human-caused climate change is already having wide impacts on nature and society. In urban areas, extreme events damage key infrastructure such as transport, water, sanitation, and energy systems, causing economic losses and service disruption. Climate-related losses also affect exposed sectors such as agriculture, forestry, fisheries, energy, and tourism.
2. UNDRR (2015). Priority 3 identifies structural and non-structural investment in disaster risk reduction as essential for stronger economic, social, and environmental resilience. Paragraphs 19(a) and (b) state that

the State has primary responsibility for disaster risk reduction and that responsibility is shared with local governments and other stakeholders.

3. CBD (2022), Target 3. The target calls for effective conservation and management of at least 30% of terrestrial and inland water areas, and of marine and coastal areas, by 2030. It does not mean a uniform 30% of each basin.
4. BBWS Citarum (2026). The article reports that irrigation networks supplied from the Citarum basin serve 522,861 hectares. For installed generating capacity, PLN Indonesia Power (n.d.) (Saguling: 175.18 MW × 4 units), PLN Nusantara Power (n.d.) (Cirata: 1,008 MW), and Perum Jasa Tirta II (n.d.) (Jatiluhur: 187.5 MW) give a combined total of 1,896.22 MW (approximately 1,900 MW).
5. Nalanda University (n.d.). The university uses the traditional Ahar-Pyne water-management system of southern Bihar and combines rainwater use, groundwater recharge, and wastewater reuse.
6. South African Department of Water and Sanitation (n.d.). The Crocodile River (West) basin extends north from the drainage divide in central Johannesburg and connects to the Limpopo River system. The basin also depends on water transferred from the Vaal River through Rand Water.
7. Republic of Indonesia (2004). The law provides for the National Long-Term Development Plan (RPJPN), the National Medium-Term Development Plan (RPJMN), and other plans.

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Chapter 7: Tokyu's Urban Development Business Model in Global Expansion: An Overview of the Tokyu Group and Urban Development Cases in Vietnam and Australia

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Part I: Overview of the Tokyu Group

1. Introduction: Overview of the Tokyu Group and Its Century-Long History

Since its founding in 1922, the Tokyu Group has consistently placed machizukuri (community-oriented urban development) at the core of its business. Its trajectory has not been limited to building railway infrastructure; rather, it has developed a distinctive management model that integrates transportation, real estate, and lifestyle services to maximise the value of the areas it serves.

(Founding History and Philosophy)

The origins of the Tokyu Group date back to the establishment of Meguro-Kamata Electric Railway Co., Ltd. on 2 September 1922. The symbolic starting point of its more than 100-year history is the opening of the Meguro Line (between Meguro and Maruko) on 11 March 1923. The founding philosophy at the time was to "lay tracks where there is nothing, draw people in, and build a town." This idea can be regarded as the origin of "transit-oriented development (TOD)," in which a railway is laid first, and residential development is promoted at the same time to create a population along the line.

(Scale and Performance of the Core Company)

TOKYU CORPORATION, the core company of the group, is listed on the Prime Market of the Tokyo Stock Exchange. According to data based on its management plan (projected figures as of the end of March 2026), it has capital of ¥121.7 billion, total assets of approximately ¥2.9 trillion (¥2,922.8 billion), and 24,262 consolidated employees.

(Analysis of the Segment Structure)

The company operates four segments: transportation, real estate, lifestyle services, and hotels and resorts. Looking at the composition of operating profit in the FY2025 plan, the real estate business (42.5%) and the transportation business (26.7%) form the two main pillars of earnings, while the lifestyle services business (21.3%) and the hotel and resort business (9.5%) contribute to diversifying revenue and enhancing added value. Although the company's brand is strongly associated with the image of a railway company, these figures show that it is, in fact, an urban development company.

Table 1. Tokyu Corporation's segment structure (FY2025 plan)

Segment (FY2025 plan)	Operating revenue	Operating profit (share)	Total assets (share)
Transportation	¥226.9 billion	¥27.3 billion (26.7%)	¥779.8 billion (26.7%)
Real Estate	¥262.9 billion	¥43.5 billion (42.5%)	¥1,301.0 billion (44.4%)
Lifestyle Services	¥533.2 billion	¥21.8 billion (21.3%)	¥463.8 billion (15.9%)
Hotels and Resorts	¥139.3 billion	¥9.7 billion (9.5%)	¥139.3 billion (4.8%)

Note: Total operating profit and total operating revenue are before eliminations and other adjustments.
Source: Compiled by the author from various sources.

2. Structural Analysis of TOD and Regional Conglomerate Management

The Tokyu Group's greatest distinctiveness lies in its fusion of transit-oriented development (TOD) with "regional conglomerate management," which pursues synergies across businesses.

(Definition and Practice of TOD: The Cyclical Reinvestment Model)

TOD (Transit Oriented Development) refers to high-density urban development centred on public transportation such as railways. Tokyu has sought to settle populations along its lines by integrating improvements in the convenience of its railway network with real estate development. The essence of this model lies in its "long-term cyclical business model." Specifically, real estate development is used as a hook to attract population, additional returns are earned through the use of railways, supermarkets, department stores, and other lifestyle services, and those profits are reinvested in enhancing the convenience of the area (value-up), thereby achieving a sustained increase in the value of the areas along its lines.

(Complementarity of the Business Portfolio and Risk-Return Profiles)

The company clearly distinguishes the risk-return characteristics and capital requirements of each business and manages its portfolio strategically.

- **Foundational businesses (transportation and real estate): These form the "foundation of the business," requiring large capital investment but generating low-risk, stable returns. They play the role of encouraging population to settle in the area.**
- **Value-creating businesses (lifestyle services and hotels): These have a strong "fee business" character that leverages the customer base formed by the railway and development; they require relatively little invested capital and, while medium- to high-risk, are expected to generate high returns.**

(The Evolution of the Shibuya Area: From a Cluster of Startups to a Base Where Growing Companies Take Root)

The emblem of this model is the Shibuya area, where "once-in-a-century redevelopment" is under way. Once known as "Bit Valley," Shibuya still boasts the highest rate of emergence of "new and startup companies" among Tokyo's 23 wards, at 6.8% (2024 survey). Leveraging this advantage, Tokyu is promoting Shibuya's evolution from merely a "startup town" into a "town where growing

companies take root," where companies remain in the area even after expanding their businesses. In addition, in 2025 the company established Tokyu Retail Management Co., Ltd., consolidating the group's commercial facility operation functions. Further, in 2023 it relaunched Tokyu Hotels & Resorts following a reorganisation. Through such organisational restructuring, it has built a structure capable of responding to increasingly diverse needs for customer experiences.

3. Integrating Sustainable Management Strategy and Sustainability

Maintaining the value of the areas along its lines in a society with a declining population requires reconciling environmental responsiveness with economic viability. Tokyu positions sustainability at the core of its growth strategy.

(Environmental Vision and Promotion of Decarbonisation)

Tokyu has achieved operation powered by 100% renewable energy across all its railway and tramway lines, taking a pioneering approach to decarbonising mobility as a social infrastructure. GX (green transformation) investment not only reduces environmental impact but also directly enhances the brand value of its areas as clean towns.

(Strategic Aspects of the Medium-Term Three-Year Management Plan (FY2024–FY2026))

The current plan, "Creative Act.: Flexibly, with Creativity, toward a 'Town the World Admires,'" marks a clear shift from the conventional pursuit of scale expansion to management that emphasises capital efficiency. This reflects changes in the business environment, such as rising interest rates accompanying monetary normalisation and a severe surge in construction costs. The company has adopted "management conscious of the cost of shareholders' equity" and is optimising its asset portfolio.

(Quantitative Analysis of Management Indicators and Future Outlook)

The quantitative targets for FY2026 reflect the company's commitment to sustained enhancement of corporate value.

Table 2. Key management indicators: FY2023 forecast and FY2026 targets

Indicator	FY2023 (forecast)	FY2026 (plan)
Operating profit	¥90.0 billion	¥95.0 billion
ROE (return on equity)	7.9%	8.0%
EPS (earnings per share)	¥99.6	¥116
Tokyu EBITDA	¥198.6 billion	¥210.0 billion

Note: "Tokyu EBITDA" is defined as the sum of operating profit, depreciation, amortisation of goodwill, loss on retirement of non-current assets, interest and dividends received, and equity in earnings (losses) of affiliates, and serves as a key indicator of the group's cash-generating capacity. The ROE target of 8.0% aims to strengthen market confidence by continuously generating profits that exceed the cost of capital. In a society with a declining population, providing social value through "mobility" and creating a "conglomerate premium" through collaboration among businesses are the keys to ensuring the company's sustainability.
Source: Compiled by the author from various sources.

4. Significance of the Tokyu Business Model and Conclusion

The strength of the Tokyu Group lies in the fusion of sound infrastructure operation based on TOD with a management capability to transform its organisation flexibly in step with the times.

Tokyu's regional conglomerate management seeks to build unique strengths by concentrating management resources in specific areas and maximising synergies among businesses. Moreover, its sustainability initiatives are not a management constraint but a necessary investment for remaining an "area that continues to be chosen" in an era when towns are increasingly being selected.

Facing macroeconomic headwinds such as soaring construction costs and rising interest rates, Tokyu continues urban redevelopment centred on Shibuya and the enhancement of the value of areas along its lines while steering its management with an emphasis on capital efficiency; this stance can serve as one model for sustainable urban management in Japan. The author believes that the Tokyu Group's challenge of deepening its cyclical reinvestment model towards creating "a town the world admires" also offers a useful reference for thinking about the future of urban development and social infrastructure in Japan.

Furthermore, against the backdrop of urban growth in Asia, Tokyu is promoting new urban management models. In Binh Duong New City, Vietnam, it has been developing "TOKYU Garden City" since 2012, drawing on its experience in developing Tama Den-en Toshi. In Yanchep, Western Australia, it has launched the "Campus in the City Project," which positions educational facilities at the core of urban development, with Tokyu serving as a platform to bring together the knowledge and technologies of universities and companies. (End)

Part II: Tokyu's International Business — Urban Development Cases in Vietnam and Australia

1. Introduction: Perspective of This Paper

In Part I, I reported that the Tokyu Group, centred on transit-oriented development (TOD), has built a cyclical reinvestment model in which transportation and real estate serve as foundational businesses, with lifestyle services and hotel businesses layered on top of the customer base they generate. This paper examines how that model has been implemented abroad, focusing on two project sites: Binh Duong New City in Vietnam and the Yanchep area in Western Australia.

I would like to make one point clear at the outset. Tokyu's overseas business is not simply a transplant of methods perfected in Japan. In Binh Duong, we started without any railway, and in Yanchep it took 50 years from the acquisition of the land until the railway arrived. In truth, there were few situations in which our domestic successes could be applied as they were. Nevertheless, the two sites share a

common structure. The concern of this paper is what that structure is and to what extent it can be transferred to other countries.

The author was stationed at the local subsidiary, Becamex Tokyu, from October 2020 to March 2026, in charge of commercial facilities, residential sales, property management and operations, and new businesses. Part of this account is based on practical observations from that period.

This paper is structured as follows. After reviewing the development stage of the Vietnamese market in Section 2 and the locational conditions of the project site in Section 3, Sections 4 through 6 describe specific business activities in Binh Duong New City. Section 7 takes up the case of Western Australia, and Section 8 summarises the structure that can be extracted from the two cases and its transferability.

2. Vietnam as a Market: A Replay of a High-Growth Period

Let me begin by describing the business environment. The Socialist Republic of Vietnam has a population of approximately 100 million and an area of approximately 330,000 square kilometres, roughly the size of Japan excluding Kyushu. In 2025, its real growth rate was 8.02%, GDP per capita was US$5,026, and inflation was 3.31%. Its administrative divisions consist of 28 provinces and 6 centrally governed cities.

Table 3. Overview of Vietnam

Item	Overview
Political system	Socialist republic
Administrative divisions	28 provinces + 6 centrally governed cities (Hanoi, Ho Chi Minh City, Hai Phong, Da Nang, Can Tho, Hue)
Population	Approx. 100 million (2025) / urban approx. 38.2%, rural approx. 59.8%
Area	Approx. 330,000 km² (equivalent to the area of Japan excluding Kyushu)
Major cities	Capital Hanoi: 8.8 million / Ho Chi Minh City: 14 million
Economy	Growth rate 8.02%, GDP per capita US$5,026, inflation 3.31% (all for 2025)

Source: Compiled by the author from various sources.

The fact that the urbanisation rate is below 40% points to both business opportunities and challenges. A rising share of the population living in cities means that demand for housing and urban services is yet to emerge. At the same time, unless cities are developed in a planned manner to receive this population, people will flow into the peripheries of existing cities in a sprawling fashion. The problem in many cities across Asia and Africa is not a lack of demand but the failure of the urban framework to keep pace with the arrival of demand. This is where the significance of planned cities such as Binh Duong New City lies.

(The Development Stage Indicated by GDP per Capita)

What deserves attention is not the level itself but the stage of development that the level signifies. Vietnam's GDP per capita has roughly tripled since 2012, maintaining the highest growth rate among ASEAN countries. The current level is comparable to that of Japan in the 1970s, when the housing market expanded in earnest.

This correspondence has practical implications for the housing business. When GDP per capita exceeds US$4,000, housing begins to change in character from a speculative asset to a durable consumer good acquired to live in. It is also from this stage that condominiums for sale become a viable product, mortgages function, and demand arises for maintaining housing through management and repairs. When Tokyu began its business in Binh Duong in 2012, the country's level was just short of that threshold.

Compared within ASEAN, Vietnam's GDP per capita has not reached the levels of Malaysia or Thailand, but its growth rate is among the highest in the region. It sits in the same band as Indonesia and the Philippines, but on a steeper trajectory. As a market, it is at a stage where its size is not yet fixed but is still being determined.

(The Time Constraint of the Demographic Dividend)

Another indicator is the population structure. Vietnam's population pyramid in 2025 almost overlaps with that of Japan in 1975. The country is in the so-called demographic dividend period, with a high share of working-age population and a low dependency ratio.

What I would like to emphasise here is not that this period is advantageous, but that it has a time limit. Japan's demographic dividend ended in the 1990s. If Vietnam follows the same trajectory, its dividend will end in the late 2030s. The framework that determines the shape of a city, namely the layout of roads, railways, water supply and sewerage, and public land, can be substantially changed only during a phase when population and capital are growing. Once this phase is missed, correcting it afterwards costs many times more money and years. Recalling that Japan's postwar urban formation proceeded under precisely this constraint, I do not think it is an exaggeration to say that time is a resource.

3. Locational Conditions of the Project Site: From the Former Binh Duong Province to the New Ho Chi Minh City

(The Former Binh Duong Province as an Industrial Cluster)

The project site, the former Binh Duong Province, is located about 30 kilometres north of central Ho Chi Minh City, a little under an hour by car. The province has 31 industrial parks, one of the largest numbers in the country. Manufacturing and high-tech industries are concentrated there, and cumulative foreign direct investment has reached US$40.4 billion.

This is also reflected in economic indicators. The province's GDP per capita is US$7,231, far exceeding Vietnam's national average of US$4,324. In 2012, when Tokyu started its business, the province's level was in the US$2,800 range, meaning that it more than doubled in 11 years.

Industrial parks came first, and there were people working in them, but there were no places for them to live or spend their time. That was the state of Binh Duong New City when Tokyu joined. In the new city of approximately 1,000 hectares, planned on the premise of relocating the administrative centre, only university and government buildings had been built in advance. The idea of putting housing, commerce, and transportation in place simultaneously was based on this situation.

A concentration of industrial parks is not necessarily good for a city. It creates a working population, but if the places where those people live, shop, and send their children to school are not within the same area, people either live scattered around the industrial parks or commute long distances. Precisely because it had led the way in developing industrial parks, the former Binh Duong Province faced this problem of separation between workplaces and residences at an early stage. The province put forward a new city plan involving the relocation of its administrative centre as a solution to this problem.

(The Administrative Reorganisation of July 2025)

In July 2025, Vietnam substantially reorganised its local administrative framework. The former Binh Duong Province, together with the former Ba Ria–Vung Tau Province, was merged into Ho Chi Minh City. The new Ho Chi Minh City has become a megacity with an area of 6,770 square kilometres, a population of approximately 14 million, and about one quarter of the national GDP. Our project site, in other words, became "part of Ho Chi Minh City" overnight.

The practical impact of this reorganisation on the business was smaller than initially anticipated. What matters more is the change in positioning. The way this land is described has changed from "the new urban core of a province" to "the northern hub of a megacity region." At the same time, because a single administrative body now oversees transportation planning, it has become easier than before to discuss connections with the city centre.

Around Ho Chi Minh City, wide-area infrastructure such as Long Thanh International Airport, Ring Roads 3 and 4, and the Chon Thanh Expressway is being developed in parallel. For urban railways, the city has also adopted a policy of promoting nine priority lines. When these projects are complete, the project site will be located at the northern gateway of the metropolitan area.

(Plan to Extend Urban Railway Line 1)

A concrete form of that connection is the plan to extend Ho Chi Minh City Metro Line 1. Line 1 opened in December 2024. The extension currently planned runs approximately 32.4 kilometres from the terminus at Suoi Tien Station to Binh Duong New City, with 19 stations. Construction is targeted to begin in 2027, with completion in 2031.

If this is realised, Binh Duong New City will for the first time become a place "along a railway line." However, the opening will come nearly 20 years after the start of the business. In the meantime, the town must function without a railway. The bus business described in the next section was a choice made to fill that gap.

4. Business Development of Becamex Tokyu: TOKYU Garden City

(The Joint Venture Framework)

The project company, Becamex Tokyu, is a joint venture established in 2012. Its partner, Becamex IDC, is a major developer funded by Binh Duong Province that has developed industrial parks and residential areas within the province. The development plan for Binh Duong New City itself was approved by the Prime Minister in 2005.

What is distinctive about this joint venture is that Tokyu participated not as an advisor but as a stakeholder that itself holds part of the project site. Had it provided know-how in exchange for fees, its risk would have been limited and withdrawal would have been easy. However, statements made from that position remain mere proposals that the counterpart is free to accept or reject. By choosing to hold land and to carry out development and operations itself, Tokyu made it impossible for itself to withdraw. This irreversibility has sustained its involvement over the subsequent 14 years.

The forms of involvement that Japanese companies can adopt in overseas urban development can be broadly classified into three types.

Table 4. Forms of involvement by Japanese companies in overseas urban development

Form	Description	What is gained	What is lost
Advisory	Provide know-how on design, sales, and operations in exchange for fees	Low risk; easy to withdraw	Weak voice; no involvement in decision-making
Equity investment	Make a minority investment in the development company and receive dividends	Some involvement in the business; risk can be limited	Cannot influence how the land is used
Landholding	Tie long-term title to part of the project site to one's own side, and develop and operate it oneself	Substantive involvement in decision-making; long-term involvement is structurally ensured	High risk; difficult to withdraw, and capital is tied up for the long term

Source: Prepared by the author.

(Development History and Track Record)

Development has proceeded in stages. Becamex Tokyu Bus was established in 2014, and the commercial facility "Hikari" opened the following year, in 2015. The detached housing development "MIDORI

PARK HARUKA" was completed in 2018, and the condominium "SORA gardens II" in 2021. In 2023, "SORA gardens SC," the first shopping centre in Binh Duong New City, opened, and in 2025 the commercial facility "MIDORI PARK SQUARE" was expanded.

Incidentally, the investment decision documents at the time of establishment included assumptions whose basis rested on the judgement of local staff. This was because there were no statistics on housing prices in the province, no estimates of the disposable income of the middle class, and no way to ascertain unit construction costs or construction periods. This is unavoidable when making decisions in a market where data have not been developed. Given that, what we thoroughly insisted on at the time was to leave a clear record that such assumptions were based on estimates. Estimates dressed up as numbers become fixed as premises without being verified. In business decisions in emerging economies, this distinction carries significant practical weight.

The development history and track record to date are as follows.

Table 5. Development history and track record of TOKYU Garden City

Year	Event	
2005	Development of Binh Duong New City approved by the Prime Minister	
2012	Joint venture Becamex Tokyu established	
2014	Becamex Tokyu Bus established	
2015	Commercial facility "Hikari" opened	
2018	Detached housing "MIDORI PARK HARUKA" completed	
2021	Condominium "SORA gardens II" completed	
2023	"SORA gardens SC," the first shopping centre in Binh Duong New City, opened	
2025	Commercial facility "MIDORI PARK SQUARE" expanded	
Category	Track record	Breakdown
Housing	2,778 units	High-rise 2,559 units, low-rise 219 units
Commercial leasable floor area	Approx. 29,000 m²	Of which SORA gardens SC: 14,500 m²
Public transportation	Route bus business	The only Japanese-affiliated public transportation operator in Vietnam
Project site	TOKYU Garden City	Within Binh Duong New City (total area approx. 1,000 ha)

Source: Compiled by the author from various sources.

In terms of the number of units alone, this is the business scale of a mid-sized developer in Japan. However, its significance for this town lies elsewhere than in quantity. Because housing, commerce, and transportation were put in place simultaneously, the town has become one where people are present on weekday evenings and on weekends. I consider the real achievement to be avoiding the

situation that often arises around industrial parks, where people are present only during the day and the area is deserted at night.

5. Development Concept: Providing Living Functions and Town Management

The development concept of TOKYU Garden City is not to supply housing but to provide the full range of functions necessary for daily life. Areas such as transportation, education, healthcare, nature, culture and entertainment, ICT, and the working environment have been bundled together as "environmental development," and specific businesses have been linked to each of them.

(Transportation: Carrying a Business That Is Not Profitable on Its Own)

The core of transportation is the route bus service operated by Becamex Tokyu Bus. Established in 2014, it is the only Japanese-affiliated public transportation operator in Vietnam. In recent years, it has also been conducting trials of autonomous vehicles.

This business does not turn a profit on its own. This outlook was shared within the company from the outset. In southern Vietnam, motorbikes are widely established as a means of transport, creating a structure in which raising fares reduces ridership and lowering them makes the business unprofitable.

The reason we continue to operate it is that we position it not as a bus business but as a precondition for the town to function. A 1,000-hectare city cannot run on motorbikes alone. Selling housing requires a means for buyers to get around. The bus deficit was treated as a cost of making the housing sales business viable. Put differently, one could say that on land without a railway, we had buses take over the role that railways played in TOD in Japan.

What we provided was not vehicles but quality of operation. We brought in standards taken for granted in Japan: punctual service and courteous customer service. The only reasons people will ride a vehicle that is neither faster nor cheaper than a motorbike are that it arrives on time and that riding it is not unpleasant. As a result, students attending nearby universities began using it to commute, and daytime ridership increased.

(Education: A Device for Gathering People First)

In education, we co-founded Viet Hoa International School in 2018, and since 2021 we have operated a Kawasaki Frontale soccer school. Universities had already been located in Binh Duong New City in advance, reflecting the province's policy of "gathering people first."

Rather than selling housing first and then attracting facilities, the approach is to put functions that draw people in place first and then provide housing and commerce for the people who gather there. This sequence has been carried over directly to the Australian concept described later. Educational institutions are one of the few functions that can be placed ahead of housing as a device for generating flows of people on land where the population has not yet settled.

(Concepts Can Be Transferred, but Implementation Cannot)

The project was named "TOKYU Garden City." The English rendering of Tama Den-en Toshi likewise uses "Garden City," and the name was intended to signal that the project is an extension of the work that began with the 1953 Josei-nan District Development Prospectus.

When this name was explained locally, a Vietnamese executive of the joint venture asked a question: what does the "Garden" in Garden City refer to? When I explained that it meant a town with secured green spaces, where housing, workplaces, and nature are close to one another, the following point came back. In southern Vietnam, temperatures hover around 32 degrees Celsius throughout the year, and no one walks through outdoor green spaces during the day. Under climatic conditions different from those of Japan, would the same green spaces not fail to work?

It was not a rejection. The point was that the name seemed appropriate, but if a garden were to be realised on this land, it would be necessary to rethink where to put the greenery: in shade and in places where the wind passes through, and not only on the ground. As a result, sky gardens and green walls were incorporated into the plans for high-rise housing. In effect, the concept was retained and only its implementation was reconfigured.

Here lies the prototype of the work that later came to be called "glocalisation" within the company. Rather than transplanting Japanese methods as they are or adapting entirely to local conditions, it involves identifying the physical conditions that a concept implicitly presupposes (climate, land area, means of transport, daily time patterns) and replacing only the parts that do not hold. I should add that this modification arose not from reflection on the Japanese side but from a point raised by the local side. If remarks from local staff that "this is different here" are treated as objections, the flow of information stops at that point. What is needed is to record them as design information and to document how they were reflected.

Table 6. Concepts brought from Japan and how they were reconfigured

Concept brought in	Implicit premise	What was reconfigured
Garden city	Temperatures around 32°C; people move about on foot	Shifted to shade and wind corridors; sky gardens and green walls
Lifestyle centred on public transportation	Railways exist as the trunk transportation mode	Substituted with route buses; use encouraged through quality of operation
Off-plan sales of housing	Trust in the supplier and backing by the legal system	Conditions for viability verified in terms of both credit and legal regulations
Maintenance by a management association	Unit owners continue to reside over the long term	Operating entity and cost-sharing arrangements redesigned case by case

Source: Prepared by the author.

In particular, the method of selling housing required careful consideration. In Japan, off-plan sales are a system in which buyers pay for a property before its completion, premised on trust in the supplier and backing by the legal system. Whether the same method would work in Vietnam had to be confirmed in terms of both credit and legal regulations. In the end, it worked, but the reasons it works are not the same as in Japan. Regulations under the Law on Housing, such as the rule that no more than 30% of the total units may be sold to foreigners, as well as the regulations on sales prior to handover, differ significantly between Vietnamese nationals and foreigners. Situations in which the same mechanism operates for different reasons occur frequently in overseas business. If one is reassured merely by confirming that a mechanism functions, it will collapse all at once when the reasons supporting it change.

(Other Functions and Partners)

In addition, efforts are underway to attract medical institutions, develop parks and green spaces, hold cultural events and festivals, including the annual "Tokyu Group Japan Festival," and improve the working and ICT environments. Most of these do not generate revenue on their own.

What actually determines the standard of a town is the allocation of who bears how much of the cost of such non-recoverable functions. In Japan, part of this would be borne by local governments and part by management associations. In countries with different institutions, there are many situations in which the developer has no choice but to bear these costs out of the profits from housing sales. My sense, gained through experience on the ground, is that designing the allocation of costs is, in effect, designing the city.

It should also be noted that the town is made up not only of our own businesses. Brands well known within Vietnam and internationally, not only Japanese ones, have opened stores and participated, and many suppliers that support the quality of life are also involved. The structure is such that, rather than the developer keeping everything to itself, the town's functions deepen as more businesses participate.

6. Connection with Public Frameworks: The Global South Future-Oriented Co-Creation Projects

The initiatives in Binh Duong are connected with Japanese government policy frameworks in several respects. For the bus business, we have made use of a demonstration project of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and technical cooperation from the Japan International Cooperation Agency (JICA), and in recent years have also conducted MaaS trials. As a broader framework, under the Global South Future-Oriented Co-Creation Projects of the Ministry of Economy, Trade and Industry (METI), we have participated in a study to formulate a master plan for the provincial capital area of Binh Duong Province. The study proceeded along the lines of a new transit system, TOD and smart cities, and the greening of industrial parks.

The effects of such frameworks appear elsewhere than in the amount of subsidies itself. First, for new overseas projects that tend to be evaluated on a single-year income and expenditure basis, being able to explain that they are connected to national policy supports internal decision-making. Second, they provide an entry point for dialogue with the partner country's government. There are limits to whom a private company can meet on its own, but working through a policy framework creates points of contact.

There is one more practical benefit. When a study is conducted as a national project, the deliverables take a form that can be submitted to the partner country's administrative agencies. A proposal compiled independently by a private company and a report compiled as a government-commissioned project are received differently. When the aim is to have the content reflected in the partner country's plans, this difference is not small.

On the other hand, there are also issues of institutional design. Public support has a fixed term, and most of it ends after one to several years. This does not match the time horizon of urban development. Who will take over operations after the support ends, and who will continue to bear the costs? Demonstration projects that have not designed this at the time of application stop at the demonstration stage. There is support for demonstrations, and there are frameworks for large-scale infrastructure exports. However, mechanisms to support the phase in between, in which a private company continues its business as a local entity, cannot yet be described as robust. I venture to add this from the practitioner's side.

I do not think the concrete measures that can be considered are particularly complicated. For example, simply requiring, as a condition for selecting demonstration projects, a clear statement of the operating entity and cost-sharing arrangements for three years after completion should change the situation. Projects for which this cannot be written will not reach implementation in the first place. In addition, for businesses that have been involved in the same region over multiple years, a framework that can be designed on a multi-year rather than a single-year basis should be made available. This is because the real state of urban development projects does not become visible until the third year or later after they start.

7. Yanchep, Western Australia: Urban Development Centred on Education

(The Difficulty of Attracting Public Transportation)

The other project site is the Yanchep area, located about 50 kilometres north of Perth, Australia's fourth-largest city, along the coast facing the Indian Ocean. Tokyu became involved in this land in 1974, acquiring a vast tract as part of its overseas expansion plans at the time.

Time was needed thereafter. The original joint venture partner withdrew early, and with no transportation link to central Perth in place, development entered a long period of waiting. The turning point came in 1999, when Tokyu concluded a memorandum of understanding with the Government

of Western Australia and the local municipal government and made a major shift towards advancing development.

Then, in the early 2000s, together with a new joint venture partner, it adopted the vision of a "Clean, Green, Sustainable City" and began work on concrete development plans. Against the backdrop of these efforts, the area's standing rose: in 2010, Yanchep was selected as one of the 10 strategic development centres designated by the Government of Western Australia, the only one on land owned by a private company. Furthermore, in 2011 a regional development plan covering approximately 7,500 ha was approved, and the project is now proceeding with the aim of realising a city of 160,000 residents and 55,000 jobs.

In Australia, a car-dependent society, extending the railway to this area was no simple matter, and Yanchep Station actually opened only in 2024. It took more than 13 years from the initial announcement of the plan.

For Tokyu, this means that the conditions for using its original method of development along railway lines have finally come together; even so, within the company the Western Australia business has been regarded as a project that took a long time to show results. Whereas domestic development along railway lines begins with laying the railway, in Yanchep, although the land was acquired in advance, attracting public transportation required various rounds of coordination, consultation, negotiation, and preparation of the environment.

(The International Campus in the City Concept)

This development is also suggestive when considering its relationship with Tokyu's domestic model. In Tama Den-en Toshi, Tokyu itself laid the railway. In Yanchep, the state government built the railway on land that Tokyu had held for a long period. Although both are cases of development along railway lines, the structure is reversed in terms of who is responsible for transportation infrastructure. There are many countries and regions where it is difficult for the private sector to take on transportation operations as well, and in such cases this reversed form becomes a realistic option.

What Tokyu is currently promoting in Yanchep is a living-lab type of urban development that, building on the vision of a "Clean Green Sustainable City" held since 2007, centres on education and research and makes the city itself a place for practice and demonstration. Internally, we call this concept "International Campus in the City."

Within the area, Tokyu builds and operates "Y.hub," a complex of office, research, and educational facilities aimed at innovation and business creation, and is also working on opening a vocational school that contributes to employment promotion and on a farm business aimed at local production for local consumption and the establishment of local brands. A situation in which a single business entity holds educational institutions, industry, and the natural environment within the same area is a condition rarely seen in domestic development along railway lines. I believe that the ability to use the

city itself as a field for education, research, and social implementation, and its value as a practical field for universities, lie in this point.

(How to Design Collaboration with Universities)

Dialogue is under way with multiple universities, and in the process the conditions that need to be overcome have also become concrete. Establishing a new overseas campus is a weighty decision for a university in terms of both investment and internal consensus. Dispatching faculty, accrediting degrees, ensuring student safety, and establishing a local entity all require several years of consideration.

A realistic entry point, therefore, is to start with short-term study abroad programmes and internships, and to review the scale and form while confirming demand. One university proposed that an effective approach might be to adopt a name reflecting collaboration between a company and a university and, in the initial stage, to send a small number of students with the university heavily subsidising the costs. The time horizon of those who build towns differs from that of universities. Designing the connection between the two is precisely the central issue of this concept.

The conditions of the area itself also affect its value to universities. Western Australia is a growth market where population growth, housing demand, and a shift towards next-generation industries are proceeding simultaneously, and Yanchep is located where transportation, industry, and the natural environment overlap. I believe that the opportunity to observe a city under development not as a finished city but as a process of change is an irreplaceable condition for education in urban planning and environmental fields.

8. Conclusion: Transferability of the Japanese Urban Development Model

Finally, let me summarise what can be drawn from the two project sites.

(At Each of the Three Sites, the Sequence Was Different)

In Tama Den-en Toshi, the railway came first. In Binh Duong, we started without a railway and substituted buses, and an urban railway is scheduled to arrive in 2031. In Yanchep, the railway came after the land had been held for 50 years. The sequence of development differed in each of the three cases, with no two alike.

Table 7. Comparison of Tama Den-en Toshi, Binh Duong New City and Yanchep

Item	Tama Den-en Toshi	Binh Duong New City	Yanchep
Land title	Acquisition and land readjustment	Long-term land use rights	Company-owned (since 1974)
Trunk transportation	Developed first	Substituted with buses; railway under planning	Roads first; railway extended later (2024)
Demand	Housing demand from central Tokyo	Working population from industrial clustering	Housing demand driven by population growth
Functions placed first	Railway and housing	Universities, commerce, and buses	In addition to housing, integrated development of research, education, and industry (in planning)

Source: Prepared by the author.

Therefore, the essence of Japanese-style urban development cannot be summarised as "railway first." My candid understanding from the field is that this was a condition in one case, Tama Den-en Toshi, and not the substance of the model.

(What, Then, Is the Essence?)

What the three sites have in common is a single point: the developer holds the land over the long term and does not withdraw from the operation of the town. We do not adopt the view that a business is complete once units are sold and handed over. There is an entity that continues to bear internally, through development profits, the costs of functions that cannot be recovered on their own, such as transportation, parks, events, and cleaning. I believe this arrangement is the core of what is called the Japanese model.

To put it briefly, it is "those who build it stay." If expressed in English, I think the phrase "The developer never leaves" is the least likely to be misunderstood. Railways are an effective device for financially supporting this arrangement, but they are not an essential condition.

(Education as the "First Function to Place," Not the "Centre")

Let me also add a note on whether education should be the axis. As devices for generating flows of people on land where the population has not yet settled, universities and schools are among the few functions that can be placed ahead of housing. In that sense they are an effective starter, but whether they should be placed at the centre of the town is another matter. In Binh Duong, universities were placed first as a matter of provincial policy, while in Yanchep the developer is trying to design this deliberately. "Education first" as a sequence is transferable, but if the goal is set as the finished form of an education city, the town's progress becomes subordinate to the decision-making speed of universities.

(Preconditions for Transfer)

Transferring this model to other countries rests on the following three preconditions. First, the developer must be able to hold long-term title to the project site. Second, there must be sources of revenue within the same entity capable of bearing the costs of functions that run deficits on their own. Third, there must be shareholders and a head office that accept a time horizon of 20 years or more. If any one of these is missing, imitating only the form will not work. Conversely, putting these three conditions in place institutionally becomes the substantive issue for host countries.

(Connection with Disaster Prevention and Resilience)

Let me touch on just one point regarding the relationship with the theme of this study group. Urban resilience is not determined by the standards of structures alone. Who will clear a drainage channel when it becomes clogged, and who will decide the order of recovery after a disaster? Whether the operating entity remains permanently present on site determines the level of maintenance in normal times and the speed of recovery in emergencies. In this sense, I believe the model of long-term ownership and internalised operation connects with the discussion of resilience.

(Issues for the Next Stage)

Let me also set out the issues ahead. Each of them has become a subject of concrete consideration only because the business has progressed to a certain stage.

First, responding to the time limit attached to the title to the project site. The original contract secured as long a term as possible in an institutional environment in which it was difficult for foreign capital to establish long-term land use rights. It is precisely because of this framework that continuous involvement exceeding ten years has been possible. Now that the town has taken shape and the value of the assets can be assessed concretely, the materials for consulting with the partner country's government on whether, and under what conditions, the term can be extended are coming together. We are at a juncture where, rather than passively waiting for the term to expire, we can actively design how to approach it.

Second, the transition of the revenue structure from development to operation. Supporting transportation and public spaces with profits from housing sales was a rational design in the early stages of development. Today, the weight of operating businesses, such as rental income from commercial facilities, property management and operation, and public transportation, is increasing. If the urban railway extension is realised, the structure will approach the domestic model in which the value of areas along the line and operating revenues mutually support each other. Shifting the centre of gravity of revenue from development to operation will be the next theme.

Third, the transfer of decision-making to the local level. Locally hired employees have grown into management positions, and the range of day-to-day operational decisions already completed locally is expanding. Going forward, we will enter a stage of codifying the scope to be delegated and the scope

to be handled by the Japanese side, and establishing this as an institutional arrangement. This is an issue that has arisen as a result of the business taking root locally.

Fourth, systematising knowledge and developing human resources. Through our practice in Binh Duong, it has become clear what combination of capabilities is required for urban development in emerging economies, namely expertise in real estate, transportation, commerce, dealing with government, and languages. We are also advancing the internal recording and sharing of the processes that led to individual decisions. I believe that shaping the knowledge accumulated here into a form that can be applied to other regions is the next role of the International Business Division.

(Closing Remarks)

Fifteen years have passed since we first stood on land that had nothing but roads. Today, more than 2,700 housing units stand there, people gather at commercial facilities, and buses run. A 1,000-hectare planned city has begun to function as a place to live, work, and learn. How to reproduce what has been gained here at the next project site is, I believe, the work ahead.

What does it mean for Japanese companies to engage with Global South countries over the long term? I hope this paper will provide material for discussing that question on the basis of concrete facts.

9. Supplementary Discussion: Issues Arising from the Q&A at the Study Group

This section summarises the questions and discussion at the study group that bear on the argument of this paper.

(1) Connection with Industrial Policy and Innovation

The former Binh Duong Province has put forward a “Science and Technology City” concept, but the elements that make up an innovation ecosystem are not yet in place. In terms of the sequence of platform development, the parts related to infrastructure and local industry come first, and research functions and startup support functions are built up afterwards. Merely proclaiming cutting-edge status while skipping this sequence will not produce substance.

(2) Urban Development Starting from Education

It was pointed out that there are few successful examples of city building centred on universities, and we were asked what the difficulties are from a private-sector standpoint. Attracting a large campus as an initial investment is not realistic; there is no choice but to start small. An educational function is defined not by the size of the campus but by how the characteristics of the town are reflected in learning. It was also pointed out that while campus-centred development is already advancing in ASEAN, there is a problem of homogenisation, with every place looking alike. The source of differentiation lies in having a campus while serving as a platform for urban development and linking it to the resolution of social issues. In Yanchep, we are working on mobility-related demonstrations of a kind that are strictly regulated in developed countries, and on a living lab in which students handle everything from design to implementation. Note that the perspective on the stage at which educational functions

should be placed differs depending on whether the project is new development or the reorganisation of an existing urban area.

(3) Energy Infrastructure and Electrification of Transportation

Infrastructure that can be installed at the time of urban development is laid out in advance. In Vietnam, the spread of EVs is advancing, led by local companies, and energy design, including charging facilities, is a central issue in urban development. The question raised in Section 5, "who bears how much of the cost of non-recoverable functions," applies here as well.

(4) Relations with Government and Local Benefits of Foreign-Funded Development

Streamlining permits and approvals and keeping plans flexible are often at odds. Changing the urban plan itself is not easy; we have proceeded within the framework of the rules without significantly changing our methods, while securing profitability. Resistance to foreign capital has not been very strong in this project; rather, Tokyu's participation has served as a catalyst, attracting developers from Singapore and Malaysia. Deregulation in areas such as electricity concerns the partner country's security, and the hurdles to full liberalisation are high. It was also pointed out that sharing, as knowledge, which methods would have been feasible in other countries could be a practical contribution of the common knowledge platform.

(5) Connection to the Common Knowledge Platform

We received the following summary: there are large-scale developments with similar outward appearances in many places, but the decisive difference is whether there is a century of experience; even if the finished forms look similar, few entities possess the process that leads there. I, too, believe that what can be shared is not the finished form but the sequence of decisions and the preconditions. The three preconditions presented in Section 8 can be used not as a list of success factors but as checklist items for identifying which missing conditions would prevent the model from working. The missing conditions should differ from country to country, and if the task is to identify those differences jointly with research institutions in each country, we on the practitioner side can provide material.

Chapter 8: A Proposal for the Creation of the "Global South Financial Liquidity Enhancement Mechanism"

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1. Theoretical Background on Start-up Finance

Given the situation of start-up finance in the Global South states described in the preceding paper of this session, this paper proposes the establishment of a new financing system called the "Global South Financial Liquidity Enhancement Mechanism." As a basis for designing this system, this section first examines the fundamental characteristics of start-up finance.

The biggest feature of start-up finance is that it is a type of developmental finance. Developmental finance refers to funds provided to cases where a "market failure" occurs—meaning the supply of goods under the market equilibrium falls far short of the socially optimal amount. Typical examples of developmental finance generally include infrastructure finance and small and medium-sized enterprise (SME) finance.

SME finance, including start-up finance, counts as developmental finance because of high information search costs and the relatively small amount of finance actually provided. In other words, for projects carried out by SMEs that are not legally required to disclose their information, lenders need to gather detailed information at considerable cost to make credit decisions. However, even after incurring such high costs for information gathering, the amount of financing actually provided is usually small. As a result, such lending tends to be commercially non-viable, financial institutions avoid it, and the amount of finance supplied in the market remains low.

On the other hand, if SME finance, including start-up finance, is supplied smoothly, start-ups can progress successfully, and SMEs can develop steadily, which is extremely important for the national economy. Under market mechanisms alone, however, the finance supplied at the market equilibrium falls far short of the socially optimal amount, leading to "market failure."

Japan's experience with SME finance in the latter half of the 20th century suggests three basic approaches to dealing with "market failure."

The first approach is for the government to provide finance from public funds, treating it as a "public activity." Using government funds as a "public activity" is the ultimate way to address market failure, but the problem is that, because public money is involved, it cannot be expanded indefinitely, and the

supply is severely limited. For this reason, this approach did not become mainstream in Japan in the latter half of the 20th century.

The second approach is for the government to take "market enhancement measures" to encourage private capital participation, which is essentially a public–private partnership (PPP).

An attempt to fully introduce this PPP approach into developmental finance was the "Working Group on Asian PPP" conducted by the Ministry of Economy, Trade and Industry (METI) in 2005. This initiative was based on the recognition that the traditional supply volume through ODA could in no way meet the rapidly expanding infrastructure demand in Asia due to rapid economic growth. By fully adopting a Japanese-style PPP approach, it aimed to expand Japan's initiative in Asian infrastructure finance and examined its basic strategy.

In this working group, PPP was defined as follows: "Private entities implement and manage the entire commercially non-viable projects (such as infrastructure) including finance, under the condition that governments should take 'market enhancement measures.'" (METI 2005).

The characteristic of this definition is that it limits the government's role to only implementing "market enhancement measures," and for projects after the government has taken such measures, all initiatives, including financing, are to be handled by the private sector. In the first approach, because a "market failure" occurs, the government takes the overall initiative for projects in the "public sector," which the private sector cannot handle, including financing. In the PPP model, however, taking the overall initiative for projects where "market failure" occurs becomes the role of the private sector.

What becomes important here are the contents of the "market enhancement measures." The 2005 METI working group listed two examples. The first is providing viability gap finance, including providing first-loss finance within a blended-finance structure. The second is taking necessary legal/institutional arrangements to decrease viability gaps, meaning that, by exercising public authority outside of providing finance, the government can shift the market equilibrium point, thereby turning projects that were commercially non-viable before implementing these "market enhancement measures" into commercially viable ones. A typical example is deregulation.

The third approach involves private financial institutions innovating in credit technologies. In Japan, several such innovations were carried out for SME financing in the mid-20th century. As a result, Japan became a so-called powerhouse in SME finance, facilitating smooth financing for SMEs and significantly contributing to the country's economic growth.

These innovations, all based on private financial institutions specialising in SME finance, took two forms: innovations in commercial finance and innovations in other financing methods.

In terms of innovations in commercial finance, there was the mutual bank system, which started with the enactment of the Mutual Bank Act in 1951. The category of mutual banks transitioned to the "Second Regional Bank" in 1989 and eventually disappeared in 1992.

Another type of innovation was the Shinkin (credit association) system, established by the enactment of the Shinkin Bank Act in 1951. It is a community finance model for SMEs, similar in principle to that of the Grameen Bank, and is unique to Japan. Its most notable feature is that the threat of ostracisation from the community functions as a substitute for collateral in lending. It played a key role as start-up finance that supported Japan's high economic growth. This is because those starting up a business are usually young people who are unlikely to own real estate or other collateral; generally, they have nothing but themselves. Even with nothing, some of these young people have great talent and could achieve significant success in business. In such cases, asking for collateral as in normal credit evaluations is impossible, and conventional finance methods would not allow these talented youths to start businesses, meaning the national economy also would not benefit from their potential achievements. By using the threat of ostracisation in place of collateral, however, it became possible for genuinely talented young people to receive proper financing to start promising businesses.

From the above, the community finance approach can generally be seen as an effective financing method for entrepreneurs without collateral. The Grameen Bank and the Shinkin system differ only in scale; the underlying principle, which uses the threat of ostracisation from the community in place of collateral, is the same. In terms of scale, while the Grameen Bank deals with a few hundred dollars per case, the Shinkin system can cover investment in small factories, ranging from several hundred thousand to a few million dollars per case. Based on the above, the author has started working on creating a framework to utilise Shinkin-style community finance in collaboration with Japanese Shinkin banks for start-up finance in the Global South states. In 2012, as part of the activities of APEN (Asia Professional Education Network), a network of engineering universities in East Asia, in collaboration with Japanese Shinkin banks and the Advanced Institute of Industrial Technology (AIIT), the ACFI (Asia Community Finance Initiative) project was launched. As part of this effort, the Digitally Transformed Shinkin project has been under way since 2026 to make it easier to expand the Shinkin system to the Global South using digital technologies.

In Japan's SME finance, therefore, private financial institutions have established, apart from government funding and in addition to commercial lending, a community finance method unique to Japan: the Shinkin system. However, all of these are forms of indirect finance, and there has been little major innovation in direct finance, which is expected to play a core role in start-up finance.

This emphasis on indirect finance is common in the Global South, as it is in Japan.

Of course, there were also movements in Asia to develop direct finance. A typical example is the ABMI (Asian Bond Market Initiative), which was proposed in 2002 by then Thai Prime Minister Thaksin

Shinawatra, based on Asia's reflections on the 1997 Asian financial crisis. Its purpose was to overcome the double mismatch of currency and maturity, and it was adopted at the 2003 ASEAN+3 (ASEAN plus China, Japan, and Korea) Finance Ministers' Meeting. Subsequently, EMEAP (Executives' Meeting of East Asia Pacific Central Banks) created ABF (Asian Bond Fund)-1 in 2003, a basket of sovereign bonds from each country, and ABF-2 in 2004, a basket of government agency bonds from each country. In addition, METI proposed ABF-3 in 2005, a basket of corporate bonds from each country, and ABF-4, a basket of project bonds.

In sum, in order to meet the enormous future demand for start-up finance in the Global South, direct finance with private funds needs to be fundamentally expanded, with the government implementing market enhancement measures.

2. The Global South Financial Liquidity Enhancement Mechanism

From the above, the author believes that a new system should be established to overcome the issues currently hindering the expansion of direct finance for start-ups in the Global South.

The first problem is the difficulty of exit. To overcome this, the creation of a secondary market is necessary.

Second, to expand direct finance, it is necessary to attract general investors from all around the world. However, under the current system, the procedures are too complicated for general investors, and it is difficult to handle small-scale investments. To solve this problem, a simple, blockchain-based system needs to be constructed.

The author proposes building a new system for raising funds for the Global South start-ups through blockchain-based STOs (security token offerings), making it easier to bring in capital from a wide range of global participants. Because this new system is blockchain-based, it has excellent anti-tampering features, and since small-scale diversification is easy, it is expected to be effective for raising funds from a broad global base. The author calls this system the Global South Financial Liquidity Enhancement Mechanism.

In the field of developmental finance, the issue of small-scale diversification is critically important. Especially in the case of infrastructure finance, where each project typically amounts to several billion dollars, without small-scale diversification, individual investors are naturally excluded, and even regular private financial institutions cannot handle finance of that scale. As a result, the only providers are donor country governments or MDBs (multilateral development banks). However, since providers are limited to a few entities, it is difficult to secure a sufficient volume of finance, and, as with the so-called "debt trap," the provision of infrastructure finance becomes a source of competition and conflict in international politics between major powers.

In contrast, small-scale diversification allows investors from all around the world, including individual investors, to participate, which can fundamentally increase the amount of financing provided. Since it is a form of direct finance, the so-called “debt trap” cannot occur in principle. Furthermore, by allowing many investors to participate, it is also expected to have international political effects by “democratising” projects.

The effects of this kind of small-scale diversification are likely to be stronger in SME finance, including start-up finance, than in infrastructure finance. This is because individual investors with expertise in the relevant field, and even members of the general public, are often better able to evaluate start-up projects appropriately than major financial institutions.

Currently, small-scale diversification in developmental finance has not progressed. There are two main reasons. First, it was physically impossible in the past to handle the massive and complex procedures instantly. Second, it was impossible to share the large amount of information related to such financing with the enormous number of investors worldwide.

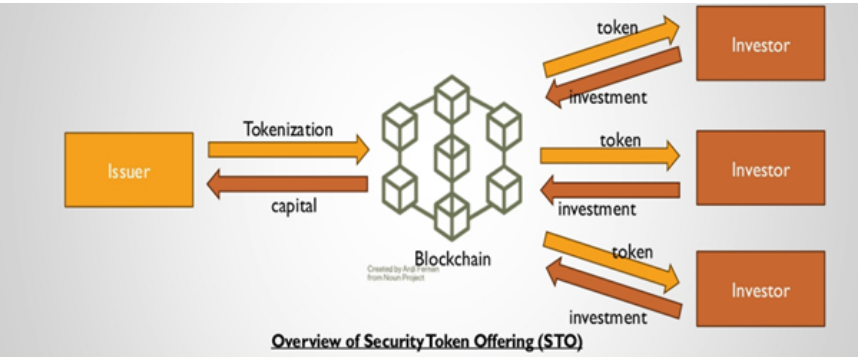
Blockchain technology fundamentally and cost-effectively solves these two problems. By utilising blockchain, it is possible to manage a huge number of investment actions from investors around the world instantly, at low cost, and with minimal risk of tampering. Additionally, by using a platform on the blockchain, it becomes possible to share vast amounts of investment-related information with many investors worldwide.

In other words, a blockchain-based system could serve as a disruptive technology for promoting small-scale diversification. To achieve this, it is necessary to design the system itself so that it is compatible with the characteristics of the blockchain. From this perspective, the author proposes constructing a system that utilises STOs.

It should be noted that STOs are already being used today in fields such as real estate development. The author’s proposal is to extend this STO system not only to real estate development but also more broadly to infrastructure finance, and further to developmental finance as a whole, including SME financing such as start-up finance.

Figure 1 shows a conceptual diagram of the proposed STO system.

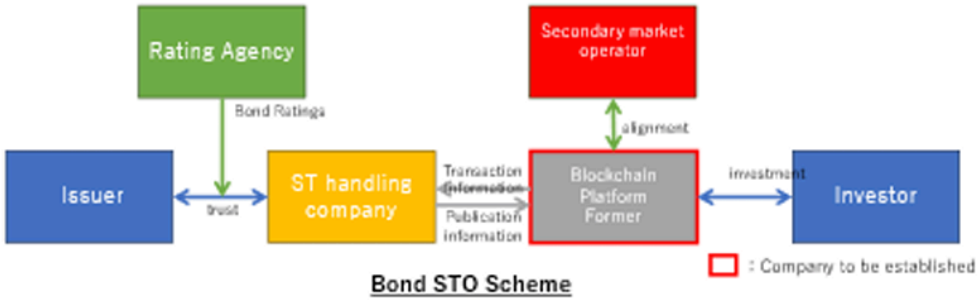
Figure 1. STO (Security Token Offering) for start-up finance in the Global South



Source: Mitsuhiro Maeda, Kazuya Takano

Figure 2 shows a conceptual diagram of the system incorporating a secondary market.

Figure 2. System incorporating the secondary market



Source: Mitsuhiro Maeda, Kazuya Takano

The author proposes operating this new system as a kind of PPP. That is, in the operation of this new system, the government would be required to implement deregulation as a market enhancement measure. The regulations concerned are those in the current legal system that either prohibit technically feasible operations or act as obstacles to them. Once these regulations are eased, the measures for the Global South Financial Liquidity Enhancement Mechanism that the author envisages could be implemented using current technologies like blockchain, attracting investments from small investors worldwide and, as a result, significantly supporting entrepreneurs in the Global South.

There do not appear to be major technical obstacles to building this new system. Blockchain itself can basically be used in a general-purpose way and does not require special technological development. As a result, "technically," it can be said that this system could be built over a few years with a few million dollars in funding. However, building this system in Japan is impossible under the current legal regulations. In present-day Japan, crypto-asset exchange services count as a specified business under

the Act on Prevention of Transfer of Criminal Proceeds (2007), and operating a secondary market could require approval under the Financial Instruments and Exchange Act since it may fall under operating a Private Trading System (PTS), assuming registration as a Type I Financial Instruments Business. Additionally, under the Companies Act (2005), handling assets requires a corporate entity, meaning various regulations affecting the handling of decentralised autonomous organisations (DAOs), both as token issuers and investors, would need to be overcome.

Although the author has not yet examined the current legal regulations in the Global South states, similar regulations are likely to be in place. It is hoped that some of the more "ambitious" states in the Global South will step up, radically ease these legal restrictions, and volunteer to become host states for the Global South Financial Liquidity Enhancement Mechanism.

Chapter 9: Recommendations for the Sustainability of Venture Ecosystems in the Global South: Resolving "Capital Circulation Failure" through a Public-Private Secondary Fund

From Entry Support to an Integrated Entry and Exit Approach

Author
Shigeru Handa, Director, AAIC Investment Pte. Ltd.

1. Executive Summary

Startup ecosystems in the Global South, including Africa, have reached a turning point following the record inflow of capital in 2021. While there are signs of a quantitative recovery in funding, the environment for investment recovery (exits) remains fragile; this deters new investment and creates bottlenecks in the flow of capital throughout the entire system.

As the starting point of this paper, the author has attempted to demonstrate quantitatively that the "challenges in exits" are a structural problem in the African startup ecosystem. When investment amounts (equity only) and exit values (with IPOs measured by transaction value rather than market capitalisation) are compared over the past 10 years (six years for India) for the United States, Japan, India, and Africa, the exit rate is 49.1% for Japan, 45.4% for the United States, and 35.9% for India, whereas it remains at only 14.1% for Africa as a whole.[1]

This result has two implications. First, Africa alone remains markedly lower than the other countries. Second, the fact that India stands at 35.9% shows that it cannot be concluded, as a general rule, that "exits are difficult in emerging economies." India has a functioning domestic capital market and a deep pool of buyers. Africa's problem is not the income level of its population but the market structure of the ecosystem itself. Other factors, such as the business environment and governance, also exist, but each country is undertaking various initiatives to address them.

Accordingly, what needs to be strengthened is financing directed towards "the creation of exits." This paper proposes the establishment of a public-private secondary fund in which Japan contributes first-loss capital to act as a catalyst, and government-affiliated funds of Global South countries serve as the principal investors. The secondary fund's primary function is to acquire stakes from existing shareholders, with growth capital provided as a supplement where needed. In addition, a matching function with Japanese companies will be institutionally built into the scheme, with the aim of enhancing corporate value through business partnerships grounded in genuine demand.

Key Points of the Recommendations

- **Recommendation 1: Establish a public-private secondary fund — a catalytic function through first-loss capital from the Government of Japan**
- **Recommendation 1-2: Attract overseas private VCs through an Israeli Yozma-style call option design, and institutionalise the government's "timely withdrawal"**
- **Recommendation 1-3 (Option): Mitigate foreign exchange risk and develop local capital markets through local-currency (onshore) operation**
- **Recommendation 2: Build a platform to support matching with Japanese companies — enhancing corporate value through business partnerships grounded in genuine demand**

Table 1. Key indicators of Africa's exit environment

Indicator	Africa data / level	Implication
Exit rate (Africa as a whole, 2016–2025)	14.1%	Markedly low compared with Japan 49.1%, the US 45.4%, and India 35.9%
Exit-to-investment ratio (AVCA, 2024)	0.13x	13 cents recovered for every dollar invested; consistent with the 10-year figure above
Dependence on trade sales (M&A)	Over 70%	IPOs barely function, and exit routes are limited
Share of overseas buyers (2020 → 2025)	56% → 33%	Global buyers are retreating from exits
Disclosure rate of exit transaction values	10–12%	Lack of price formation function and transparency
Involvement of government VCs/ DFIs (2024)	42%	3% in the US; private capital is not being crowded in

Sources: The exit rate is from Figure 2 of this paper. Others are from Stears, "2025 Africa VC Exit & Liquidity Report"; AVCA, "2024 African Private Capital Activity Report"; and OECD, "Benchmarking government support for venture capital."[1, 2, 3, 11] In the latest edition published by AVCA in March 2026 (covering 2025), this ratio improved to 0.2x, but secondary transactions have not yet become mainstream in the market.[21]

2. Why Strengthening Venture Ecosystems Matters

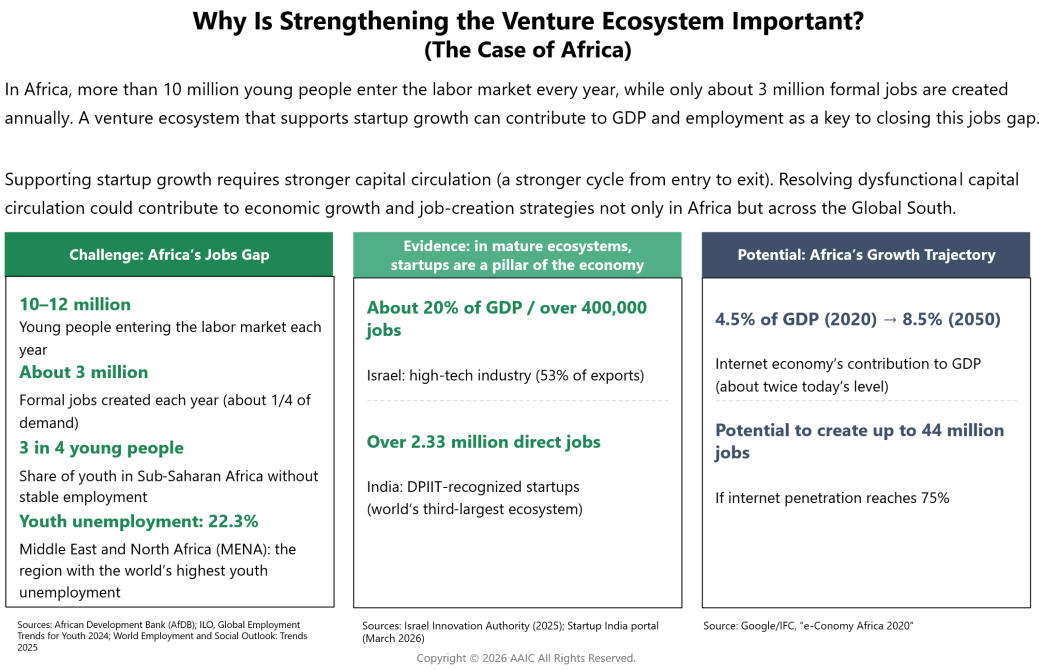
In Africa, 10–12 million young people enter the labour market every year, while only about 3 million formal jobs are created annually.[4] Only about one quarter of the demand for jobs is being met. In sub-Saharan Africa, three out of four young people are unable to obtain stable employment.

In June 2026, Claver Gatete, Executive Secretary of the United Nations Economic Commission for Africa (ECA), stated that Africa's main obstacle "is no longer simply a shortage of innovation or talent, but the capacity to execute and scale," pointing to an "implementation gap."[5] According to him, an

estimated 70–80% of African startups fail within five years of launch, not because of a lack of ideas but because of insufficient growth capital, limited market access, and inadequate support systems.

Meanwhile, in countries where the ecosystem has functioned, startups already form a core part of the economy. Israel's high-tech industry accounts for about 20% of GDP and more than 400,000 jobs (11.5% of the labour force), and in India, startups registered with the Department for Promotion of Industry and Internal Trade (DPIIT) have generated more than 2.33 million direct jobs.[6] Africa also has potential. Google and IFC estimate that the contribution of the internet economy to GDP will expand from 4.5% to 8.5% by 2050, with the potential to create up to 44 million jobs if internet penetration reaches 75%.[7]

Figure 1. Africa's employment gap and the economic role of startups in mature ecosystems



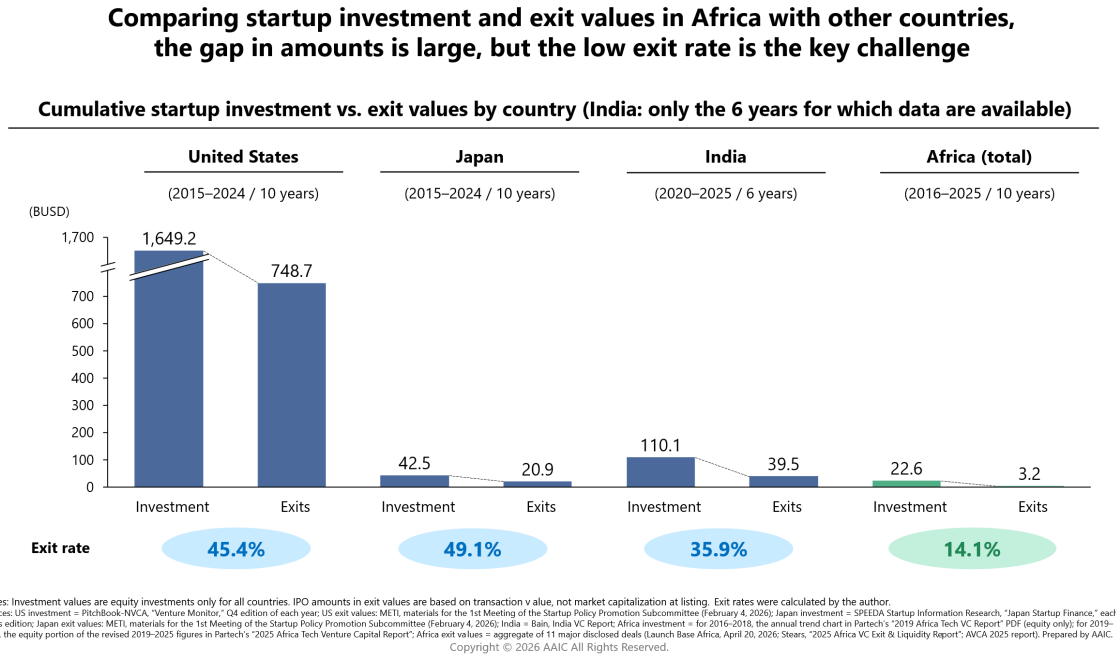
Sources: AfDB; ILO, World Employment and Social Outlook: Trends 2025; Israel Innovation Authority (2025); Startup India portal (March 2026); Google/IFC, "e-Conomy Africa 2020."[4, 6, 7]

What is needed to unlock this potential is not support for individual companies but a capital circulation structure for the ecosystem as a whole. Capital circulates only when players exist at every stage, from pre-seed and seed through Series A, B, and C to strategic sales (trade sales), secondary transactions, and IPOs. If there is a bottleneck at even a single point, capital will not flow from stage to stage. This paper addresses the final stage of this cycle, where the bottleneck occurs, and how to resolve it. If existing investors cannot recover the capital they have invested, it is difficult to attract new capital.

3. Implications from a Four-Country Comparison

Practitioners widely recognise that Africa's exit environment is relatively challenging. However, to serve as a basis for policy recommendations, figures that are comparable across countries on the same basis are required. Here, this paper presents a value-based comparison of four countries/regions centred on data published by the Ministry of Economy, Trade and Industry (METI). Note, however, that the exit rates were calculated by the author based on these data.

Figure 2. Comparison of cumulative startup investment and exit values by country



Notes: Investment values are equity investments only for all countries. IPO amounts in exit values are based on transaction v alue, not market capitalization at listing. Exit rates were calculated by the author.
Sources: US investment = PitchBook-NVCA, "Venture Monitor," Q4 edition of each year; US exit values: METI, materials for the 1st Meeting of the Startup Policy Promotion Subcommittee (February 4, 2026); Japan investment = SPEEDA Startup Information Research, "Japan Startup Finance," each year's edition; Japan exit values: METI, materials for the 1st Meeting of the Startup Policy Promotion Subcommittee (February 4, 2026); India = Bain, India VC Report; Africa investment = for 2016–2018, the annual trend chart in Partech's "2019 Africa Tech VC Report" PDF (equity only); for 2019–2025, the equity portion of the revised 2019–2025 figures in Partech's "2025 Africa Tech Venture Capital Report"; Africa exit values = aggregate of 11 major disclosed deals (Launch Base Africa, April 20, 2026; Stears, "2025 Africa VC Exit & Liquidity Report"; AVCA 2025 report). Prepared by AAIC.
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3.1. Key Observations

First, Africa's exit rate of 14.1% is markedly lower than those of the other three countries/regions. Although the absolute scale of investment is also small (US$22.6 billion), there is a decisive gap in the share of invested capital that has been recovered.

Second, this figure is consistent with another study. The African Private Capital Association (AVCA) reported an exit-to-investment ratio of 0.13x for Africa in its 2024 African Private Capital Activity Report.[2] This is a single-year figure for 2024 (26 exits ÷ US$3.2 billion raised) and differs from the 10-year cumulative figure in Figure 2 in both calculation method and period; nevertheless, the convergence at a similar level suggests that this structure is not a temporary phenomenon. In mature markets, it is generally considered standard to recover 60–80 cents for every dollar invested within the same investment period.[2] In AVCA's latest report (published March 2026, covering 2025), this ratio rose to 0.2x.[21] Although there are signs of improvement, a large gap remains compared with the 0.6–0.8x of mature markets, and this does not overturn the central concern of this paper.

3.2. Key Implication

The key implication of Figure 2 lies in India's exit rate of 35.9%. India does not differ greatly from African countries in terms of GDP per capita. Nevertheless, its exit rate is close to those of the United States and Japan. India has a functioning domestic IPO market, and in 2024 about three quarters of exit value came through IPO (public markets). In addition, there is a deep pool of buyers, including global PE funds, sovereign wealth funds, and crossover funds, and in the deep-tech sector, secondary sales have become established as a major exit route.[8]

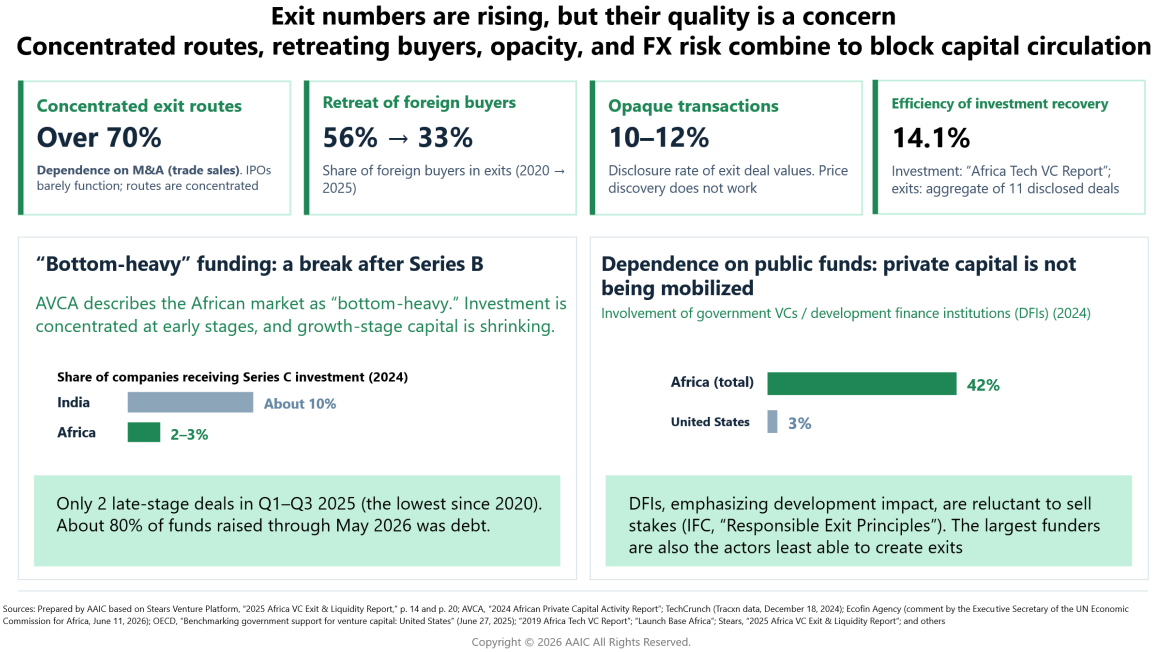
In other words, Africa's challenge lies not in its income level (GDP per capita) but in a structural problem: the absence of a domestic capital market and a pool of buyers. The focus needs to shift from "supporting and aiding entrepreneurs with the funds they lack to launch their businesses" to "supplementing the functions that a circulating market structure would normally perform, where that structure is missing." And for the structural absence of a pool of buyers, a mechanism that creates the buyers themselves, namely a secondary fund, is one possible solution.

In preparing Figure 2, a similar comparison was also attempted for Indonesia, Brazil, and South Africa; however, no published data aggregating 10-year exit values under the same definition exist, and calculation and comparison were not possible. Because speculative estimates risk undermining the credibility of the recommendations, the comparison was limited to the four countries/regions above.

4. Africa's Exit Environment: Where Is the Bottleneck?

Behind the figure of 14.1% lie several overlapping structural factors.

Figure 3. Structural challenges facing Africa's exit market



Sources: Stears, "2025 Africa VC Exit & Liquidity Report," p. 14 and p. 20; AVCA, "2024 African Private Capital Activity Report"; TechCrunch (Tracxn data, December 18, 2024); Ecofin Agency (June 11, 2026); OECD (June 27, 2025); "2019 Africa Tech VC Report"; "Launch Base Africa"; Stears, "2025 Africa VC Exit & Liquidity Report."[2, 3, 5, 10, 11]

4.1. Limited Exit Routes and a Thin Pool of Buyers

More than 70% of exits in Africa are concentrated in M&A (trade sales), and IPOs have not become a realistic option.[3] Over the past 10 years, IPOs by African startups have effectively been limited to two: Jumia (2019, NYSE) and Swvl (2022, SPAC). The number of exits itself is on an upward trend; according to AVCA, exits in 2025 reached a record high of 34, up 31% year on year,[9] but the recovery in numbers has not been accompanied by a diversification of routes. In AVCA's Private Capital in Africa Report published in March 2026 (a broader aggregation including private equity, covering 2025), of the 81 exits (up 27% year on year), trade sales accounted for 38%, secondaries for a record 26%, and IPOs numbered four.[21] Because the population differs from that of venture capital–only aggregations, a simple comparison is not possible; nevertheless, the upward trend of secondaries in the broader private capital market indicates that the market is moving forward.

A bigger challenge is the change on the buyer side. The share of overseas buyers in exits fell sharply from 56% in 2020 to 33% in 2025.[3] Buyers within the region are few, and the values of almost all of

their transactions are undisclosed. For comparison, in Brazil, although there have been no IPOs since December 2021, an exit market has been sustained by overseas buyers accounting for 41% of deal value. A deep pool of buyers, including overseas buyers, functions as an alternative route when an IPO market is absent or limited, but in Africa this alternative is thin.

4.2. Lack of Information Transparency and the "Bottom-Heavy" Distribution of Capital

According to a Stears survey, transaction values are disclosed for only 10–12% of tracked VC exits.[3] This is not merely a statistical inconvenience: there are no reference values for price formation and no benchmark for negotiation between buyers and sellers, making transactions difficult to close. Price visibility is a prerequisite for the formation of a secondary market.

AVCA also describes the African market as "bottom-heavy." Investment activity is concentrated in early-stage rounds, while growth-stage capital is shrinking. In the first three quarters of 2025, there were only two late-stage deals, the lowest level since 2020.[5] By stage, only 2–3% of funded companies whose stage was disclosed raised a Series C round in 2024, compared with about 10% in India in the same year, revealing a large gap in later-stage financing.[10]

4.3. Dependence on Government-Affiliated Capital and Foreign Exchange

Government VCs and development finance institutions (DFIs) carry a heavy weight in African venture investment, accounting for 42% of the total in 2024, compared with 3% in the United States.[11] The large weight of DFIs creates a structural dilemma. Because they prioritise development impact, DFIs are reluctant to engage in secondary transactions that buy out the stakes of existing investors, and the requirement for responsible divestment set out in IFC's "Responsible Exit Principles" also works to restrain timely sales of stakes. As a result, a situation has arisen in which the largest supplier of capital is also the actor least able to create exit opportunities.

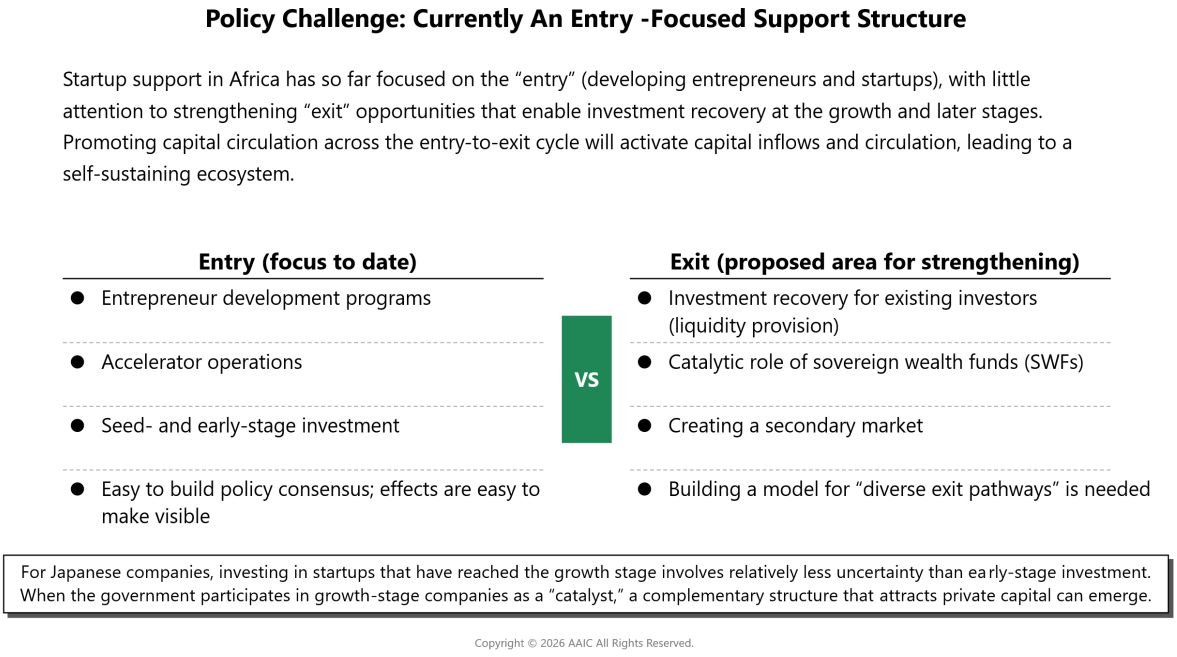
In addition, the sharp depreciation of the Nigerian naira and the Egyptian pound in 2023/2024 meant that companies growing in local-currency terms recorded negative growth in US-dollar terms.[3] This makes exits within a fund's standard ten-year term difficult in practice, and it dampens the willingness of overseas investors, who measure returns in US dollars, to enter the market. This currency fluctuation risk also highlights the importance of a local-currency-based fund.

5. The Balance of Policy Emphasis: An Entry-Focused Support Structure

Consistent with AVCA's "bottom-heavy" characterisation noted above, support for startups in emerging economies by many developed-country donors, including the Government of Japan, has so far focused on the "entry": entrepreneur development programmes, accelerator operations, and seed- and early-stage investment. This can be considered partly attributable to practical advantages: policy consensus is easy to build, and the effects of support are easy to make visible. However, as shown in

the analysis above, what is hampering the sustainability and capital circulation of the ecosystem is not the narrowness of the entry but the scarcity of exit opportunities and liquidity provision.

Figure 4. From an entry-focused support structure: a proposal to strengthen the "exit" domain

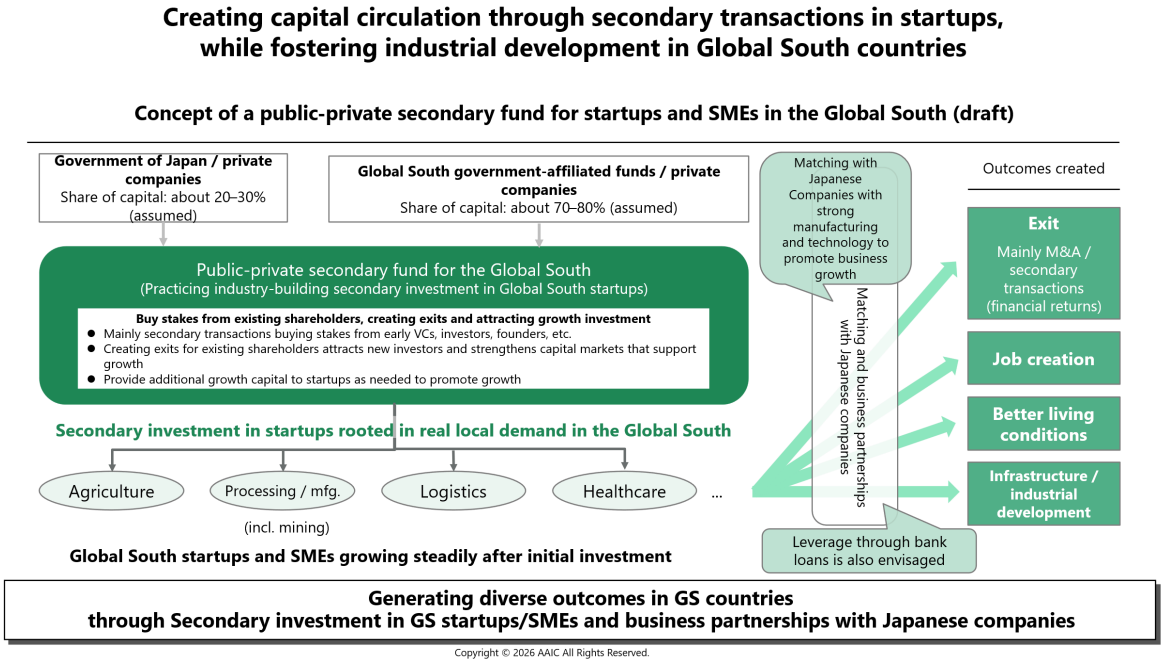


In light of the concept of "Path Diversity" advocated by the Musashino Institute for Global Affairs (MIGA), Musashino University, this bias can be described as a distortion arising from excessive reliance on a "single path," in which developed countries seek to apply their own development path (supplying growth capital through capital markets) directly to emerging economies.[12] What Global South countries need is a twin-track approach that develops the entry and the exit simultaneously.

This proposal could be positioned in relation to the "Indian Ocean–Africa Economic Zone Initiative" that the Government of Japan announced at TICAD 9 in August 2025. The initiative, which is also mentioned in the Japan Growth Strategy, aims to work with India and other Indian Ocean coastal countries to contribute to regional integration and industrial development in Africa. Its three pillars are "strengthening cooperation with Indian Ocean countries," "enhancing the connectivity of the economic zone," and "developing regional industries and creating jobs." This proposal would contribute to "developing regional industries and creating jobs" and may also provide opportunities for investment recovery.

6. Core Recommendation: Concept of a Public-Private Secondary Fund

Figure 5. Conceptual image of a public-private secondary fund for the Global South (draft)



Note: The investment ratios are assumptions of this paper and not a finalised design. JICA-NSIA (Nigeria) is a precedent for co-investment with a government-affiliated fund. Prepared by AAIC Investment Pte. Ltd.

6.1. Capital Structure: Japan Takes the First Loss and Leads the Scheme

The fund's capital structure assumes that the Japanese government and private companies contribute about 20–30%, and Global South government-affiliated funds and private companies about 70–80%. For example, for a fund totalling about JPY 10 billion, the Japanese side would contribute about JPY 2 billion.

What matters is the nature of the Japanese contribution. This paper recommends that, rather than bearing risk in proportion to its investment share, Japan take on the first loss. The Impact Innovation Fund established by the Japan International Cooperation Agency (JICA) and the Nigeria Sovereign Investment Authority (NSIA) shares the same concept of Japan acting as a catalyst, but uses a different instrument: JICA contributes grant funding to mobilise co-investment, rather than taking a subordinated first-loss position (see Section 8.2). This paper proposes to take that catalytic role one step further. Secondary transactions involve existing portfolios with long and uncertain exit horizons, so private buyers demand a high risk premium. A first-loss position taken by Japan is the most direct way to close that gap. The scheme would start with a pilot of, for example, JPY 2 billion, as in JICA's Nigerian case, and an increase would be considered while monitoring capital demand and risk.

6.2. Two-Pillar Structure: Secondaries as the Main Pillar, Growth Capital as the Sub-Pillar

The fund's investments will have two pillars, but their relative weight will be clearly distinguished, with secondaries always being the main focus.

Core: Purchase of stakes from existing shareholders (secondary transactions)

The fund purchases stakes held by early-stage VCs, investors, founders, and others. It is the existing investors who obtain the "exit" opportunity; these are not transactions in which money flows into the startup or company. This point must be made clear in this scheme. Its significance lies in creating exit opportunities and track records for existing investors in a market where there are no exit opportunities and capital circulation is blocked. This enables existing investors to redeploy capital to their next investments, or to raise capital from investors for their next fund on the strength of their track record, and the evidence that "returns can be realised in this market too" encourages new investors to enter. Resolving the bottlenecks and the vicious cycle is the essential function of secondaries.

Supplementary: Additional growth capital (primary investment)

As needed, the fund supplies additional growth capital to target companies. In practice, for example, when a company seeks US$1 million in growth capital, the fund would, where possible, arrange US$2 million, combining the growth capital with the purchase of stakes from existing investors using the other US$1 million after negotiating the valuation (including a discount). However, the core is secondaries, not growth capital. Putting growth capital at the forefront would make the startups' funding needs the centre of discussion and push the original objective, resolving the capital circulation problem, into the background.

6.3. Investment Targets: Startups in an "Organic Growth" Phase

The investment targets are Global South startups that have received initial investment but need support to scale up. They are growth companies that are growing steadily at 10–20% per year but have not reached the rapid growth of 30–50% per year that VCs require.

These companies are unlikely to qualify for follow-on investment under most existing VC investment criteria. On the other hand, as businesses they are growing steadily, creating jobs, and meeting local demand. It is precisely this segment, which is unlikely to be served by conventional venture investment frameworks, that this fund targets. Sectors will centre on areas rooted in genuine local demand, such as agriculture, processing and manufacturing (including mining, in line with responsible mining investment principles), logistics, and healthcare. The current model of rapid growth with high return and high risk is the US-originated venture ecosystem; building an ecosystem that targets startups and companies that lead to industrial development based on genuine demand could become a new approach co-created by the Global South, which is promoting industrial development, and Japan, which has a track record of having gone through that process.

6.4. Matching with Japanese, Indian and Other Global South Companies

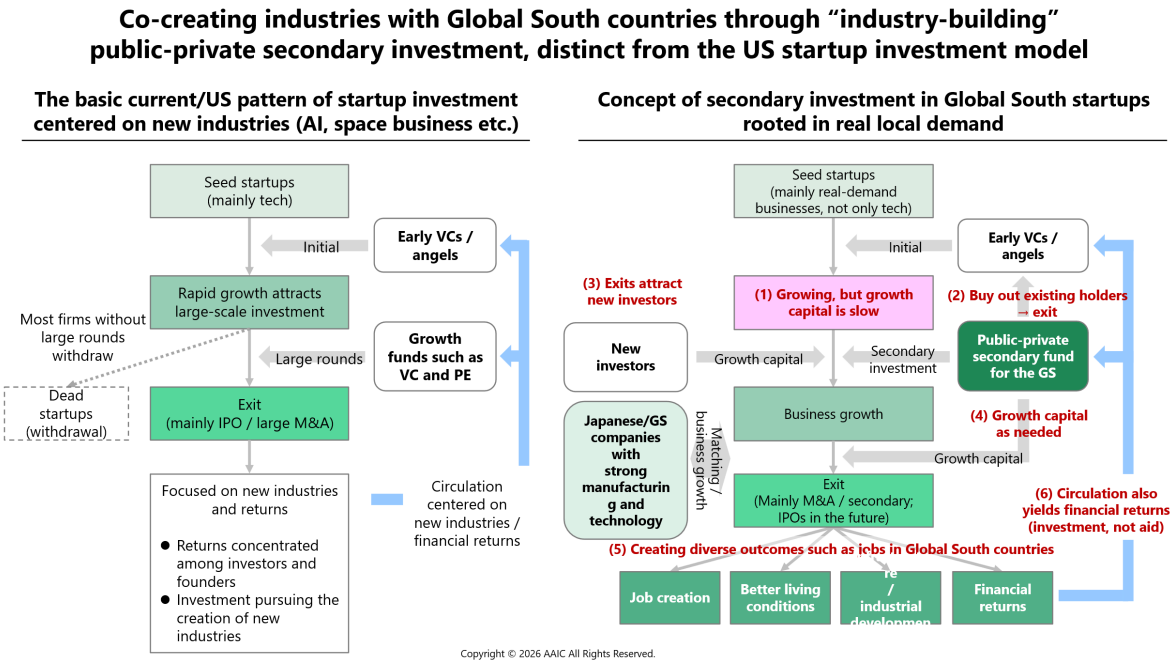
For companies in which the secondary fund acquires stakes, business partnerships will be supported with Japanese, Indian and other Global South companies that have strong manufacturing and technological capabilities. Business growth will be promoted through technology provision, the provision of sales channels, the establishment of joint ventures, and the like. For example, the value chain of the sector in which a startup operates will be mapped, companies (including SMEs) that are interested in entering the target business domains and that can complement the startup will be identified, and matching will be carried out. When a Japanese company is considering entering an emerging market, the possibility of a product sales partnership with a startup that already controls distribution channels (for example, a pharmacy chain) will be discussed. In addition, as growth capital, public and private financial institutions in Japan and the Global South will consider providing loans, offering companies the opportunity to leverage debt for growth. As for target countries, if involving all four Global South countries, which are at different stages, is not realistic, this paper proposes starting with South Africa and similar markets, that is, beginning with Africa.

Furthermore, in light of the framework of the Indian Ocean–Africa Economic Zone Initiative, the matching partners need not be limited to Japanese companies. Indian companies and overseas Indian (Non-Resident Indian) businesses with sales channels or production bases in Africa, the Indian operations of Japanese companies, and Japan–India joint ventures could also be included. For example, Daikin and Suzuki export products manufactured in India to Africa; there are already several cases of Japan–India collaboration in expanding into Africa. These companies could become strategic buyers of the stakes acquired by the secondary fund and, ultimately, exit destinations.

7. Industry-Building Investment: The “Global South–Japan Model” and Its Differentiation from the “US Model”

The model presented in this paper rests on a “philosophy” different from that of US-style startup investment centred on Silicon Valley. This recommendation is intended to be unique to Global South–Japan cooperation and to create distinctive added value.

Figure 6. The US investment pattern and the "Global South–Japan model" of public-private secondary investment



Note: This figure shows types of investment flows and does not represent the performance of any individual fund. The growth-rate level for organic growth is a practical assumption of this paper. Prepared by AAIC Investment Pte. Ltd.

The US pattern can arguably be described as a mainstream flow in which angels and VCs make initial investments in startups centred on new industries (such as tech, AI, and the space business); companies that grow rapidly attract large-scale investment from growth funds and exit through an IPO or a large M&A deal. Many companies that fail to secure large-scale investment are forced to exit the market. In the United States in 2025, there were 995 M&A deals and 62 IPOs by count, while by value the two were nearly equal, at US$112.7 billion versus US$119.4 billion.[13]

The US model can be said to focus on investment leading to "the creation of new industries of the future" through innovation, which differs from developing existing industrial bases. It is also designed to maximise financial returns, which tend to be concentrated among investors and founders, and it is a mechanism that achieves strong results in light of that objective.

In contrast, the model of this paper targets startups and growth-capable small, medium-sized, and mid-tier enterprises rooted in genuine local demand. This paper proposes that value creation in this model include, in addition to financial returns, job creation, improved living conditions, infrastructure development, and industrial development, which are "presently ongoing challenges" in the Global South. This model is conceived not as aid but as investment that generates financial returns while

creating industrial development and capital circulation. In this way, the paper presents a third vision, distinct both from traditional ODA and from investment focused on financial returns.

7.1. Why Japan's Contribution Is Meaningful

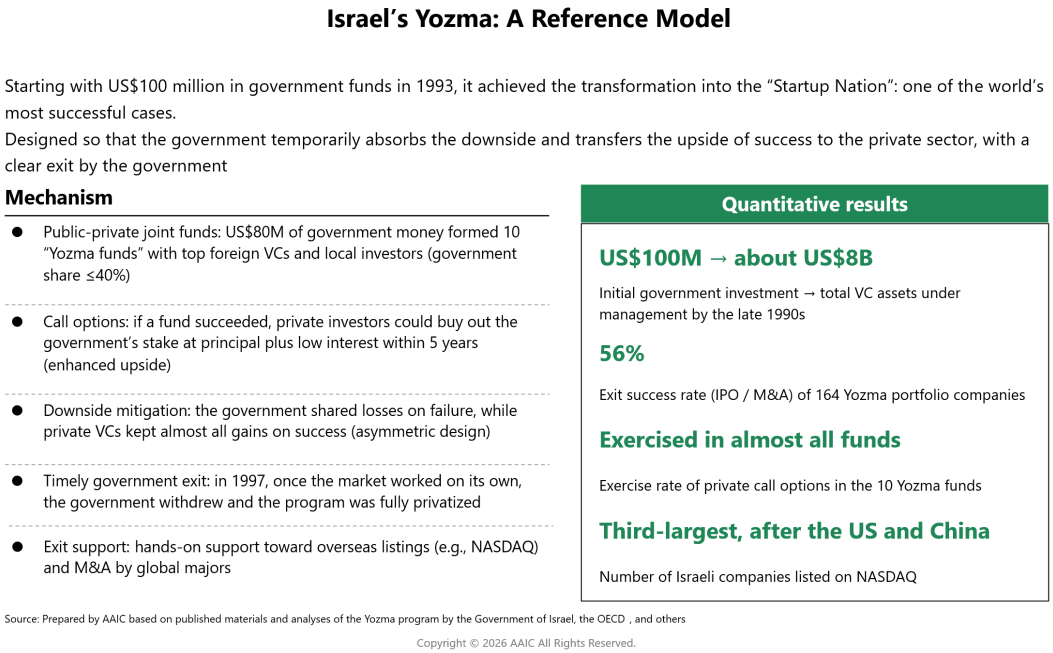
First, Africa has a large population and potential for scale-up. Strengthening local production and local distribution in Africa means building an industrial base that responds to this population growth and economic growth, and it is in line with the "Made in Africa" initiatives of many countries. Second, the target sectors overlap with the strengths of Japanese companies. In areas such as agriculture, processing and manufacturing (including mining), logistics, and healthcare, manufacturing and technological capabilities translate directly into competitive advantage. Areas are selected in which Japanese companies can actually provide value. Third, while bringing change to the structure of capital circulation, the initiative will help strengthen medium- to long-term bilateral and interregional cooperation by identifying concrete challenges from the investors' perspective, such as those related to the business environment, and jointly improving the business environment and other conditions through policy dialogue.

8. Reference Models: Israel's Yozma and the JICA-NSIA Fund

8.1. Israel's Yozma Program

In 1993, the Israeli government launched the Yozma programme with US$100 million in public funds. Of this, US$80 million was co-invested in 10 private VC funds, with the government's share in these funds capped at 40% and private investors providing 60% or more. The remaining US$20 million was invested directly by the government. The programme laid the foundation for Israel's transformation into the "Startup Nation." Its design is an important reference model for this paper.[14]

Figure 7. Design and outcomes of Israel's Yozma programme



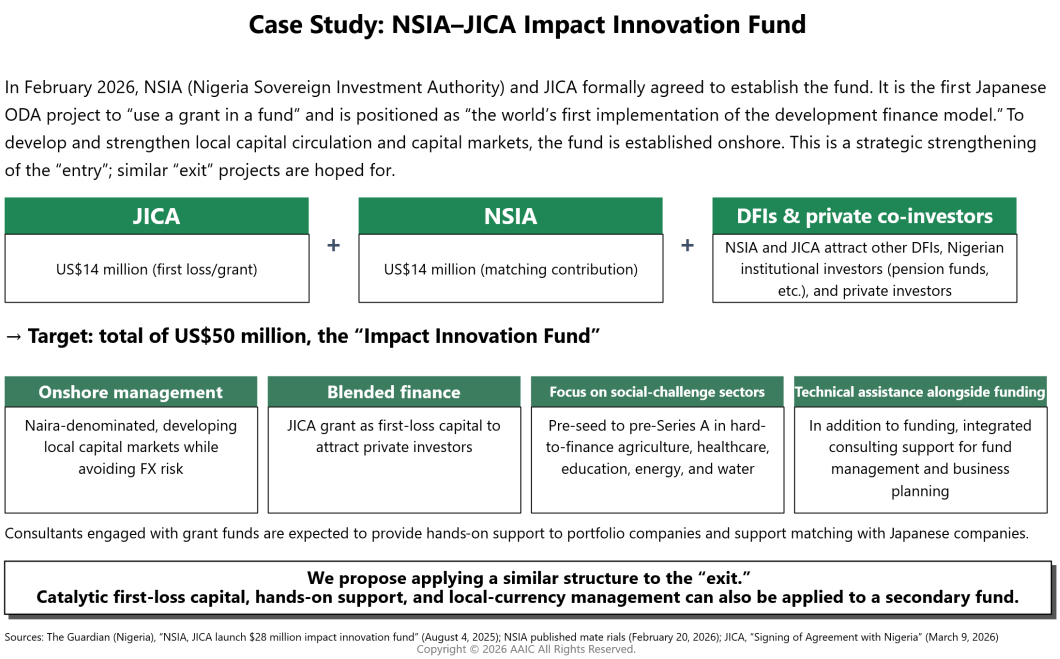
Source: Prepared by AAIC Investment Pte. Ltd. based on published materials and analyses of the Yozma programme by the Israeli government, the OECD, and others.[14]

The role of government is not to supply capital continuously but to act as a catalyst at the high-risk early stage, lay down pathways for the market to function autonomously, and withdraw once the market begins to operate. The call option design is a means of building this "timely withdrawal" into the system, and it is adopted as Recommendation 1-2.

8.2. JICA-NSIA Impact Innovation Fund

In February 2026, the Nigeria Sovereign Investment Authority (NSIA) and JICA formally agreed to establish the "Impact Innovation Fund," with a total size of US$50 million.[15] It is the first Japanese ODA project to "use a grant for a fund," and the Ambassador of Japan to Nigeria has described it as "the world's first implementation of a development finance model incorporating private capital."[16]

Figure 8. Structure of the NSIA-JICA Impact Innovation Fund



Sources: The Guardian (Nigeria) (August 4, 2025); NSIA published materials (February 20, 2026); JICA, "Signing of Agreement with Nigeria" (March 9, 2026).[15, 16, 17]

The key point is that this fund strengthens the "entry." It targets pre-seed to pre-Series A and supports the pipeline in sectors that struggle to attract investment capital. This paper asks whether the same structure could be applied to the "exit." The combination of catalytic public capital, local-currency operation, and hands-on support can be applied to a secondary fund, with Japan's contribution strengthened from grant-based catalytic capital into an explicit first-loss position. The Nigerian case serves both as a precedent for institutional design and as evidence of political feasibility.

9. International Comparison: Secondary Market Promotion Measures in Six Countries/Regions

There are multiple examples worldwide of governments leading the development of secondary markets. The common success factors are the catalytic effect of public funds, the standardisation of transaction rules, and the timing of the government's "withdrawal."[18]

Figure 9. Secondary market promotion measures and their effects in six countries/regions

International Comparison: Secondary-Market Promotion in 6 Countries/Regions

Several cases worldwide show government-led development of secondary markets.
Common success factors: the catalytic effect of public funds, standardized transaction rules, and the timing of the government's exit.

Country/region	Mechanism	Quantitative effect
Israel (Yozma)	Public-private joint funds with call options	Exit success rate 56% / VC assets grew to US$8 billion within a few years
South Korea (KVIC / Korea Growth Investment Corp.)	Secondary fund-of-funds formed with an anchor LP	About KRW 1 trillion per year; 30–40% of maturing funds made liquid
Europe (EIF)	Anchor investment in vehicles dedicated to GP-led secondaries	€1 catalytic → €3–5 private; 20–30% of exits via secondaries
China (government guidance funds / S funds)	Local governments set up S funds and exchange platforms	About RMB 10 billion in annual transactions; deal completion rates rose sharply
Japan (JIC, etc.)	Expanded LP commitments to dedicated secondary funds	Specialized funds of tens of billions of yen launched one after another
United Kingdom (British Business Bank)	Funding secondary transactions of mature funds through ECF and others	Capital circulation efficiency improved by about 15–20%

Sources: Prepared by AAIC based on published materials of the Government of Israel and OECD analyses, KVIC / Korea Growth Inv estment Corp., EIF, China's government guidance funds, JIC, and the British Business Bank

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Sources: Prepared by AAIC Investment Pte. Ltd. based on analyses by the Israeli government, the OECD, and others, and on published materials of Korea's KVIC/Korea Growth Investment Corporation, Europe's EIF, China's government guidance funds, Japan's JIC, and the UK's British Business Bank.[18]

For reference, the current state of private-sector-led secondary markets is also reviewed. In 2025, secondary transactions accounted for about 31% of US VC exits, reaching US$113.6 billion in value,[19] and the United States is said to account for 58% of the global VC secondary transaction market.[20] Market participants themselves are also consolidating: Goldman Sachs acquired Industry Ventures for US$965 million, and Charles Schwab acquired Forge Global for US$660 million.[20] Secondaries are already an established asset class in the United States, at a stage where major financial institutions are entering. In Africa, by contrast, trade sales account for more than 70%, and secondaries, though emerging, are not mainstream. That said, in AVCA's 2025 results (private capital as a whole), the share of secondary transactions rose to 26%, indicating their growing use.[21] To extend this to the venture domain and establish it as a sustainable mechanism, deliberate catalytic action through public funds is necessary. Rather than waiting for a market to emerge spontaneously, proactive measures should be taken to create the market through public catalytic capital.

10. Practical Insights: Co-Creation with Japanese Companies and Secondary Cases

Since 2017, AAIC Investment Pte. Ltd. has invested in about 60 companies in Africa (cumulative investment of about US$80 million). This paper illustrates with concrete cases how the mechanism envisaged in this paper can work in practice.

10.1. Africa Healthcare Network: Achieving an Exit through Secondaries

Africa Healthcare Network (AHN) is a dialysis service provider founded in 2015. In Africa, only about 5% of patients who need dialysis actually receive it, and lack of access is a serious challenge. AHN's model establishes dialysis centres within hospitals through revenue sharing with hospitals; it is the largest dialysis chain in sub-Saharan Africa, with 60 sites across four countries: Rwanda, Tanzania, Kenya, and Zambia.

AAIC Investment Pte. Ltd. invested at Series A. Subsequently, AHN expanded from one centre (2015) to more than 60 (2025) and from fewer than 10 employees to more than 700, growing to the stage at which PE funds invest. In 2023, it raised US$20 million in a round led by Africa50, and early investors achieved an exit through a secondary transaction. Most of its dialysis equipment is supplied by Japanese manufacturers. This case shows that for companies that have achieved accelerated growth, buyers can emerge and secondary transactions can be realised. The issue, however, is that such successes are rare, deal-specific cases, and that this still does not function as a market mechanism.

10.2. Revital Healthcare: Value Creation through Co-Creation with Japanese Companies

Revital Healthcare (EPZ) Limited is a medical supplies manufacturer in Mombasa, Kenya. It operates the largest medical supplies manufacturing plant in sub-Saharan Africa, and the disposable syringes it manufactures are auto-disable (AD) and re-use prevention (RUP) syringes prequalified under WHO PQS (seven models). AAIC Investment Pte. Ltd. invested in 2021.

In Africa, even medical supplies are about 80% dependent on imports. Revital aims to break away from this import dependence; it employs more than 600 people, with Kenyan nationals making up 99% of its workforce and women 80% of its staff. Partnerships with Japanese companies are also progressing concretely: it has signed a memorandum of understanding on a strategic partnership with the Mitsui O.S.K. Lines (MOL) Group towards establishing a healthcare logistics hub in the Mombasa Special Economic Zone, and Ohara Pharmaceutical has also invested in the company. In addition, about half of the company's injection moulding machines are made by Japanese manufacturers. This case shows that the added value Japanese companies can provide is not limited to capital: it also includes technology, logistics networks, and quality-control know-how. The hurdles for Japanese companies entering emerging markets on their own are high, but by co-creating with players who have accumulated long-term local knowledge, business partnerships that generate mutual synergies can be realised. However,

the presence of a player that serves as a catalyst is key to realising such partnerships. In this case, AAIC Investment Pte. Ltd. has played that role.

On the other hand, even companies that have created several hundred jobs or multiplied their sales several times over through five to seven or more years of hands-on support face the risk of being unable to secure sufficient liquidity within the fund's investment period because of constraints in the macro exit environment. Here lies the structural problem this paper seeks to resolve: even excellent companies are affected by the challenges of exits.

11. Policy Recommendations

Recommendation 1: Establish a Public-Private Secondary Fund

This paper proposes establishing a secondary fund that purchases investment stakes held by existing funds, with sovereign wealth funds (SWFs) and public pension funds of Global South countries as the principal investors, in partnership with private-sector GPs (general partners). Building on the Nigerian case, where JICA's grant funding served as catalytic capital, Japan will go one step further: Japanese public capital will take on risk by providing first-loss capital and play the role of attracting private capital. The capital structure assumes about 20–30% from the Japanese side and about 70–80% from the Global South side. If implemented in a single country, a 50/50 split, as in Nigeria, will serve as the starting point.

SWFs and pension funds in Global South countries build their investment strategies around the missions of "investing for the next generation" and "maintaining domestic employment." Ensuring that growth-stage startups are not held back by funding constraints is consistent with the investment objectives of these institutions.

Expected effects

- Catalytic effect on new risk capital inflows through liquidity provision to existing investors
- Preservation of asset value, avoiding fire sales at steep discounts, alongside long-term industrial development
- (Shift away from offshore dependence in return expectations, driven by the participation of local-currency buyers)

Recommendation 1-2: Yozma-Style "Call Option" Design

For the government-funded portion, a right will be built into the institutional design allowing overseas private VCs that achieve results within a set period to buy it out at principal plus a low interest rate. This yields two effects: (1) the upside for overseas private VCs is enhanced, increasing the effect of attracting them; and (2) the government's "timely withdrawal" is made institutionally clear. In Israel, this design led to call options being exercised in almost all of the 10 funds, and the government

fully withdrew its capital in 1997.[14] Government capital that remains in the market indefinitely can, conversely, hinder the development of the private market.

Recommendation 1-3: Local-Currency (Onshore) Operation (Option)

Following the JICA-NSIA case in Nigeria, the fund will be structured and operated in local currency (onshore) to the extent possible. This reduces the risk that local-currency gains turn into losses in US-dollar terms caused by exchange rate volatility, and it can also be expected to have the ancillary effect of developing local pension funds and institutional investors as participants in local capital markets.

However, local-currency operations may be difficult to achieve in some countries. Capital controls, the absorptive capacity of local institutional investors, and currency stability vary greatly from country to country. At the pilot stage, feasibility must be examined case by case, and it should not be made a uniform requirement.

Recommendation 2: Build a Platform to Support Matching with Japanese Companies

For companies in which the secondary fund acquires stakes, a matching function that brokers business partnerships with Japanese companies (technology provision, joint ventures, supply chain integration, etc.) will be institutionalised as an integral part of fund management. "Business partnerships grounded in genuine demand," such as those between AHN and Japanese medical equipment manufacturers and between Revital and the MOL Group, could be replicated as a system rather than through individual efforts.

This function has significance on both sides. First, by providing technology, sales channels, and logistics networks, it strengthens the business foundations of target companies, leading to higher corporate value. Second, it opens access for Japanese companies to growth-stage startups and small, medium-sized, and mid-tier enterprises in emerging economies, which carry relatively low risk. This paves the way for Japan to work with the Global South to achieve both local industrial development and value creation on the one hand and financial returns on the other.

12. Implementation Structure, Roadmap, and KPIs

Table 2. Implementation roadmap (indicative)

Phase	Indicative period	Main activities (not yet initiated)
Phase 1 Research and design	Up to 1 year	Selection of target countries and sectors; establishment of valuation methods for stakes in existing funds; consultations with SWFs and local authorities; examination of the feasibility of local-currency operation
Phase 2 Pilot formation	1–3 years	Formation of a pilot fund with first-loss capital plus SWF capital (in one or two countries, such as South Africa or Nigeria); development of the matching support system
Phase 3 Rollout and expansion	3–7 years	Expansion of target countries (East and West Africa, etc.); broadening of the base of private co-investors; strengthening of links with local capital markets; start of call option exercises
Phase 4 Expansion to other regions	7 years and beyond	Horizontal rollout to India, Brazil, Indonesia, etc.; systematisation of knowledge and international dissemination; phased withdrawal of government capital

Source: Prepared by AAIC Investment Pte. Ltd.

Table 3. Expected effects and KPIs (examples)

Perspective	Indicators (examples)
Capital circulation	Total value of stakes purchased by the secondary fund / number of cases of liquidity provided to existing investors
Catalytic effect	Multiple of private/SWF co-investment per 1 unit of Japanese contribution (leverage ratio)
Improvement of the exit rate	Changes over time in the exit rate of target countries (using the calculation method of Figure 2 of this paper)
Partnerships with Japanese companies	Number of successful matches; number of local business partnerships (JVs, technology alliances, etc.) by Japanese companies
Reduction of foreign exchange risk	Share of local-currency operation; local-currency returns within the fund's investment period
Employment and industrial development	Number of jobs created by portfolio companies; benefits in social-issue areas (health, education, agriculture, etc.)
Market transparency	Change in the disclosure rate of exit transaction values in target countries

Source: Prepared by AAIC Investment Pte. Ltd.

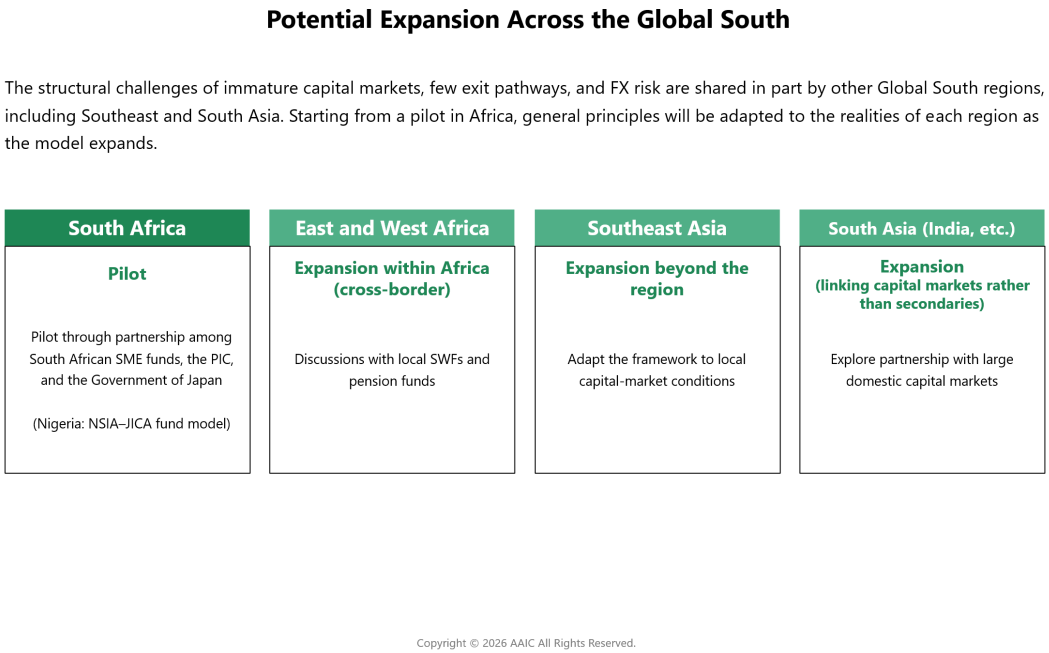
In particular, this paper proposes making "improvement of the exit rate" the primary KPI. The exit rate shown in Figure 2 (14.1% for Africa) is a reproducible indicator with an explicit calculation method.

By monitoring it at fixed points in time, the outcomes of policy interventions can be continuously verified.

13. Potential for Expansion across the Global South

Although this paper focuses mainly on Africa, its structural challenges (immature capital markets, scarce exit routes, and foreign exchange risk) may be common to other Global South regions, including Southeast Asia and South Asia.

Figure 10. Potential for expansion across the Global South



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The secondary fund concept of this paper is not a solution specific to a particular country or region; it consists of three general-purpose principles, namely "catalytic government capital," "designing timely withdrawal through call options," and "matching with Japanese companies" (plus the optional "local-currency operation"). After a pilot is established, it can be rolled out while being adapted to the realities of each region's capital markets. As MIGA points out, Global South countries have in recent years enhanced their capacity to pursue endogenous modernisation, and collaborative models based on equal partnerships, rather than one-way external aid and guidance, are now required.[12]

14. Conclusion

The discussion in this paper started from a quantitative look at the liquidity problem faced by many VCs: the fact that the exit rate over the past 10 years is only 14.1% for Africa as a whole, compared with 49.1% for Japan, 45.4% for the United States, and 35.9% for India (six years of data for India). What this

figure shows is where the structural problem of Africa's venture ecosystem lies. India's level shows that being an emerging economy does not in itself make exits difficult. What Africa lacks is not capital as such but the market structure that allows capital to circulate, above all a pool of buyers and a price formation function.

The role of government is not to supply capital in perpetuity. It is to act as a "catalyst" at the high-risk early stage, lay down pathways for the market to function autonomously, and "withdraw" once the market begins to operate. The withdrawal of government capital under Israel's Yozma programme in 1997 demonstrates that this design philosophy works in practice.

For Africa's venture ecosystem to evolve into a sustainable industry, it is essential to secure "multiple layers of buyers" and "information transparency" in exits. The creation of a secondary market proposed in this paper is a first step for the Global South itself to build a sustainable and autonomous circulation of capital. It is also important, in the course of building it, to improve the business environment and governance in parallel so that investment can be further promoted.

This paper recommends that the Government of Japan, through participation in this "exit support," build a new model of international cooperation that opens a path to growth-stage startups in emerging economies as relatively low-risk investment targets, and that co-creates the overseas business expansion of Japanese companies and industrial development in emerging economies. It is investment, not aid: a mechanism that draws on the wisdom and experience Japan has gained in achieving economic growth with manufacturing as its backbone, and that promotes both the industrial development and job creation of the Global South and, through capital circulation, the resolution of bottlenecks and financial returns.

Notes

The entries below correspond to the superscript numbers 1–21 in the text. Because web pages may be updated, the paragraph and page positions in the articles as of the time of reference (September–October 2026) are noted as a guide.

1. Data sources for Figure 2. (1) US investment = PitchBook-NVCA (n.d.), Q4 edition of each year (Q4 2021 edition, p. 3, "Executive summary," 2nd paragraph; data labels on the "Deal activity" chart in the Overview of each year's edition). (2) US and Japan exit values = METI (2026), p. 6, "Exits Other Than IPOs (M&A)," right-hand chart "Shares of IPOs and M&A in Startup Exits by Country (Value Basis)," data labels at the top of each bar (original source: JETRO (2025); PitchBook data retrieved March 2025). (3) Japan investment = SPEEDA Startup Information Research (n.d.), main text (excluding debt). (4) India = Bain & Company and IVCA (n.d.), 2024 edition, main text: "from $25.7 billion to $9.6 billion over 2022–23" and "Exits surged by almost 1.7x to reach $6.6 billion in 2023"; 2025 and 2026 editions. (5) Africa investment = Partech (n.d.-b), EQUITY DEAL AMOUNT labels in "01 TOPLINE DEALS AND VOLUMES (EQUITY & DEBT)," and the annual trend chart in Partech (n.d.-a). (6) Africa exit values = aggregate of 11 major disclosed deals (Launch Base Africa (2026), items 3, 4, and 12; Stears Venture Platform (n.d.), p. 3, Preface, 9th paragraph; AVCA (n.d.-b)).
2. AVCA (n.d.-a), introduction page, Key findings, "Relative exit resilience" section (exit-to-investment ratio of 0.13x). As a secondary source, Clyde & Co (n.d.) (source stated in its footnote 17), main text, "Exits and liquidity" paragraph (26 exits in 2024 against US$3.2 billion raised, a ratio of 0.13x; mature markets recover 60–80 cents).
3. Stears Venture Platform (n.d.), p. 3, Preface, 9th paragraph; p. 4, final paragraph of the Executive Summary; p. 14, 1st paragraph (disclosure rate of 10–12%); p. 20, analysis of exit routes (trade sales over 70%, overseas buyers 56% → 33%, foreign exchange).
4. AfDB (n.d.); ILO (n.d.-a); ILO (n.d.-b) (10–12 million annual entrants versus about 3 million formal jobs; in sub-Saharan Africa, three out of four young people are unable to obtain stable employment).
5. Ecofin Agency (2026), comments by Claver Gatete, Executive Secretary of the United Nations Economic Commission for Africa (ECA), paragraphs 2–4 (implementation gap; 70–80% of startups failing within five years; AVCA's "bottom-heavy" characterisation; two late-stage deals in Q1–Q3 2025; about 80% of capital raised being debt).
6. Israel Innovation Authority (2025) (high-tech industry at about 20% of GDP, more than 400,000 jobs / 11.5% of the labour force, 53% of exports); Startup India portal (2026) (more than 2.33 million direct jobs at DPIIT-registered startups).
7. Google and IFC (n.d.) (contribution of the internet economy to GDP rising from 4.5% to 8.5% in 2050; potential to create up to 44 million jobs when penetration reaches 75%).
8. Bain & Company and IVCA (n.d.), 2025 edition / Business Standard (2025) (coverage of the Bain-IVCA report), main text: "India's exit environment improved significantly in 2024, with exit values reaching $6.8 billion. Public markets were the primary driver, accounting for three-quarters of this value" / Blume Ventures (n.d.) (establishment of secondary sales in the deep-tech sector).
9. Africa Global Funds (n.d.) (coverage of AVCA (n.d.-b)), 1st paragraph: "Venture-backed exits reached a new high of 34, rising 31% YoY".
10. TechCrunch (2024) (Tracxn data); The African Tech Startups Funding Report 2024 (n.d.) (2–3% of companies in Africa received Series C investment, compared with about 10% in India). Note: based on the 84 deals for which the funding stage was disclosed.

11. OECD (2025) (3% in the United States); AVCA (n.d.-a) (42% for Africa as a whole). On DFIs' reluctance to sell, see IFC (n.d.).
12. Nishimura and Maeda (2024), Chapter 1 of MIGA (2024a), pp. 2–17.
13. PitchBook-NVCA (n.d.), Q4 2025 edition (in 2025, the US recorded 995 M&A deals totalling US$112.7 billion and 62 IPOs totalling US$119.4 billion).
14. Published materials and analyses of the Yozma programme by the Israeli government, the OECD, and others (10 funds formed with US$80 million in government capital, government share of up to 40%, call option within five years, 56% exit success rate among 164 portfolio companies, US$100 million ⟶ about US$8 billion, full privatisation in 1997).
15. NSIA (2026), paragraphs 1–2 and 7–8 (JICA grant of US$14 million, NSIA matching of up to US$20 million, target total of US$50 million).
16. Voice of Nigeria (2026), paragraphs 7–8 (remarks by Hideo Suzuki, Ambassador of Japan to Nigeria: "the world's first implementation of a development finance model incorporating private capital").
17. JICA (2026), Specific Project Details section (grant amount of JPY 3.142 billion, implementation period of 159 months, corresponding to SDGs 8 and 9) / The Guardian (Nigeria) (2025), paragraphs 1–3.
18. Analyses by the Israeli government, the OECD, and others, and published materials of Korea's KVIC/Korea Growth Investment Corporation, Europe's EIF (European Investment Fund), China's government guidance funds, Japan's JIC (Japan Investment Corporation), and the UK's British Business Bank.
19. Theory Ventures (n.d.) (source: PitchBook, data as of 30 September 2025) (in 2025, secondaries accounted for about 31% of US VC exits, at US$113.6 billion out of a total of US$366.5 billion).
20. Global Venturing (2025) (the United States accounts for 58% of the global VC secondary transaction market). Restructuring on the buyer side: Goldman Sachs ⟶ Industry Ventures (US$965 million), Morgan Stanley ⟶ EquityZen, Charles Schwab ⟶ Forge Global (US$660 million).
21. AVCA (2026), p. 5, "Exits: Liquidity Gains Momentum" (81 exits, up 27% year on year; exit-to-investment ratio rose from 0.1–0.13x in 2024 to 0.2x), and p. 29, "3.1 Africa in the Global Exit Landscape" to "3.2 Exit Routes" (trade sales 38%, secondaries 26%, four IPOs).

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Part II.

Sectoral Studies and Policy Recommendations

C. Energy, Resources, and Circular Industrialization

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Chapter 10: Building a Common Knowledge Platform with Global South Countries in the Energy Sector

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1. Introduction

The Takaichi administration has identified 17 strategic fields for its growth strategy and is promoting the simultaneous achievement of economic security, a nation built on technology, and Green Transformation (GX). These 17 fields include resources and energy, with the aim of achieving a stable energy supply and GX for Japan. However, achieving a stable energy supply and decarbonisation is an urgent challenge not only for Japan but also for the Global South countries, whose rise in recent years has been remarkable. This paper therefore focuses on the resources, energy, and GX fields among the 17 fields of Japan's growth strategy and examines co-creation relationships with Global South countries. Of the Global South countries, four—Indonesia, India, Brazil, and South Africa—were selected for the study. These countries held the G20 presidency in succession from 2022 to 2025, and among the Global South countries they are extremely important to Japan both economically and in terms of energy. Examining energy co-creation relationships with these four countries requires an understanding of the current energy supply and demand situation of the five countries including Japan; the paper therefore first clarifies the energy supply and demand structures of the five countries on the basis of publicly available international energy statistics. It then reviews Japan's growth strategy in the energy field and, with reference to the basic energy policies set out by the four countries, examines the applicability of each strategy to these four countries. Underlying this analysis is the view that co-creation relationships in the energy field will enable Japan and the four countries to jointly enjoy economic development through the transfer of Japan's energy laws and institutions and innovative technologies to the four countries. Although the 17 growth strategy fields include critical minerals and fusion technology, which are closely related to resources and energy, these are discussed in separate papers and are not addressed here.

2. Energy Supply and Demand Structure of the G5

As stated in the Introduction, examining co-creation relationships in resources and energy requires an investigation of the energy supply and demand structures of the five countries including Japan

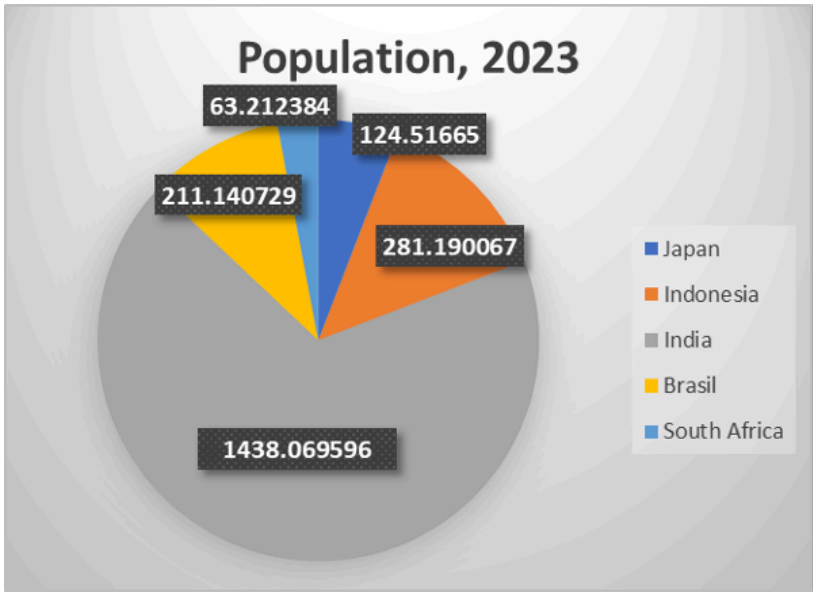
(referred to here as the G5: Japan, Indonesia, India, Brazil, and South Africa). This is because a country's energy supply and demand is determined by its stage of socioeconomic development and its endowment of natural resources. It is therefore necessary to identify resource and energy co-creation relationships suited to each country. We therefore first examine the social and economic conditions that affect energy supply and demand, taking up population and GDP.

2.1. Socioeconomic Indicators

(1) Population

In 2023, the total population of the G5 was approximately 2.12 billion. India has the largest population at over 1.4 billion, followed by Indonesia at approximately 280 million, Brazil at approximately 210 million, and Japan at approximately 120 million, so that as many as four countries have populations exceeding 100 million. South Africa's population is approximately 60 million. As a result, the G5 accounts for 26% of the world's population (see Figure 1). Japan is the only one of these countries whose population has been declining recently; the populations of the other four countries continue to grow. The annual growth rates were India (1.3%), South Africa (1.3%), Indonesia (1.1%), and Brazil (0.8%).

Figure 1. Population of the G5 (million people)



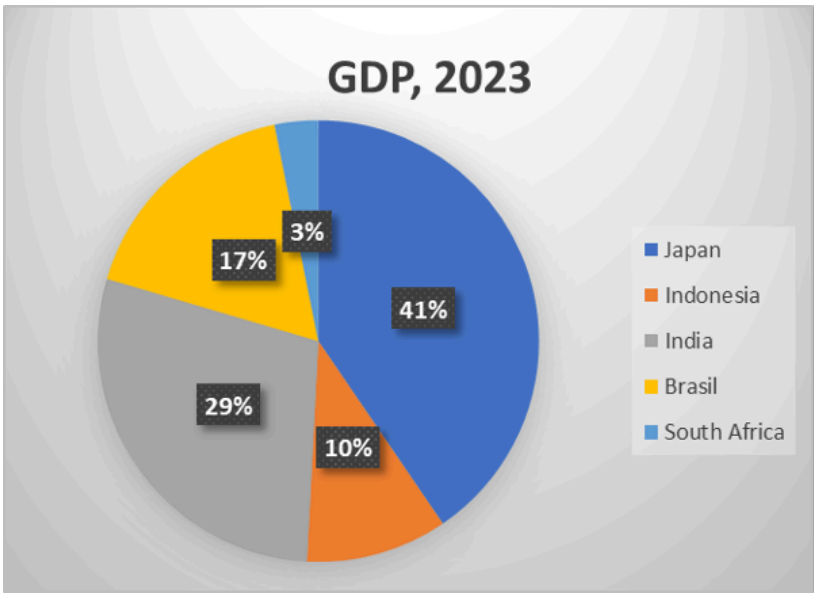
Source: World Development Indicators, World Bank

(2) Gross Domestic Product (GDP)

In 2023, the total GDP of the G5 was US$11.37 trillion (in constant 2015 US dollars). By country share, Japan was the largest at 41%, followed by India at 29%, Brazil at 17%, Indonesia at 10%, and South Africa at 3%. The G5 accounted for 12% of total world GDP (see Figure 2). In terms of GDP per capita, Japan was the highest at 36,952 USD/person, followed by Brazil at 9,288 USD/person, South Africa at 5,756 USD/person, Indonesia at 4,192 USD/person, and India at 2,270 USD/person. Looking at GDP growth rates over 2000–2024, India had the highest at 6.3% per year, followed by Indonesia at 4.8%, Brazil at

2.2%, and South Africa at 2.1%. Japan's economic growth remained low at 0.6%. The average GDP per capita of the G5 was 5,368 USD/person.

Figure 2. Composition of the Economic Size of the G5



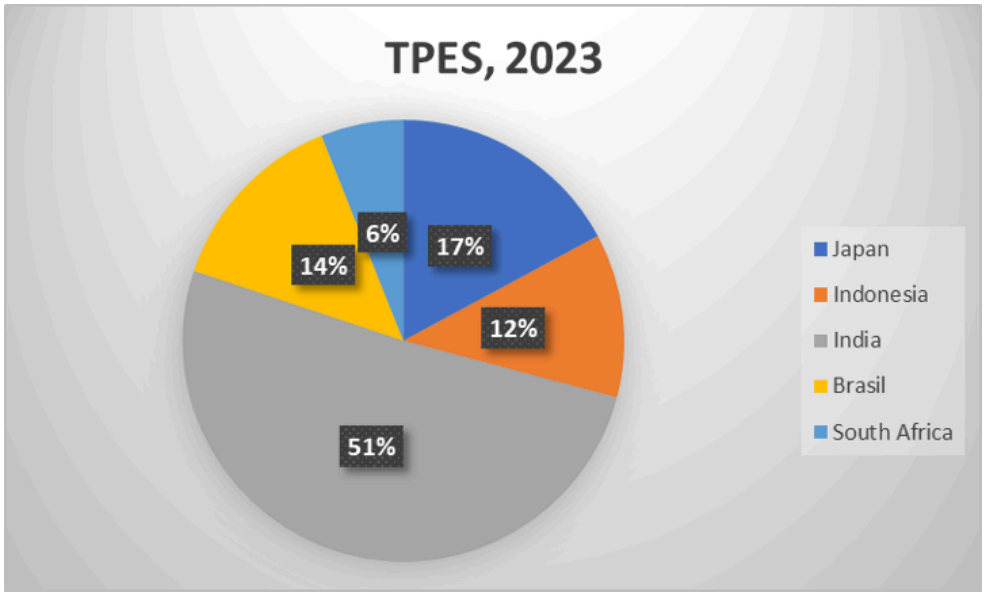
Source: World Development Indicators, World Bank

2.2. Energy Supply and Demand Structure

(1) Total Primary Energy Supply (TPES)

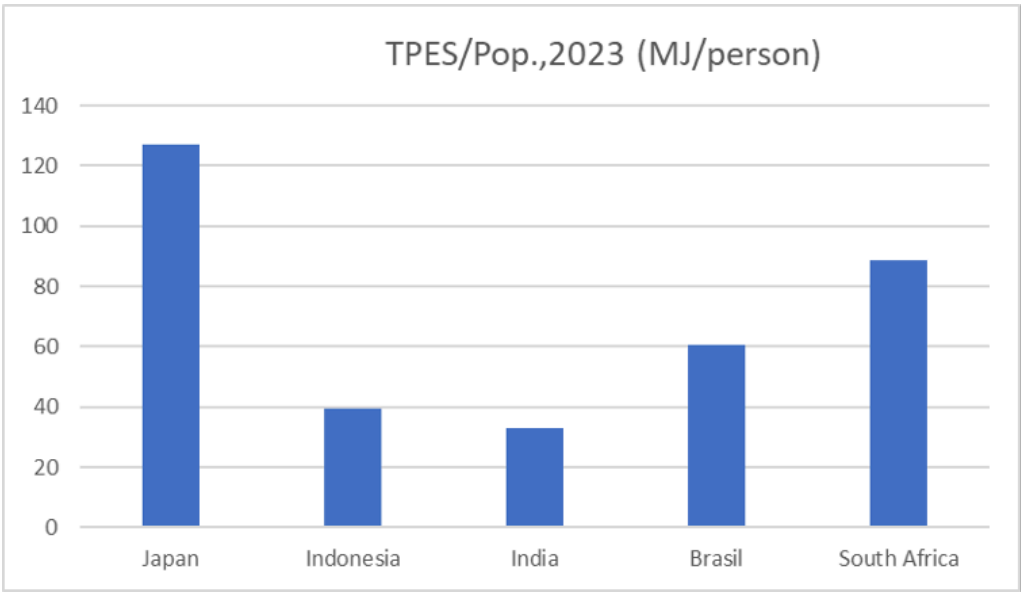
In 2023, the total primary energy supply of the G5 (in other words, inland deliveries) was 92,463 petajoules (PJ). By country share, India was the largest at 51%, followed by Japan at 17%, Brazil at 14%, Indonesia at 12%, and South Africa at 6% (see Figure 3). However, in terms of consumption per capita, Japan was the highest at 127 GJ/person, followed by South Africa at 88 GJ/person, Brazil at 60 GJ/person, Indonesia at 39 GJ/person, and India at 33 GJ/person (see Figure 4). The amount of energy required to increase GDP by one unit is obtained by dividing primary energy supply by GDP and is also called energy intensity. The country with the highest energy efficiency was Japan (3.44 MJ per 2015 US$), followed by Brazil at 6.51 MJ/US$, Indonesia at 9.41 MJ/US$, India at 14.43 MJ/US$, and South Africa at 15.36 MJ/US$ (see Figure 5). Energy intensity depends heavily on each country's industrial structure and socioeconomic conditions, but given the increase in energy consumption expected to accompany the high economic growth of the four countries other than Japan, improving energy efficiency in these countries will become an important policy objective.

Figure 3. Composition of Primary Energy Supply of the G5



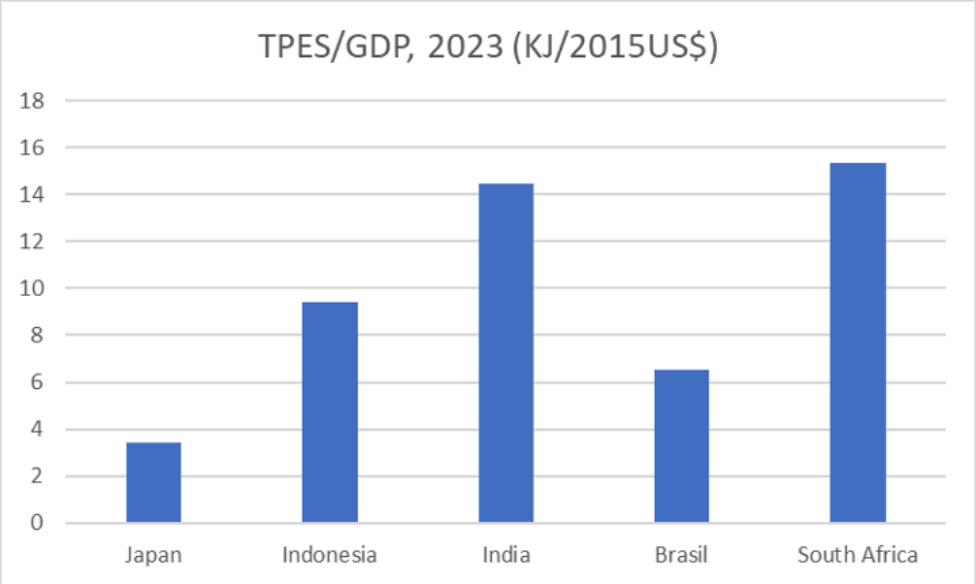
Source: APEC Energy Database (https://www.egeda.ewg.apec.org); UN Energy Statistics 2023, UNSD

Figure 4. Per Capita Energy Consumption of the G5



Source: World Development Indicators, World Bank; APEC Energy Database (https://www.egeda.ewg.apec.org); UN Energy Statistics 2023, UNSD

Figure 5. Energy Intensity of the G5



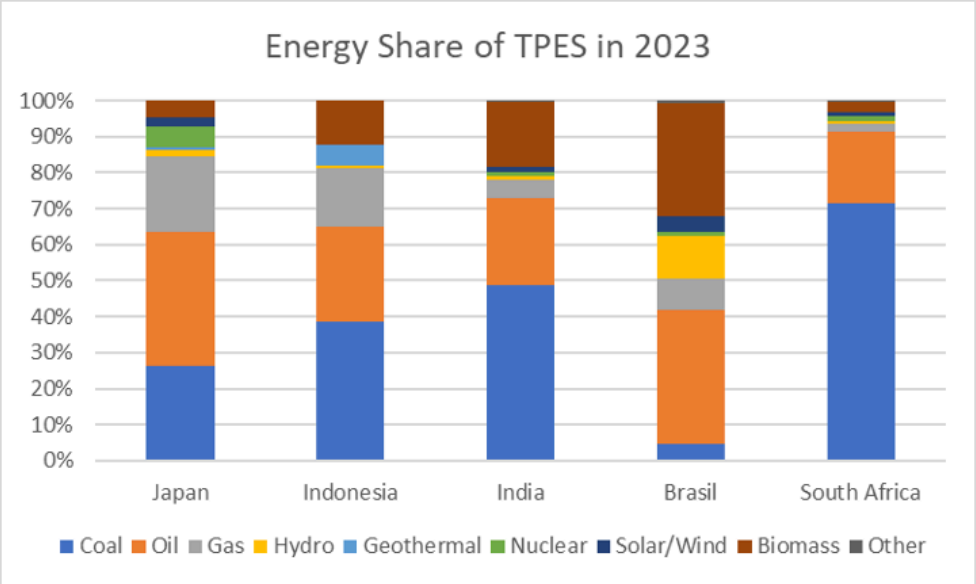
Source: World Development Indicators, World Bank; APEC Energy Database (https://www.egeda.ewg.apec.org); UN Energy Statistics 2023, UNSD

(2) Energy Mix of Primary Energy Supply

Next, we look at the energy mix of primary energy supply for each country (see Figure 6).

1. **Japan**: The share of fossil fuels was 84%, the second highest after South Africa. The remaining 16% consists of, in descending order, nuclear power, solar and wind, hydropower, and geothermal. Among fossil fuels, oil had the highest share, followed by coal and gas.
2. **Indonesia**: The share of fossil fuels was 81%, the next highest after Japan. Among fossil fuels, coal had the highest share, followed by oil and gas. Among non-fossil fuels, biomass had the highest share, followed by geothermal, hydropower, and solar and wind.
3. **India**: The share of fossil fuels was 77%, the fourth highest among the five countries, with coal accounting for more than half, reflecting a high dependence on coal. Among non-fossil fuels, biomass was overwhelmingly dominant, followed by solar and wind, hydropower, and nuclear power, but their shares were only about 20% of that of biomass.
4. **Brazil**: The share of fossil fuels was 50%, the lowest among the five countries. Oil had the highest share, followed by gas and coal, and the share of coal is the lowest among the five countries. Among non-fossil fuels, biomass was the highest (mainly biofuels for transport rather than for cooking), followed by hydropower, solar and wind, and nuclear power.
5. **South Africa**: The share of fossil fuels exceeded 90%, the highest among the five countries. Coal accounted for more than 70%, followed by oil and gas, while the share of gas consumption was the lowest among the five countries. Among non-fossil fuels, the order was biomass, nuclear power, solar and wind, and hydropower.

Figure 6. Composition of Primary Energy Supply by Energy Source



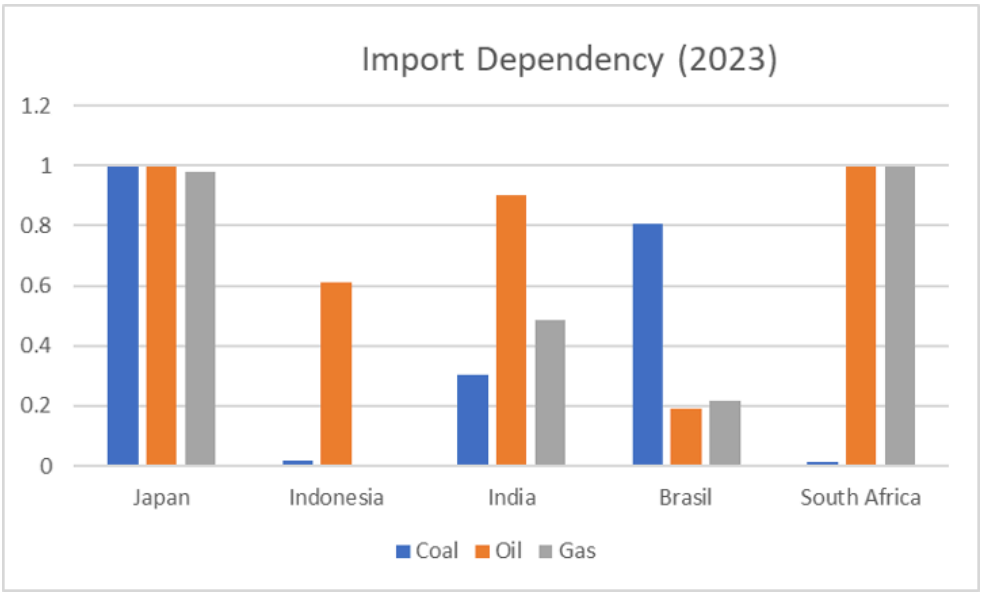
Source: APEC Energy Database (https://www.egeda.ewg.apec.org); UN Energy Statistics 2023, UNSD

(3) Import Dependence of Fossil Fuels

Non-fossil fuels are classified as domestic energy, whereas fossil fuels consist of domestic production and imports. We therefore look at the import dependence of fossil fuels in the five countries (see Figure 7).

1. **Japan**: Coal, oil, and gas all depend almost 100% on imports.
2. **Indonesia**: Import dependence for oil is 60%, but coal and gas are covered by domestic energy.
3. **India**: Import dependence is 90% for oil, 48% for gas, and 30% for coal; India is thus characterised by high import dependence for fuels other than coal, particularly oil.
4. **Brazil**: Coal consumption is not large, but it is procured through imports. On the other hand, import dependence for oil and gas is around 20%; in other words, their domestic shares are high.
5. **South Africa**: Apart from coal, import dependence for oil and gas is almost 100%, as in Japan.

Figure 7. Import Dependence of Fossil Fuels by Country

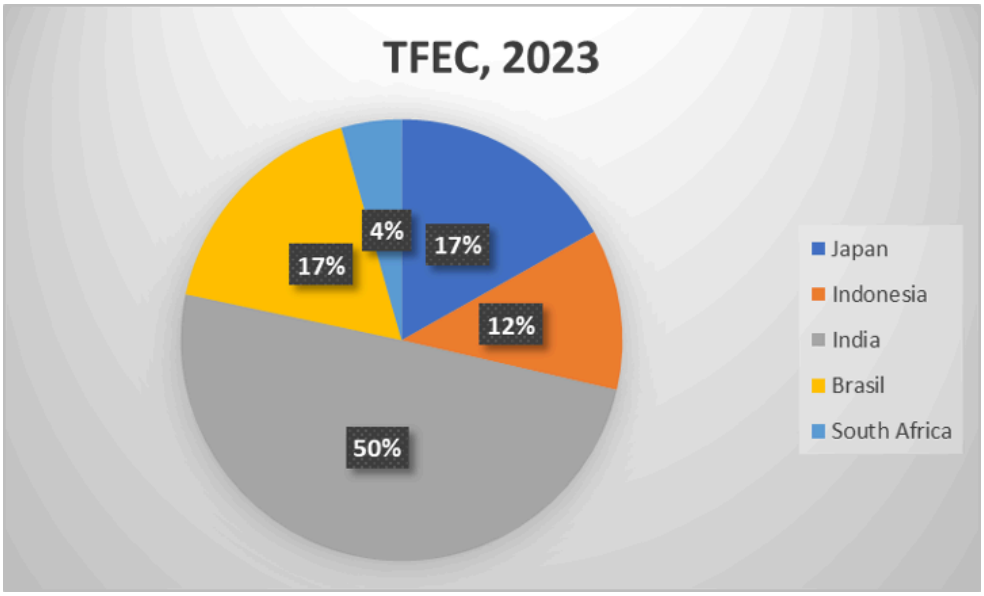


Source: APEC Energy Database (https://www.egeda.ewg.apec.org); UN Energy Statistics 2023, UNSD

(4) Total Final Energy Consumption (TFEC)

The final energy consumption of these five countries was 62,100 PJ (2023), of which India accounted for 50%. Japan and Brazil followed at 17% each, Indonesia at 12%, and South Africa at 4%, results almost identical to those for TPES.

Figure 8. Share of Final Energy Consumption by Country



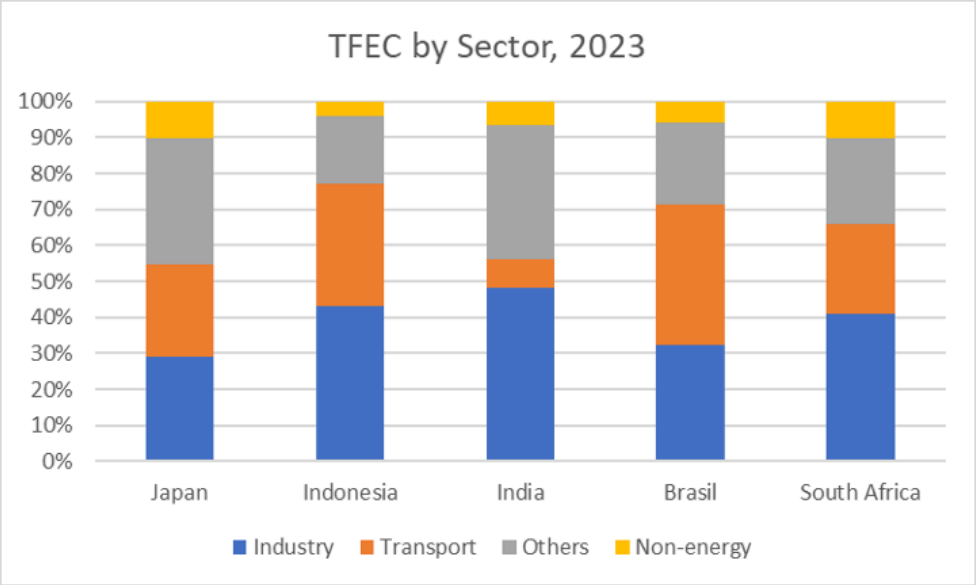
Source: APEC Energy Database (https://www.egeda.ewg.apec.org); UN Energy Statistics 2023, UNSD

(5) Final Energy Consumption by Sector

Final energy consumption is classified by end use into three sectors: industry, transport, and others (buildings, i.e. the residential and commercial sectors, plus agriculture, forestry, fisheries, etc.). We look at their shares for each country (see Figure 9).

1. **Japan**: The others (mainly residential and commercial) were the largest, followed by the industry and transport sectors, but there is no great difference in the consumption shares of the three sectors.
2. **Indonesia**: The industry sector was the largest, accounting for more than 40%, followed by transport and others.
3. **India**: As in Indonesia, the industry sector was the largest, accounting for nearly 50%. It was followed by others, and the share of the transport sector was below 10%.
4. **Brazil**: The transport sector was the largest, accounting for nearly 40%. It was followed by industry and others. A closer look at the transport sector shows that road transport accounts for 90%, indicating a heavy dependence on automobiles.
5. **South Africa**: The industry sector was the largest, followed by transport and others. However, as in Japan, there was no great difference in the shares of the three sectors.

Figure 9. Final Energy Consumption by Sector

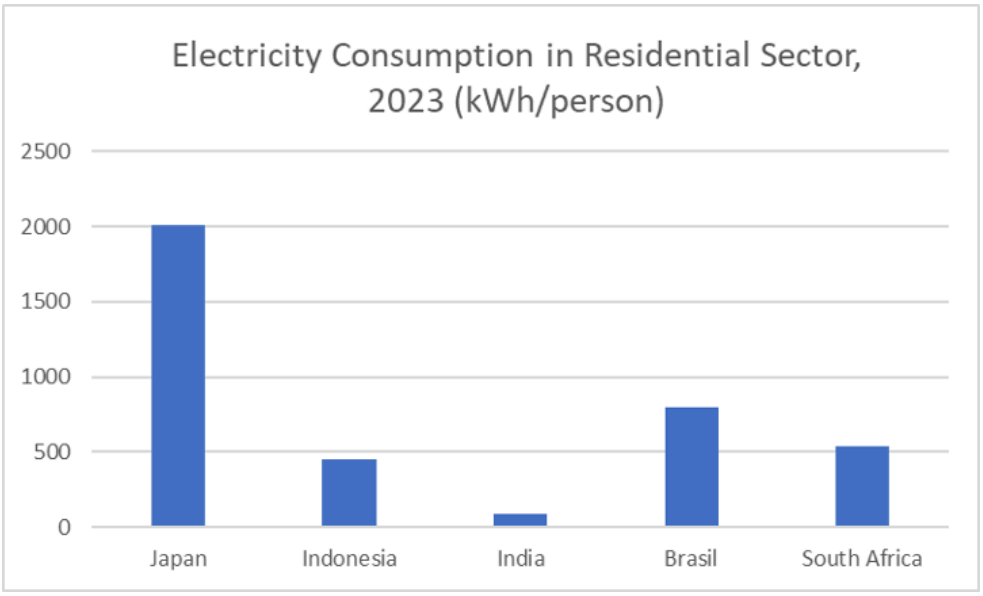


Source: APEC Energy Database (https://www.egeda.ewg.apec.org); UN Energy Statistics 2023, UNSD

(6) Electricity Consumption in the Residential Sector

In recent years, electricity demand has increased significantly, particularly in emerging economies. We therefore look at per capita electricity consumption in the residential sector (2023) in these five countries (see Figure 10). Japan was the highest at approximately 2,000 kWh/person, followed by Brazil (approximately 800 kWh/person), South Africa (540 kWh/person), Indonesia (approximately 450 kWh/person), and India (approximately 90 kWh/person).

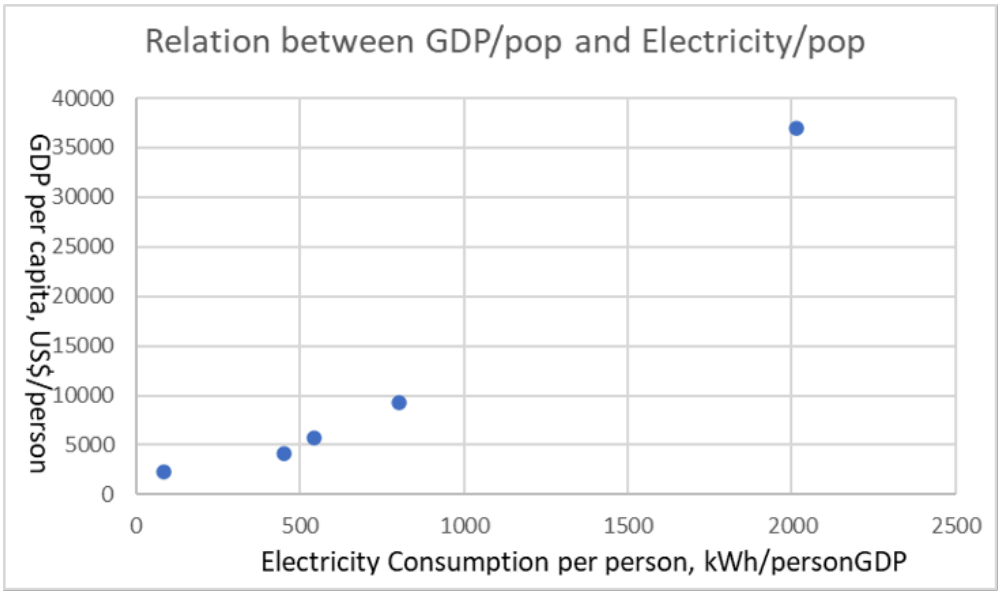
Figure 10. Comparison of Per Capita Electricity Consumption by Country



Source: APEC Energy Database (https://www.egeda.ewg.apec.org); UN Energy Statistics 2023, UNSD

Next, looking at the correlation between per capita electricity consumption and per capita GDP, we find that it is very high at 0.98 (see Figure 11). Since the four countries other than Japan (Indonesia, India, Brazil, and South Africa, referred to as the G4) are expected to continue achieving high economic growth, electricity demand is projected to expand steadily as per capita electricity consumption in these four countries increases.

Figure 11. Correlation between Income and Electricity Consumption

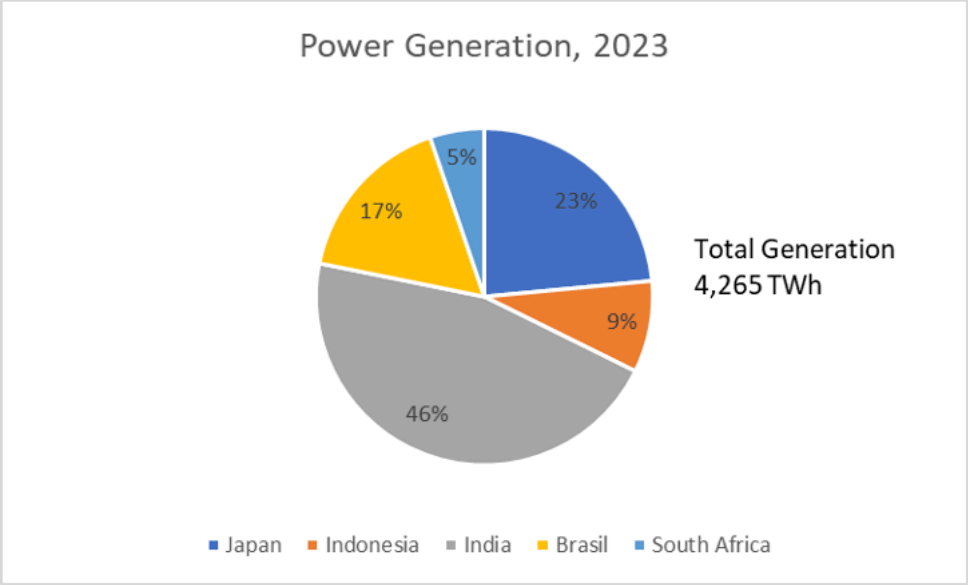


Source: World Development Indicators, World Bank; APEC Energy Database (https://www.egeda.ewg.apec.org); UN Energy Statistics 2023, UNSD

(7) Electricity Generation

In 2023, the total electricity generation of the five countries was 4,265 TWh, accounting for 14% of world electricity generation. India was the largest at 46%, followed by Japan at 23%, Brazil at 17%, Indonesia at 9%, and South Africa at 5%.

Figure 12. Electricity Generation of the Five Countries (2023)



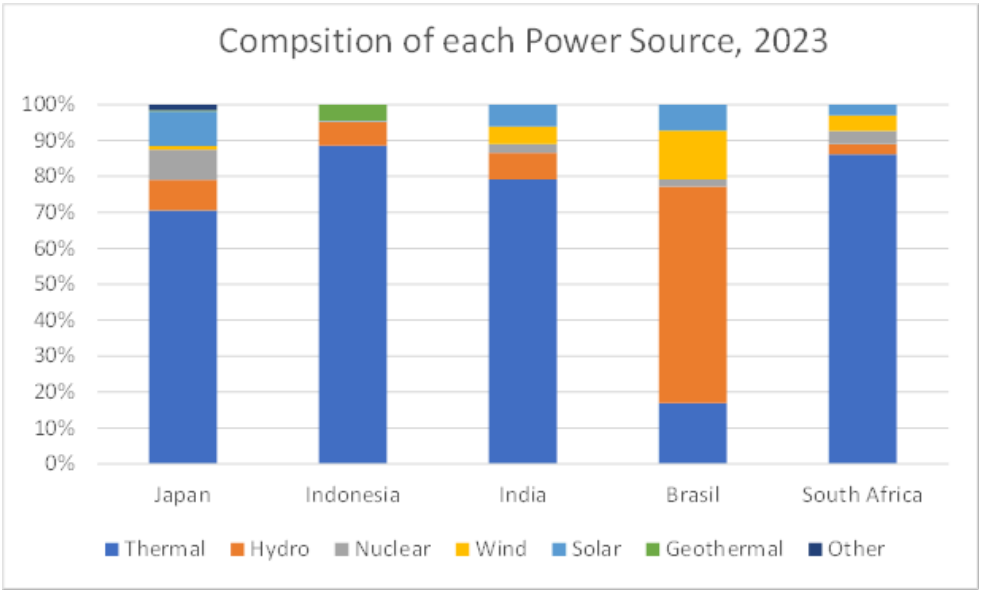
Source: UN Energy Statistics 2023, UNSD

(8) Power Generation Mix of the Five Countries

Next, we look at the 2023 power generation mix by country (see Figure 13).

1. **Japan**: Thermal power accounted for about 70%, followed by solar, hydropower, and nuclear power. Solar is the second largest after thermal power owing to renewable energy deployment policies, including the feed-in tariff (FIT) scheme.
2. **Indonesia**: Thermal power accounted for just under 90%, followed by hydropower and geothermal power. Other renewable power generation such as solar and wind is expected to increase in the future.
3. **India**: Thermal power accounted for about 80%, with the remainder made up of hydropower, solar, wind, and nuclear power. The combined generation from solar and wind was the largest among the five countries.
4. **Brazil**: Hydropower was the largest at 60%, followed by gas-fired, wind, and solar power. There is also nuclear power, but it accounted for only 2%. The share of renewables (hydropower, wind, and solar) has reached 80%.
5. **South Africa**: Thermal power accounted for 86%, with the remainder consisting of wind, nuclear, solar, and hydropower, each with a share of only a few per cent.

Figure 13. Power Generation Mix of the Five Countries (2023)



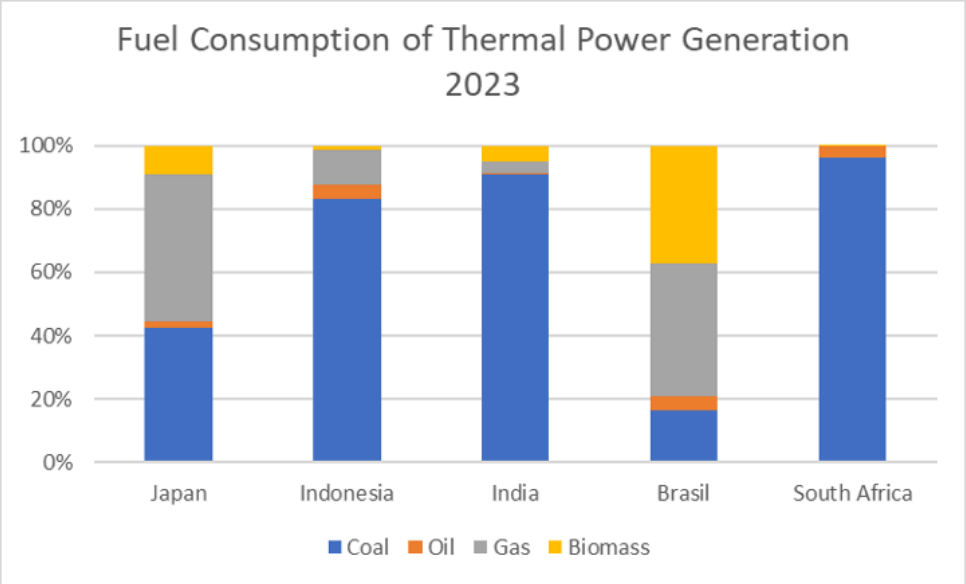
Source: UN Energy Statistics 2023, UNSD

(9) Fuel Consumption Mix for Thermal Power Generation

Since the four countries other than Brazil depend heavily on thermal power, we next look at the fuel consumption mix for thermal power generation in each country (see Figure 14).

1. **Japan**: Gas consumption was the largest at 46%, followed by coal at 42%. Gas-fired and coal-fired power are positioned as important power sources, but fuel procurement depends on overseas sources.
2. **Indonesia**: Coal accounted for more than 80% of consumption, while gas accounted for only 10%. Oil also accounted for 4% of consumption, which is thought to be for diesel power generation on remote islands.
3. **India**: Coal accounted for more than 90% of consumption, followed by biomass and gas. As in Indonesia, coal is procured mainly from domestic sources.
4. **Brazil**: Gas and biomass together accounted for just under 80% of consumption, while the share of coal was only 16%.
5. **South Africa**: Coal accounts for 96% of consumption and is supplied almost 100% by domestic coal. The remainder consisted of oil and biomass.

Figure 14. Fuel Consumption Shares for Thermal Power Generation

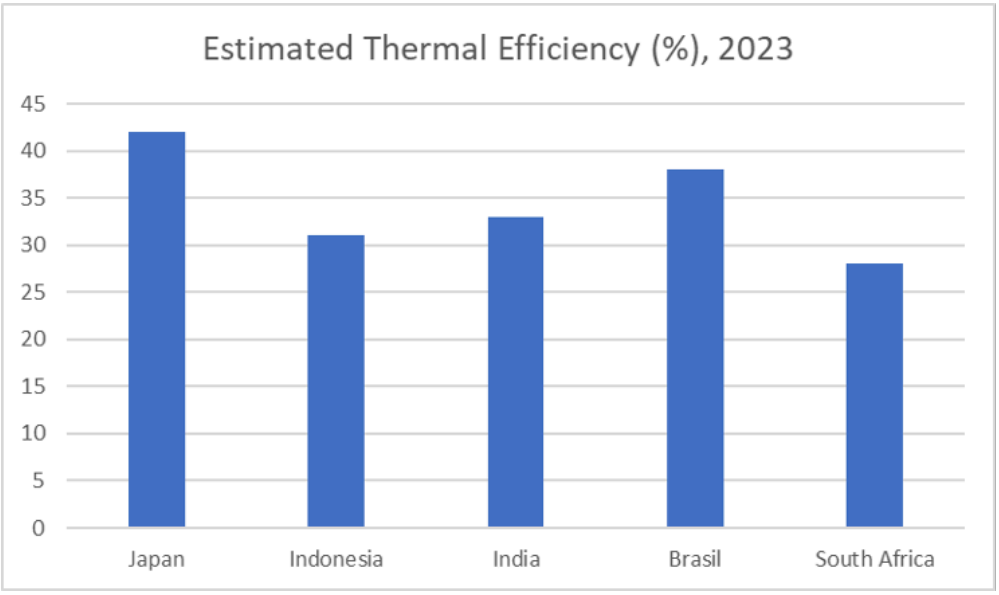


Source: UN Energy Statistics 2023, UNSD

(10) Generation Efficiency of Thermal Power

In 2023, the generation efficiency of thermal power was highest in Japan at 42%, followed by Brazil (38%), India (33%), Indonesia (31%), and South Africa (28%). In Japan's case, a generation efficiency of 42% means that 42 units of electricity are produced from 100 units of fuel input. In general, gas-fired power has high generation efficiency (particularly combined cycle gas turbines, CCGT), and newer power plants have higher generation efficiency owing to improvements in boiler combustion efficiency and other factors (see Figure 15).

Figure 15. Generation Efficiency of Thermal Power

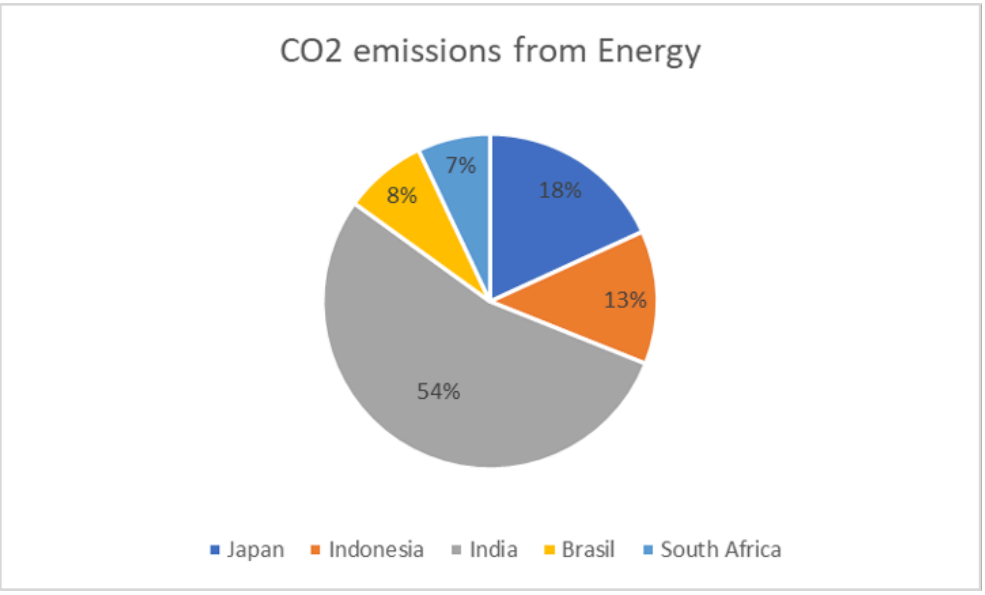


Source: UN Energy Statistics 2023, UNSD

(11) CO2 Emissions

In 2023, the total CO2 emissions of the five countries were 5.12 billion t-CO2, accounting for 14% of world emissions. By country, India had the most at 2.76 billion t-CO2, followed by Japan at 0.93 billion t-CO2, Indonesia at 0.66 billion t-CO2, Brazil at 0.41 billion t-CO2, and South Africa at 0.36 billion t-CO2. CO2 emissions are determined by the amount of fossil fuels consumed and the level of their CO2 emission factors (coal is the highest, followed by oil and gas) (see Figure 16).

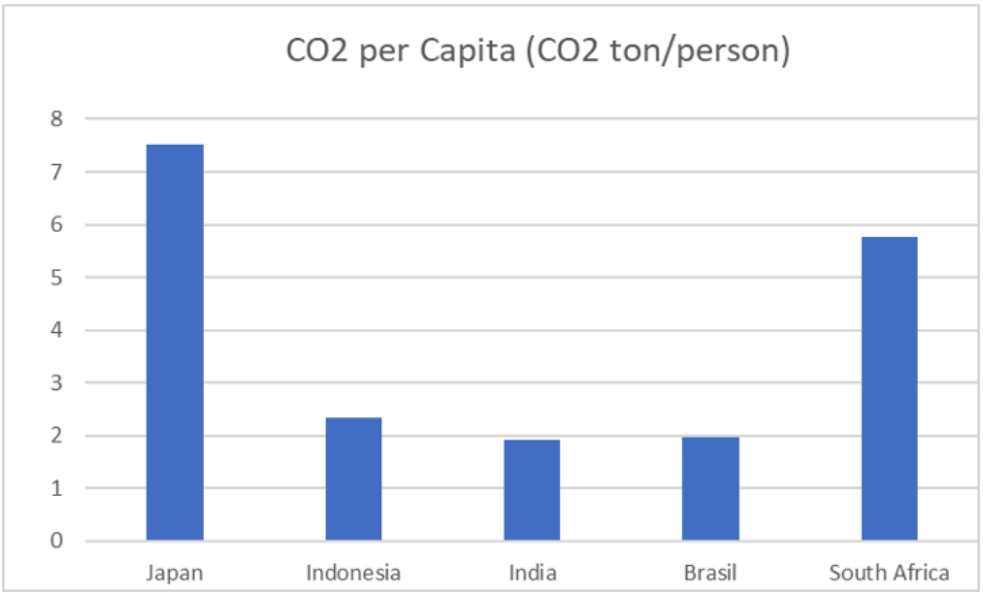
Figure 16. CO2 Emissions by Country



Source: Greenhouse Gas Emissions from Energy 2023, International Energy Agency

However, in terms of per capita CO2 emissions, Japan was the highest at 7.52 t-CO2/person, followed by South Africa at 5.77, Indonesia at 2.34, Brazil at 1.97, and India at 1.92. The world average was 4.30 t-CO2/person (see Figure 17).

Figure 17. Comparison of Per Capita CO2 Emissions by Country



Source: Greenhouse Gas Emissions from Energy 2023, International Energy Agency

2.3. Summary

The findings on the energy supply and demand structure of the G5 are summarised below from three perspectives: energy consumption, energy supply, and country-by-country assessment.

(1) Energy consumption

1. **Energy intensity**: Japan's energy intensity was the lowest among the five countries (i.e., its energy efficiency was the highest), followed by Brazil. In 2023, Japan's GDP per capita was approximately US$40,000 and Brazil's approximately US$10,000, suggesting that energy conservation has taken hold as economic development has progressed. South Africa's GDP per capita, at approximately US$6,000, was next after Brazil's, but its energy intensity was worse than those of Indonesia and India. One possible factor is its high dependence on coal. In South Africa, coal is consumed for industrial heat demand, as fuel for power generation, and for coal liquefaction, and the low efficiency of these uses is thought to be the cause. Because coal has a lower calorific value than oil or gas, large volumes of coal must be consumed to generate heat at a given temperature level. In any case, it is desirable for Indonesia, India, and South Africa to improve their energy efficiency by making use of Japan's Act on the Rational Use of Energy and its energy conservation technologies.

2. **Electricity consumption**: In 2023, per capita electricity consumption was highest in Japan, followed by Brazil and South Africa. Indonesia's was less than one-quarter of Japan's, and India's less than one-twentieth. Per capita electricity consumption is highly correlated with per capita GDP, so electricity consumption is projected to rise substantially as these economies grow. Indonesia and India are expected to continue achieving high economic growth, so electricity consumption in these two countries is expected to increase dramatically.

(2) Energy supply

1. **Coal**: Indonesia, India, and South Africa depend heavily on coal, but because domestically produced coal is mainly used in these countries, they will likely continue to consume coal for reasons of energy security. However, because coal emits more CO2 than oil or gas, it will be necessary to introduce technologies that reduce CO2 emissions. Examples include the introduction of high-efficiency coal-fired power plants (not included in Japan's infrastructure export policy), ammonia co-firing at coal-fired power plants, and the use of CCS (Carbon Capture and Storage) in hard-to-abate sectors (for example, the steel sector and coal-fired power generation). In addition, since about 60% of coal is used for power generation, a shift to renewable energy, nuclear power, and other sources is also an important option.
2. **Oil**: Except for Brazil, import dependence for oil is high. Holding oil stockpiles as Japan does is therefore important for the security of oil supply. In addition, since oil consumption in the G5 is heavily concentrated in the transport sector, measures to reduce dependence on oil are also needed. Examples include the introduction of EVs (Electric Vehicles), the promotion of biofuels, and the use of hydrogen and synthetic fuels.
3. **Gas**: Gas has the lowest CO2 emission factor among fossil fuels, but except for Indonesia and Brazil, import dependence is high. In addition, since the shift from coal to gas as a fuel for power generation is expected to continue, demand for gas, whether domestic or imported, is likely to increase. Joint gas development by gas-producing and gas-consuming countries (increasing supply) will therefore also be an important initiative.
4. **Nuclear power**: Since the accident at the Fukushima Daiichi Nuclear Power Station caused by the Great East Japan Earthquake of March 11, 2011, the promotion of nuclear power has stalled in Europe and parts of Asia, but with the recent momentum towards decarbonisation, the use of nuclear power is being reconsidered. This is because nuclear power has a high capacity factor and does not emit CO2 (although there is the problem of the treatment and disposal of radioactive waste). Among the G5, Indonesia is the only country without nuclear power plants, but the Indonesian government has shown a positive stance towards nuclear power. For the G5 (excluding Brazil), which are highly dependent on coal, the use of nuclear power is one important option.
5. **Hydropower and geothermal**: Hydropower is a traditional renewable energy source available to the G5. However, consideration must be given to the climate of the tropical zone. The tropical zone has rainy and dry seasons, and hydropower faces the challenge that it delivers maximum output in the rainy season but its output declines in the dry season. Since solar power can maximise its output in the dry season, one option is to build hybrid hydro-solar systems. Geothermal energy, on the other hand, has potential only in Japan and Indonesia, but neither country has fully developed its geothermal potential. Policy support for geothermal development and the use of next-generation geothermal power technologies are therefore desirable.
6. **Solar and wind**: Because the output of solar and wind power fluctuates significantly depending on the weather, they are called variable renewable energy. These power sources require a mechanism to cover output that fluctuates greatly over time, for example, backup systems such as storage batteries

and gas-fired power (whose output is easy to adjust). The cost of solar power generation has fallen sharply as the market has expanded, but it is essential to assess its cost in terms of integration costs, including these backup systems. As for wind power, the climatic conditions of the G5 are not as favourable as those in Europe due to unstable wind speeds, so high capacity factors cannot be expected, and because there are few shallow waters, floating offshore wind power systems are required; costs are therefore high.

7. **Biomass**: The traditional use of biomass is for cooking, but in Indonesia, India, and Brazil its use as a transport fuel has become widespread: biodiesel in Indonesia, CNG produced from biogas (as a substitute for LPG) in India, and bioethanol in Brazil. These contribute to reducing oil consumption, but their high production costs are a challenge. If the G5 cooperate to expand the market for transport biofuels, these high costs could be eased somewhat. In addition, the production scale of SAF (Sustainable Aviation Fuel) is likely to expand in the future.

(3) Country-by-country assessment

1. **Japan**: While Japan is advanced in energy technologies (energy conservation, next-generation nuclear reactors, innovative solar panels, decarbonisation, etc.), it has weaknesses such as a scarcity of energy resources and critical minerals and low renewable energy potential, including biomass. It is essential to build co-creation relationships with the G4 countries (Indonesia, India, Brazil, and South Africa) in which Japan and these countries can mutually complement each other's strengths and weaknesses.
2. **Indonesia**: Indonesia is a producer of fossil fuels, but it relies on imports for about 60% of its oil. Oil is mainly used in the transport sector. It is therefore essential to reduce the transport sector's dependence on oil by adopting policies to promote biofuels, EVs, and the like. Indonesia is also an archipelagic country. The population is concentrated on the four main islands of Java, Sumatra, Kalimantan, and Sulawesi, but people also live on the other small and medium-sized islands. There, small and medium-scale diesel power generation is common, and oil is also used for the maritime transport of that diesel. It is therefore also essential to integrate existing diesel generation into hybrid systems based on solar and biomass, reducing oil dependence even if only modestly. In addition, since electricity demand is expected to increase significantly as Indonesia's GDP per capita rises, further energy conservation in the industry and buildings sectors will be necessary. Furthermore, a cleaner power generation mix (a transition from coal-fired power to gas-fired power, renewable energy, nuclear power, etc.) will be required. In addition, depleted oil and gas fields and deep saline aquifers have been identified in Indonesia, and the country is said to have a large capacity for storing CO2. It is also important to view CO2 storage as a business by accepting not only domestic CO2 emissions but also those of other countries. Becoming the hub of a regional CCS network would serve energy policy as well as economic and industrial policy.
3. **India**: India's recent economic growth has been remarkable, with momentum suggesting it may overtake Japan's GDP, but its energy supply depends heavily on domestic coal and biomass. Its import dependence for oil is also high (about 90%), and concerns have been raised about the security

of its supply. Compared with Japan and others, there is still room for improvement in energy efficiency. Promoting energy conservation and reducing oil dependence are therefore important policy priorities. Shifting from coal to renewables and nuclear power in the power sector is also an important policy, but since coal is also used in the industry sector, using domestic energy cleanly with CCS would achieve energy security and decarbonisation at the same time. CCS is one decarbonisation technology option for India.

4. **Brazil**: Brazil is a producer of oil and gas, and just under half of its oil production is exported. Gas is in short supply, and Brazil imports LNG. Brazil is also famous as a producer of biofuels, and flex-fuel vehicles are therefore widespread. It also has abundant hydropower resources, and hydropower accounted for more than 50% of total electricity generation in 2023. Its energy efficiency, reflecting its economic development, is also the second highest after Japan. Brazil can therefore be said to be an important partner for Japan in the procurement of biofuels, oil and gas, and green hydrogen, but since it is located very far from Japan, attention must be paid to transport costs.
5. **South Africa**: South Africa has abundant domestic coal, while its production of oil and gas is almost zero. Coal-to-liquids (CTL) production, which converts coal into liquid fuels, has therefore long been practised. Its energy efficiency also leaves room for improvement for a middle-income country. Promoting energy conservation and expanding renewables and nuclear power are therefore important, but there is also a pathway in which decarbonisation can be pursued while using domestic coal by utilising CCS. Another possible pathway is to produce synthetic fuels (e-fuels) by chemically reacting captured CO2 with green hydrogen rather than storing it underground.

3. Growth Strategy Fields of the Takaichi Administration

3.1. Resource and Energy Security

The growth strategy for the resources and energy field set out by the Takaichi administration is as follows.

- Ensuring a stable and affordable energy supply
- Use of energy conservation technologies (more efficient energy consumption)
- Securing domestic energy: maximum use of decarbonised power sources, while giving consideration to local understanding and the environment
  - Nuclear power: restart of nuclear reactors and development and installation of next-generation innovative reactors
  - Renewable energy: introduction of perovskite solar cells and next-generation geothermal power generation facilities
  - Early social implementation of fusion energy (covered in a separate paper)
- Realisation of a hydrogen society
- Resource development (rare earths at Minamitorishima Island) and resource circulation (storage batteries) (critical minerals are covered in a separate paper)

3.2. Decarbonisation and GX

The growth strategy for the decarbonisation and GX field is as follows.

- GX-oriented industrial clusters
- Carbon pricing, including an emissions trading system (ETS)
- CCS
- Biofuels and synthetic fuels
- Heat pumps
- Promotion of watt–bit collaboration (linking power and communications infrastructure) to form new industrial clusters, including the regional dispersal of data centres
- Contribution to decarbonisation in Asia through the Asia Zero Emission Community (AZEC)

4. Basic Energy Policies of the G4 Countries

Next, we provide an overview of the most recent basic energy policies of the G4 countries.

4.1. Indonesia

Indonesia is currently formulating its National Energy Plan (2026–2035), whose pillars are "strengthening energy security," "moving away from fossil fuels," "expanding renewable energy," "regional optimisation," and a "long-term decarbonisation roadmap." Measures for moving away from fossil fuels include expanding alternatives to oil, such as increasing biofuel consumption, shifting to EVs, and increasing the use of renewable energy (replacing diesel power generation). Regional optimisation means dividing Indonesia into seven regions and preparing energy supply and demand projections for each region. As means of decarbonisation, the plan cites CCUS (Carbon Capture, Utilisation and Storage), nuclear power, EVs, and BESS (Battery Energy Storage Systems). Since Indonesia is highly dependent on oil imports, it is also considering processing more of its domestically produced crude oil, much of which is currently exported, by expanding refinery capacity.

4.2. India

India has adopted a "multilayered energy policy" that simultaneously advances an expansion of the share of renewables, electricity market reform, efficient use of fossil fuels, and decarbonisation while supporting rapidly increasing electricity demand. The renewables strategy centres on solar, together with wind, and on green hydrogen for use in hard-to-abate sectors. Electricity market reform aims to strengthen transmission and distribution infrastructure, make the electricity market more flexible, and expand electricity supply. Under the efficient use of fossil fuels, India seeks to reduce coal consumption by installing more efficient coal-fired power (high-efficiency coal-fired power plants and coal gasification), and to reduce import dependence by substituting biofuels and other alternatives for oil and gas. As a means of decarbonisation, it is considering the expansion of nuclear power, green hydrogen, the diffusion of EVs, and CCUS.

4.3. Brazil

Brazil's pillars are "a power structure centred on renewable energy (hydropower, wind, and solar)," "promoting competition through liberalisation," "institutionalising low-carbon fuels (SAF and hydrogen) and CCUS," and "long-term energy security." Promoting competition through liberalisation refers to the electricity market: Brazil is moving to full liberalisation of electricity retail (to all consumers by 2028), aiming to lower electricity prices through competition. In addition, although not described in its energy policy, the stable supply of oil and gas (centred on domestic production) and the expansion of biofuel production are also important policies. Brazil has also announced decarbonisation efforts through regulations for SAF and hydrogen and the institutionalisation of CCUS. Through the expansion of renewable electricity, the wider use of biofuels, efforts on SAF, hydrogen, and CCUS, and the liberalisation of the electricity market, Brazil aims to achieve long-term energy security.

4.4. South Africa

Against the backdrop of chronic power shortages and an ageing transmission grid, South Africa's basic policies for the power sector are electricity market liberalisation, the unbundling of the transmission grid, and large-scale investment in renewable energy. South Africa has a state-owned power utility, Eskom, and the policy is to separate its transmission division as an independent entity and create a competitive retail electricity market. South Africa also intends to expand the transmission grid on a large scale to resolve the insufficient grid capacity that has been an obstacle to the introduction of renewable energy. As a result, 23,900 MW of solar and wind power capacity is expected to be added by IPPs (Independent Power Producers). The basic policies for oil and gas consist of legislating national strategic stockpiles, diversifying import sources, reassessing domestic refining capacity, and establishing a mechanism for releasing stockpiles in emergencies.

Table 1. Basic Energy Policies of the G4 Countries

Energy technology	Indonesia	India	Brazil	South Africa
Renewables (solar and wind)	✓	✓	✓	✓
Renewables (hydropower)			✓	
Renewables (geothermal)	✓			
Nuclear power	✓	✓		✓
High-efficiency coal-fired power (HELE)		✓		
Strategic petroleum reserves				✓
Strengthening of refineries	✓			✓
Electricity market reform		✓	✓	✓
Biofuels	✓	✓	✓	
SAF			✓	
EV & BESS	✓	✓		✓
CCUS	✓	✓	✓	
Hydrogen		✓	✓	✓

Source: Prepared by the authors based on the current energy policies of the G4 countries

5. Potential for Co-creation with the G4 Countries in Advanced Energy Technologies Supporting Japan's Growth Strategy

For each of the energy-field growth strategies listed in Section 3, we examine, country by country, the potential for co-creation relationships with Japan.

5.1. Stable Energy Supply

To ensure a stable energy supply for Japan, it will be essential to examine the potential for supplying oil, gas, biofuels, hydrogen, ammonia, and other fuels from the G4 countries. For example:

1. Oil: procurement from Brazil (subject, however, to high transport costs)
2. Gas: procurement from Indonesia and Brazil (subject, however, to high transport costs)
3. Biofuels: procurement from Indonesia and Brazil (subject, however, to high transport costs)
4. Synthetic fuels: Japan could develop the production technology, and Japanese companies could produce the fuels jointly with local companies, procuring CO2 and hydrogen locally.
5. Hydrogen and ammonia: If Japanese and local companies produce hydrogen and ammonia in Indonesia, Brazil, and India using inexpensive renewable electricity and export them to Japan and third countries, the market for hydrogen and ammonia is expected to expand and production costs to fall.

5.2. Energy Efficiency and Conservation

Japan could contribute to energy efficiency and conservation in the G4 countries in the following ways.

1. Sharing the energy conservation law and energy conservation systems: Promote the enactment of an energy conservation law such as the Act on the Rational Use of Energy and the effective use of energy conservation systems (Standard & Labeling and the Top Runner Program).
2. Training energy managers: Support the training of licensed energy managers well versed in energy saving for electricity and heat.
3. Establishing ESCOs (Energy Service Companies): If energy prices are market-linked (i.e., if there are no energy subsidies), energy conservation reduces energy costs, so establishing ESCOs will allow energy conservation to be promoted on a business basis in the industrial and commercial sectors.
4. Deploying energy-efficient Japanese products in the G4 countries: High-efficiency, low-emissions (HELE) products have higher initial costs but reduce energy costs; by visualising indicators such as the investment payback period and the internal rate of return (IRR), and by publicising through campaigns and other means that HELE products in fact make economic sense, promote exports of HELE products to the G4 countries.

5.3. Securing Domestic Energy

Possible areas of technology co-creation with the G4 countries in decarbonised power sources are as follows.

1. **Nuclear power**: Since nuclear fuel can be used for several years, nuclear power can be positioned as a quasi-domestic energy source even if the raw materials for nuclear fuel depend on overseas sources. Nuclear power is currently in operation in the G4 countries other than Indonesia, and Indonesia is also looking ahead to the future use of nuclear power. Future nuclear power is expected to centre on next-generation innovative reactors (advanced light water reactors, small light water reactors, fast reactors, high-temperature gas-cooled reactors, and fusion reactors) and SMRs (small modular reactors), and Japan's technical cooperation could play an effective role. In particular, if the G5 is treated as a single market for nuclear power plants, economies of scale could lower construction costs and hence generation costs.
2. **Solar power**: A shift from silicon-based to perovskite-based cells is expected. Perovskite sheets are expected to spread because they are thin and flexible, but the issues are their cost and the improvement of generation efficiency. If Japan's industry, government, and academia take charge of perovskite technology development (improving generation efficiency), and Japanese companies produce them in each of the G4 countries and work to spread perovskite solar power systems, the market could expand substantially.
3. **Geothermal power**: Japan is focusing on developing next-generation geothermal power systems, but unfortunately the application of this technology is limited to Indonesia.
4. **Wind power**: Wind power is actively used in Brazil, India, and South Africa, but onshore wind power systems are mainstream in these countries. Japan, by contrast, is advancing the development

and commercialisation of floating offshore wind systems, which could be applied in Indonesia, whose geography is similar, although cost remains a problem. Commercialisation of offshore wind power systems in Japan will be key.

5.4. Realising a Hydrogen Society

Hydrogen burns without emitting CO2 and can therefore be used as a clean fuel. Since fossil fuels are widely used as fuel for power generation, transport, industry (boilers and furnaces), and hot water supply and cooking, the range of applications for hydrogen is broad. Clean hydrogen includes blue hydrogen (produced from fossil fuels, with the associated CO2 emissions captured and stored through CCS) and green hydrogen (hydrogen produced by electrolysis of water using renewable electricity), but high production costs are a bottleneck. Japan is therefore considering producing green hydrogen overseas, where renewable energy costs are low, transporting it to Japan, and using it for various purposes in Japan—that is, building a hydrogen supply chain. Moreover, since the G4 countries also depend heavily on fossil fuels, the hydrogen market including the G4 countries is expected to be large. Sharing hydrogen utilisation technologies with the G4 countries would create a large hydrogen market within the G5 region.

5.5. Resource Development and Resource Circulation (Storage Batteries)

Japan has few energy resources, but some of the G4 countries are well endowed with them: Indonesia with coal, oil, and gas; India with coal; Brazil with oil and gas; and South Africa with coal. Sharing energy resources through development support for these countries is meaningful for Japan. Other mineral resources (copper, cobalt, rare earths, etc.) are also abundant in the G4 countries, and building critical mineral supply chains with these countries is an urgent task (critical minerals are covered in a separate paper). In addition, attention must also be paid to promoting co-creation with the G4 countries in the development of seabed resources, typified by rare earth mining off Minamitorishima Island, and in resource circulation (storage batteries, plastics, CO2, etc.) based on circular-economy principles, including the 3Rs (reduce, reuse, recycle). Seabed rare earth mining at Minamitorishima Island not only contributes to the supply of domestic rare earths, but also makes possible co-creation with each of the G4 countries using this seabed rare earth mining technology, although prior seabed exploration is of course necessary. Furthermore, battery recycling contributes to increasing the supply of critical minerals within the G5 region, plastic recycling to reduce oil consumption within the G5 region, and CO2 capture and utilisation (carbon recycling) to curbing CO2 emissions within the G5 region.

5.6. GX-Oriented Industrial Clusters

It is important to expand industrial clusters that contribute to decarbonisation not only in Japan but also in the G4 countries. Examples include industrial clusters in technology fields where Japanese companies have an advantage, such as next-generation solar and geothermal power, next-generation nuclear power, biofuels and synthetic fuels, hydrogen and ammonia, HELE equipment manufacturing

(excluding coal-fired power), and CCS. Building supply chains linking the G4 countries and Japan will also contribute to market expansion in each technology field. Circular industrial clusters (circular economy) aimed at reusing energy and mineral resources are also an important consideration.

5.7. Carbon Pricing

Because decarbonisation technologies are relatively new, their markets are small and their costs high, so their diffusion is slow. If a price is put on carbon, the price of fossil fuels that emit large amounts of CO2 will also rise, making these technologies more cost-competitive. Instruments include an ETS, under which emitted carbon is bought and sold, and carbon taxes levied on fossil fuels. There is also the JCM (Joint Crediting Mechanism) promoted by Japan. Since carbon pricing raises energy prices, institutional design matched to the level of economic growth of each G4 country is required.

5.8. CCS

CCS stands for Carbon Capture and Storage, a technology that captures emitted CO2, transports it, and stores it in aquifers deep underground. It is envisaged for application in hard-to-abate sectors such as thermal power plants, steelworks, and chemical plants. Applying it in countries that use domestic coal and gas for power generation and other purposes is expected to achieve energy security and decarbonisation together. For capturing CO2 emitted from means of transport (automobiles, etc.), households, commercial buildings, and so on, there is a technology called DACCS. It stands for Direct Air Capture with Carbon Storage, a technology that captures CO2 directly from the atmosphere and stores it underground. Because it captures CO2 directly from the atmosphere, it is classed as a negative emissions technology (net reduction of CO2). Since neither CCS nor DACCS has yet been widely deployed, their costs are currently very high. Moreover, the place where CO2 is emitted and the place where it is stored are not necessarily the same; that is, captured CO2 must be transported to the storage site. However, if, for example, CO2 captured in Japan, India, and South Africa is transported to Indonesia and stored in Indonesian aquifers, economies of scale would come into play and costs could be expected to fall. In addition, since Brazil is an oil and gas producer with many depleted wells, Brazil is also thought to have capacity for CO2 storage. South Africa could therefore also transport CO2 to Brazil. Japanese companies have built up their respective technological capabilities in CO2 capture, transport, and storage with the support of the Japanese government, so win-win relationships with these four countries can be expected.

5.9. Biofuels and Synthetic Fuels

Biofuels are liquid fuels produced from biomass that substitute for petroleum products. Because they are derived from biomass, the CO2 emitted by burning biofuels is regarded as carbon neutral (CO2 does not accumulate). Brazil actively produces bioethanol (a gasoline substitute), and Indonesia biodiesel (a diesel substitute). Both countries produce biofuels for domestic demand, but Japan is considering importing these biofuels in the future. This is because, to achieve Japan's FY2030 greenhouse gas reduction target (a 46% reduction from FY2013), the use of biofuels in ICE (Internal Combustion

Engine) vehicles is indispensable in addition to the diffusion of EVs. India, with Japan's cooperation, is considering increasing biogas production and using it as CNG (Compressed Natural Gas) for transport. LPG vehicles are widespread in India, and India is exploring the use of biogas as a substitute for LPG. Since this LPG is imported from the Middle East (the Persian Gulf states), this would also contribute to India's energy security.

Synthetic fuels are produced by a technology that captures CO2 emitted in many sectors and uses chemical reactions to produce hydrocarbons or methane from the captured CO2 and clean hydrogen. Because it uses captured CO2 and clean hydrogen, it is an important technology from a long-term perspective, but the challenge is its high production cost. Further technological progress and market expansion will be key. As with biofuels, the CO2 emitted when synthetic fuels, including synthetic methane, are burned is regarded as carbon neutral; that is, it does not contribute to the accumulation of CO2 emissions.

5.10. Heat Pumps

A heat pump is a technology that produces heat using electricity. Examples include EcoCute heat-pump water heaters used in Japanese homes, washer-dryers, refrigerators, and air conditioners for both cooling and heating. Heat pumps can also be used in the commercial sector for temperatures of 100°C or below (for example, heat demand in hotels). Since industrial heat demand is at high temperatures, the use of heat pumps there is limited. Since generating and using heat with clean electricity substitutes for fossil fuels, technology transfer to Brazil, where the share of thermal power generation is relatively low, can be considered.

5.11. Watt–Bit Collaboration and Photonics-Electronics Convergence Technology

With the spread of generative AI, demand for data centres is growing, and many data centres are being built or planned within the G5 countries as well. Inside data centres, many computers perform computations day and night, which generates heat from the computing devices (semiconductors); cooling equipment must therefore be operated day and night to cool the data centres, which is said to consume enormous amounts of electricity. Measures to reduce this electricity demand for cooling are therefore urgently needed; at the same time, this electricity should preferably be clean electricity that does not involve CO2 emissions, and renewable electricity (wind, solar, etc.) is a candidate. Because renewable electricity, especially wind, is distributed across regions outside major cities, revitalisation of regional areas is expected through the spread of watt–bit collaboration technologies that locate data centres close to this renewable electricity. Efforts are also being made to network data centres dispersed across regional areas with next-generation communication networks (such as IOWN (Innovative Optical and Wireless Network)) to optimise computational processing. In addition, computational processing involves frequent data exchange (Load & Store) between computing devices (processors) and data storage devices (storage), and this data exchange (transfer) is also carried out with electrical signals. Technology to replace the electrical signals used for this data transfer with optical

signals, thereby reducing the electricity consumed in computation, is also currently being vigorously developed (photonics-electronics convergence technology).

5.12. Contributing to Decarbonisation of the Asian Region through AZEC

Under AZEC (which includes Indonesia), public-private pilot projects using various decarbonisation technologies are being implemented under signed MOUs. It is therefore conceivable to extend the implementation of these public-private pilot projects to the other three G4 countries (India, Brazil, and South Africa). The content of the projects must, however, match each country's stage of economic development and energy supply and demand structure.

The above can be summarised as shown in Table 2.

Table 2. Potential Areas of Co-creation between Japan and the G4 Countries

Technology	Indonesia	India	Brazil	South Africa
Stable supply of oil and gas	✓		✓	
Use of HELE equipment (excluding coal-fired power)	✓	✓	✓	✓
Procurement of biofuels	✓		✓	
Energy conservation systems	✓	✓	✓	✓
Energy conservation equipment	✓	✓	✓	✓
Nuclear power	✓	✓		✓
Solar power (perovskite)	✓	✓	✓	✓
Geothermal power	✓			
Wind power (offshore)	✓			
Hydrogen and ammonia supply chain (procurement)	✓	✓	✓	✓
Hydrogen and ammonia utilisation (demand)	✓	✓	✓	✓
Procurement of critical minerals	✓	✓	✓	✓
Resource circulation (storage batteries, plastics, CO2, etc.)	✓	✓	✓	✓
CCS (storage)	✓		✓	
CCS (capture)	✓	✓	✓	✓
Synthetic fuels		✓		✓
Heat pumps			✓	
Watt–bit collaboration	✓	✓	✓	✓

Source: Authors

6. Policy Recommendations

The preceding sections examined potential cooperation with the G4 countries in Japan's innovative energy technologies, focusing on resources, energy, and GX among Japan's 17 growth fields. When Japan advances energy cooperation with Indonesia, India, Brazil, and South Africa, it is necessary, in addition to examining individual technologies and projects, to share several cross-cutting perspectives.

First, the objectives of energy cooperation should be both decarbonisation and a stable supply of energy, including fossil fuels. Until recently, energy cooperation between Japan and Global South countries tended to be discussed mainly from the standpoint of reducing greenhouse gas emissions, such as through renewable energy and energy conservation. However, the global energy security environment has changed significantly owing to the war in Ukraine, the Iran war that began at the end of February 2026, the intensifying US–China rivalry, and growing instability over maritime transport routes. Future cooperation therefore needs to take a broader perspective that, in addition to reducing greenhouse gases, includes an affordable and stable energy supply, diversification of energy sources and suppliers, strengthened emergency response capabilities, the development of domestic industries and employment, economic security, and more resilient supply chains for critical minerals and energy equipment. Rather than Japan unilaterally providing its technology and funding, it is important to build co-creation relationships that contribute to both sides' energy security and economic growth by combining the partner countries' resources, manufacturing capabilities, markets, and human capital with Japan's technology, finance, and institutional design capabilities.

Second, demanding a uniform and early phase-out of coal and fossil fuels solely from the standpoint of decarbonisation is out of step with the economic, social, and energy realities of these countries. In Indonesia, India, and South Africa, coal supports power generation, industry, employment, and regional economies, and plays an important role as a domestic energy resource that limits dependence on imported fuels. As shown in Section 2.3, these three countries are highly dependent on coal and meet much of that demand with domestic coal, so they are likely to continue using coal for reasons of energy security. Brazil, too, while having a high share of renewable energy, is using the expansion of oil and gas production to secure economic growth and export revenues. Moreover, the more geopolitical tensions rise and the more uncertain international energy supply becomes, the stronger the incentives for countries to limit import dependence and utilise domestic resources such as coal, oil, and natural gas. Such moves should not be regarded simply as a retreat from decarbonisation policy, but should be squarely recognised as rational policy responses by countries seeking to secure energy security, economic growth, employment, and fiscal revenues.

Third, with regard to the clean energy transition, rather than applying specific technologies or a single timeline to all countries, it is important to accept diverse pathways that reflect each country's stage of development, resource endowment, existing infrastructure, growth in electricity demand, fiscal capacity, and industrial and employment structure. In India and Indonesia, electricity demand is expected to

increase substantially with population growth, industrialisation, and urbanisation. The challenge for these countries is not simply to replace existing fossil fuels with renewable energy immediately, but to expand the overall electricity supply while adding low-carbon power sources to meet growing demand. The energy transition should be understood not as a "simple substitution of renewable energy for fossil fuels," but as a process of "energy addition" that combines renewable energy, nuclear power, natural gas, storage batteries, transmission and distribution grids, energy conservation, CCUS, biofuels, and other elements according to each country's conditions.

Fourth, premised on the reality that fossil fuels must continue to be used for the time being, emphasis should be placed on cooperation to reduce the emissions associated with their use as much as possible. Specific measures could include the retirement or replacement of ageing coal-fired power plants (with replacement premised on emission abatement measures), improving the efficiency of thermal power generation, reducing transmission and distribution losses, energy conservation in the industry sector, reducing methane emissions, switching from coal to natural gas, utilising biomass and low-carbon fuels, and introducing CCUS.

Fifth, energy cooperation needs to be linked to industrial development in partner countries. Global South countries emphasise not merely importing equipment or exporting resources, but domestic processing, manufacturing, technology transfer, job creation, and human resource development. By incorporating local production, joint research, engineer training, and the building of maintenance and operation capabilities, Japan can contribute to the development of partner countries while also building long-term, stable business foundations for Japanese companies. In doing so, attention should also be paid to the excessive concentration in specific countries of supply chains for solar panels, storage batteries, transmission equipment, electric vehicles, and the refining and processing of critical minerals. Prioritising only the procurement of inexpensive products risks creating new external dependencies and increasing vulnerabilities in terms of economic security. If Japan and the four countries form mutually complementary supply chains by dividing roles appropriately in resource development, refining and processing, parts and materials, manufacturing, recycling, and offtake, this will contribute both to industrial development in each country and to the diversification of supply chains.

In light of the above, energy cooperation between Japan and the four countries should be conceived not within the limited framework of "decarbonisation cooperation," but as comprehensive cooperation that simultaneously pursues energy security, economic growth, industrial development, economic security, and reduced environmental burden. Rather than presenting one-size-fits-all prescriptions that ignore each country's circumstances, linking Japan's technologies, institutions, and funding with partner countries' resources, markets, and industrial bases, while respecting the diverse pathways each country chooses for itself, is the prerequisite for a sustainable co-creation relationship.

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Chapter 11: The Potential for Cooperation on Critical Minerals between Japan and the Global South

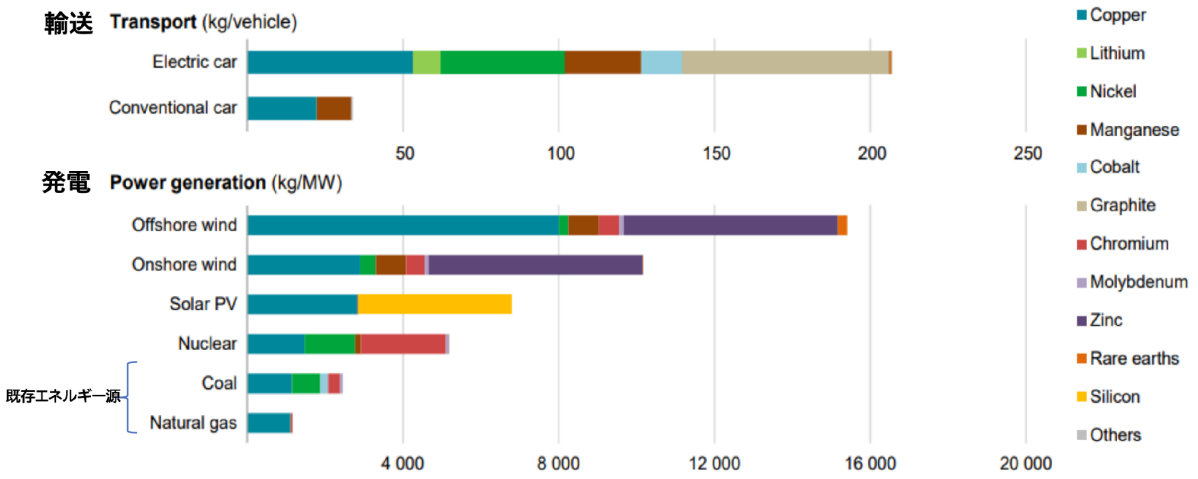
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1. The New Security Landscape Surrounding Critical Minerals

Oil was the resource that symbolised energy security in the 20th century. Triggered by the oil crises, resource-importing countries have pursued stockpiling, diversification of supply sources and energy conservation. However, in the 21st century, characterised by decarbonisation and digitalisation, the scope of energy security has broadened significantly. Solar power, wind power, electric vehicles (EVs), storage batteries, power transmission and distribution networks, and data centres all require large quantities of lithium, nickel, cobalt, copper, graphite and rare earth elements.

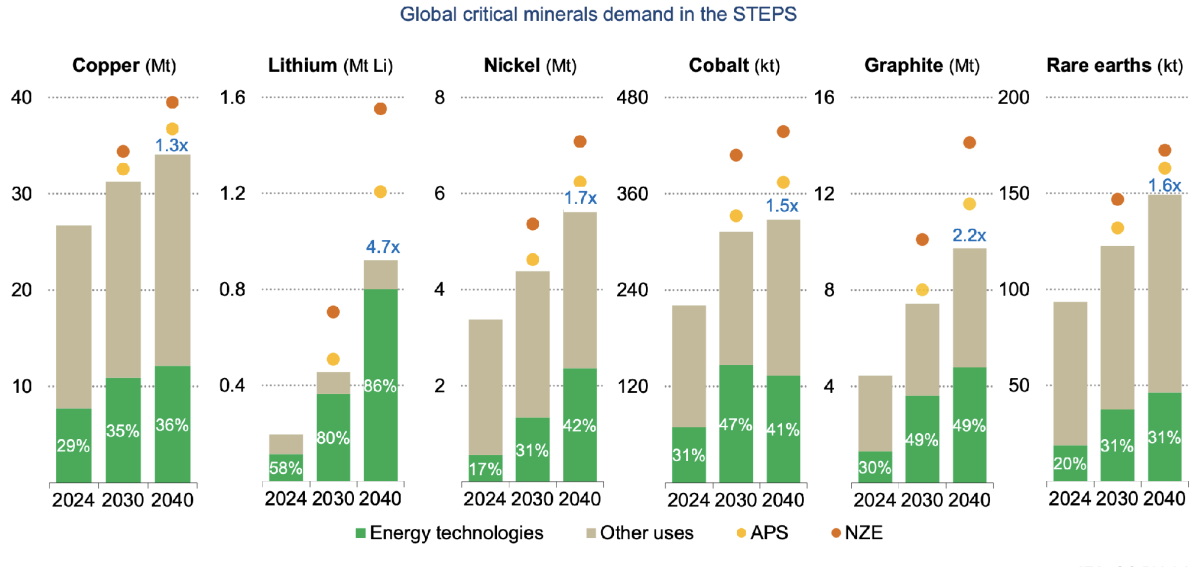
Figure 1. Critical minerals required for clean energy technologies



Source: IEA, The Role of Critical Minerals in Clean Energy Transitions (2021)

According to the International Energy Agency (IEA), demand for critical minerals is set to expand significantly; even under the Stated Policies Scenario, demand is expected to increase by 1.3 times for copper, 4.7 times for lithium, 1.7 times for nickel, 1.6 times for rare earths and 2.2 times for graphite by 2040 compared with 2023 levels. A comparison of demand driven by energy technologies with demand from other sources clearly shows that the clean energy transition is driving the growth in demand for critical minerals.

Figure 2. Future Outlook for Critical Mineral Demand



Source: IEA Global Critical Minerals Outlook 2025

The importance of critical minerals extends beyond decarbonisation alone. Virtually all cutting-edge industries of the 21st century—including semiconductors, artificial intelligence, telecommunications equipment, the space industry and defence equipment—require critical minerals. For example, permanent magnets made from neodymium and dysprosium are indispensable for the high-performance motors in fighter jets, whilst submarines' sonar systems and missiles also utilise large quantities of rare earths and tungsten. Critical minerals have become strategic commodities that simultaneously influence both economic and national security.

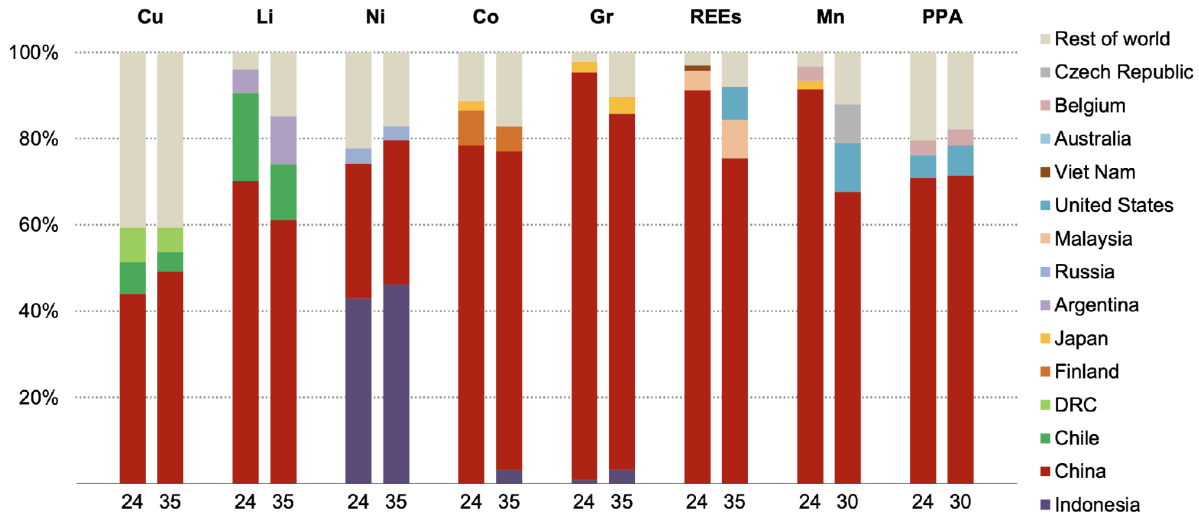
A key difference from oil is that the value of critical minerals is not determined solely by reserves or extraction volumes. Ore can only be utilised in end products after undergoing separation, refining, processing, conversion into materials and component manufacturing. Consequently, when considering the stability of supply chains, one must look not only at the location of mines but also at who controls refining and processing capacity, technology, human resources, manufacturing facilities, logistics and demand markets. Furthermore, whilst the development of mines and refineries takes a long time, demand can surge rapidly as a result of policy changes or technological innovation. This time lag is amplifying price volatility and supply uncertainties.

2. China's Dominance and Its Strategic Implications

China currently lies at the centre of the critical minerals supply chain. According to the IEA's outlook, China's dominance in the refining of critical minerals will remain largely intact through 2030–35. This dominance stems not only from its domestic resource reserves but also from an integrated industrial

ecosystem spanning mining, refining, processing, magnet and battery materials, and end products such as electric vehicles and solar panels.

Figure 3. Geographical Distribution of Refined Critical Minerals in the Reference Case



Source: IEA Global Critical Minerals Outlook 2025

There are four key factors behind China's dominance.

The first is long-term government industrial policy. Since the early 1990s, the Chinese government has designated rare earths as a strategic industry and has fostered the sector from upstream to downstream over the long term through the restructuring of state-owned enterprises, research and development, human resource development, low-interest loans, tax incentives and cheap electricity.

The second is cost competitiveness. Refining and processing consume large amounts of electricity and chemicals, and environmental measures such as waste liquid treatment also incur costs. Whilst plant closures have progressed in Europe, the US and Japan due to tighter regulations and rising costs, China has achieved lower costs through government support and large-scale production. Furthermore, low labour costs and lenient environmental standards also bolster China's cost competitiveness. The fact that Western companies continued to source from China, prioritising price, also encouraged the concentration of capacity. Today's dependence is not only the result of China's industrial policy but also of choices made by consumer nations that have prioritised market efficiency.

The third is China's enormous domestic demand. Smelters, magnet manufacturers, battery materials firms, and battery, motor and EV manufacturers are located in close proximity, resulting in reduced logistics costs, rapid specification changes, technological innovation and economies of scale.

The fourth is access to resources: Chinese companies have secured mining interests and long-term supply contracts in Africa, South America and South-East Asia, combining these with spot purchases

underpinned by large-scale demand, thereby linking the world's resources to China's processing and manufacturing base. China has become not merely a resource-rich country, but a manufacturing hub that gathers resources from around the world and transforms them into high-value-added products.

This industrial advantage has also been translated into diplomatic and security power. The effective halt of rare earth exports to Japan following the 2010 collision incident off the Senkaku Islands demonstrated that the supply of critical minerals can be swayed by political disputes. Since then, China has institutionalised its export control system and, in recent years, has expanded its scope to cover items such as gallium, germanium, graphite, antimony and rare earths. China's objective is not necessarily a total embargo, because the very ability to "restrict supply when necessary" serves as a bargaining chip. However, as excessive regulation would encourage investment in alternatives and weaken China's market dominance, the country employs selective control through a licensing system and adjustments to the list of controlled items.

3. The G7's Response and Its Limitations

Drawing on its experience in 2010, Japan has adopted a combined approach involving the diversification of supply sources—including to Australia—alongside the use of alternative materials, resource conservation, recycling and stockpiling. What significantly altered the perception in Europe and the US were the supply chain disruptions caused by the COVID-19 pandemic and Russia's invasion of Ukraine. As dependence on cheap Russian gas had become a geopolitical vulnerability for Europe, a shared sense of urgency emerged that the same mistake must not be repeated with critical minerals.

At the 2023 G7 Hiroshima Summit, the "Five-Point Plan for Critical Minerals Security," agreed at the Sapporo Climate, Energy and Environment Ministers' Meeting that same year, was endorsed and its implementation confirmed. This Five-Point Plan was based on the pillars of long-term supply and demand forecasting, the development of responsible supply chains, recycling, resource efficiency and alternative technologies, and preparedness for supply disruptions. At the 2025 Kananaskis Summit, this evolved into an action plan centred on standards-based markets, capital mobilisation and international partnerships, and technological innovation, whilst also explicitly addressing the creation of local added value in resource-rich countries. At the 2026 Evian Summit, emphasis was placed on transparency, traceability, environmental and labour standards, and diversification of supply sources, and there was a further strengthening of the recognition that mutually beneficial cooperation with resource-rich countries outside the G7 is essential.

However, even with these policy documents in place, dependence on China will not decrease immediately. The greatest challenge lies not in mining, but in smelting and processing. Even if ore is mined in countries other than China, the core of the supply chain remains unchanged if it is refined in China. Furthermore, constructing new facilities in accordance with high environmental and labour standards

will drive up costs. Should Chinese companies lower their prices, there is a risk that new ventures could become unprofitable. Reducing dependence on China requires mechanisms to support market formation, such as long-term off-take commitments from consumers, public finance, stockpiling and, where appropriate, price stabilisation measures.

The aim should not be the complete exclusion of China, but rather to alleviate excessive concentration on China and to build the capacity to find alternatives should supply disruptions occur. Complete decoupling is unrealistic and would entail significant costs. What is needed is a long-term strategy that combines market principles with public support to foster sustainable supply chains spanning multiple countries.

4. The Need for Cooperation with the Global South

The diversification of critical mineral supply chains cannot be achieved by the G7 countries alone. This is because many deposits of minerals such as nickel, cobalt, manganese, copper, lithium, graphite and rare earths are located in the Global South—in Asia, Africa and Latin America. Furthermore, strengthening supply chains requires not only the development of mines but also the integration of smelting, processing, component materials, infrastructure, human resources and demand markets; it cannot be achieved in isolation from the industrial policies of resource-rich countries. Even if the G7 were to attempt to establish self-sufficient supply chains within its own borders or with a small number of allies, there would be limitations in terms of resource volume, cost and market size.

Consequently, cooperation between the G7 and the Global South must not be limited to a relationship of sourcing ore from outside China. Many resource-rich countries are seeking to move away from the traditional model of exporting ores at low prices whilst importing high value-added products, and instead aim to carry out smelting, processing, and the manufacture of components and finished goods domestically. To ensure the sustainability of supply chain diversification, industrial cooperation is required that simultaneously achieves the expansion of employment, technology, tax revenue and export markets in resource-rich countries, whilst ensuring stable supplies for consumer nations.

Economic relations with China remain important for many countries in the Global South. Chinese enterprises provide capital, technology, markets and rapid decision-making; it is not realistic to deny their role. However, if investors, technology providers, processors and export markets are concentrated in a single country, the resource-rich countries' own bargaining power and scope for policy choices are diminished. Increasing the number of partners beyond China does not mean joining a confrontation with China, but rather broadening options and enhancing strategic autonomy.

5. The Position of Indonesia, India, South Africa and Brazil

The Global South is not a homogeneous bloc, and the same form of cooperation cannot be established with every country. The reason this research group places particular emphasis on Indonesia, India, South Africa and Brazil is that these four countries possess distinct resources, industries, markets and regional networks, enabling the creation of mutually complementary supply chains. All four countries are major members of the G20; they prioritise the advancement of their own industries and strategic autonomy, whilst pursuing a non-exclusive foreign policy that maintains relations with both China and the G7. For this reason, they are important partners with whom to discuss cooperation aimed at increasing options for investment destinations, technology, processing hubs and markets, rather than seeking to encircle China.

Indonesia is a prime example of a resource-rich country seeking domestic processing, as it is moving to establish a battery and EV industry centred on nickel. South Africa possesses a foundation in the mining, smelting and automotive industries, in addition to platinum group metals, manganese and chromium, and has the potential to become a regional hub in Southern Africa. Brazil combines diverse resources such as niobium, lithium, graphite and rare earths with a vast market, low-carbon electricity and a manufacturing base. India is a major future consumer and, through its manufacturing capacity, human resources and networks with third countries, is well-placed to play a key role in establishing mid- and downstream supply chains. By linking these four countries, it becomes possible to move beyond the simple dichotomy of resource-supplying and resource-consuming nations and envisage a model in which extraction, processing, manufacturing and demand are shared amongst multiple countries.

6. Japan's Role

In giving concrete form to cooperation between these four countries and the G7, Japan can act as a bridge. This is not so much because Japan is particularly outstanding, but rather because it occupies a unique position that facilitates the connection between the industrialisation strategies of the four countries and the G7's capital, markets and technology.

Firstly, rather than severing ties with China entirely, Japan's approach is based on diversification to avoid excessive dependence. This stance is highly compatible with the positions of Indonesia, South Africa, Brazil and India, which wish to maintain relations with China whilst ensuring policy autonomy. It can easily be presented as a form of cooperation that increases each country's options, rather than requiring them to join either the US or Chinese camp.

Secondly, as a resource-importing nation that has experienced both the oil crisis and the rare-earth crisis, Japan possesses practical policy experience in combining supply stability, cost management, substitution and stockpiling.

Thirdly, Japan possesses a technological base covering mid- and downstream sectors, including refining and processing, raw materials, manufacturing equipment, quality control, energy conservation, environmental measures and recycling. What resource-rich countries seek is not merely investment in mines, but the retention of industry and skills within their own countries; Japan is therefore able to offer cooperation that emphasises not only quantity and price, but also operational reliability and the accumulation of technological expertise.

Fourthly, through organisations such as the Japan Organization for Metals and Energy Security (JOGMEC), the Japan Bank for International Cooperation (JBIC), Nippon Export and Investment Insurance (NEXI) and the Japan International Cooperation Agency (JICA), Japan has institutional mechanisms that combine exploration, investment, financing, insurance, infrastructure and human resource development. Fifthly, Japan has built long-term economic relationships with these four countries. However, Japanese companies tend to be cautious in their decision-making, and in many cases fall short of China in terms of the scale of funding and the speed of implementation. For Japan to fulfil its role as a bridge, it must not treat resource-rich countries merely as supply bases for raw materials, but must put into practice joint ventures with local companies, technology transfer, local employment and profit-sharing. Japan's role is not to unilaterally export G7 policies, but to connect G7 capital, markets and standards with the industrialisation strategies of the four countries.

7. Potential for Cooperation with the Four Countries

(1) Indonesia – From Nickel to the Low-Carbon Battery Industry

Backed by some of the world's largest nickel reserves, Indonesia has restricted exports of unprocessed ore and has been promoting domestic smelting and the development of its EV and battery industries. Whilst this policy has generated employment and investment, it has also increased the proportion of Chinese companies in smelting capacity and the battery supply chain. Furthermore, challenges remain regarding carbon emissions from smelting reliant on coal-fired power, waste disposal, water resources and the impact on ecosystems.

Cooperation with Japan should not aim merely to provide investors as a substitute for Chinese firms. A viable model could involve combining high-efficiency, low-carbon smelting; wastewater and residue treatment; power supply utilising geothermal and renewable energy; battery materials; recycling; quality control; and human resource development, thereby supplying nickel and battery products with high environmental performance to the international market. Linking long-term off-take agreements by Japanese companies with public finance would bring market diversification and higher value-added production to Indonesia, whilst ensuring a stable supply of materials for Japan. It would also be effective to link existing energy cooperation frameworks, such as the Asia Zero Emission Community (AZEC), to the decarbonisation of the minerals and battery industries.

At the 2026 Japan–Indonesia Summit, cooperation on resources and infrastructure—including critical minerals—was positioned as a form of collaboration that reconciles energy security with decarbonisation (MOFA 2026a). In 2026, a Memorandum of Cooperation on Critical Minerals (METI 2026) was signed, establishing an institutional framework that extends beyond the mining of nickel and other minerals to link smelting, processing, the battery industry and the energy transition.

(2) South Africa – Mineral Processing and the Formation of Regional Industrial Hubs

South Africa possesses a diverse range of resources, including platinum group metals, manganese, chromium and vanadium, and has a solid foundation in the mining, smelting and automotive industries. Platinum group metals are used not only in automotive exhaust catalysts but also in fuel cells and water electrolysis systems. Manganese and vanadium are crucial in the battery and steel sectors, and, looking at Southern Africa as a whole, regional collaboration with producers of copper, cobalt and lithium is also possible.

Challenges include an unstable electricity supply, ageing railways and ports, a shortage of skilled labour, and the investment climate. Japan is in a position to provide integrated support for energy-efficient smelting, mining machinery, electricity and logistics infrastructure, environmental management, vocational training, and the demonstration of hydrogen and fuel cell technologies. Rather than relying solely on South Africa's resource exports, establishing a regional hub for processing, manufacturing and logistics—including minerals from neighbouring countries—would enable supply to multiple markets whilst retaining added value within the African region. Ensuring consistency with a just energy transition and incorporating employment transition and regional development in mining areas will form the social foundation for this cooperation.

At the 2026 Japan–South Africa Foreign Ministers' Meeting, both sides agreed to continue public–private cooperation on strengthening critical mineral supply chains and to advance this in tandem with cooperation on the energy transition (MOFA 2026b).

(3) Brazil – Creating High Added Value through Low-Carbon Electricity

In addition to niobium and iron ore, Brazil possesses a diverse range of resources, including nickel, lithium, graphite and rare earths. Its vast domestic market, manufacturing base and a power mix centred on renewable energy offer significant advantages for fostering low-carbon smelting and processing industries. Rather than exporting critical minerals in their raw ore form, there is potential to develop them into refined products, battery materials, permanent magnets and recycled materials.

Cooperation with Japan could involve a combination of geological surveys and exploration, mine development, environmental conservation, smelting and processing technologies, integration with renewable electricity, and long-term procurement agreements. It is important to incorporate consideration for forests, biodiversity, and indigenous and local communities from the early stages of projects, and to establish a system whereby traceability and low-carbon characteristics are recognised

as product value in international markets. If Brazil can be established as a South American hub for processing and research and development, linking resource-rich countries in the region with Japanese companies, it will be possible to achieve both the diversification of supply chains and the advancement of Brazil's industry.

The 2025 Japan–Brazil Strategic and Global Partnership Action Plan (Ministry of Foreign Affairs of Brazil 2025) outlined directions for cooperation, including critical and strategic minerals, processing and recycling. By combining Brazil's abundant resources and low-carbon electricity with Japan's smelting, processing and recycling technologies, there is scope to build a high-value-added supply chain that goes beyond mere ore exports.

(4) India – Joint Manufacturing and Third-Country Cooperation

Whilst India possesses a certain amount of mineral resources, its huge population and manufacturing sector mean it is highly likely to become a major consumer nation in the future. Although it is expanding domestic production of batteries, EVs, solar power and electronic devices, it remains dependent on China for raw materials, smelting, magnets, battery components and manufacturing equipment. Therefore, Japan–India cooperation should focus not on a relationship between resource seller and buyer, but on jointly forming a manufacturing ecosystem that is not reliant on China alone.

There is scope for joint production of magnets, motors, battery materials and battery cells by combining Japan's expertise in materials, equipment, quality control and recycling technologies with India's markets, human resources and manufacturing capabilities. Furthermore, third-country cooperation—combining Japan's public finance and technology with the networks of Indian companies in Africa, the Middle East and South Asia—also holds great promise. By jointly supporting not only mining in resource-rich countries but also local processing, human resource development and infrastructure development, benefits will be brought not only to Japan and India but also to third countries.

At the 2025 Japan–India Summit (MOFA 2025), strengthening the resilience of supply chains for critical materials was identified as a pillar of economic security cooperation, and the two countries signed a Memorandum of Cooperation in the field of mineral resources (METI 2025). Through policy dialogue, joint investment and cooperation between companies, the foundations are being laid for the formation of mineral and manufacturing supply chains that do not rely excessively on China alone.

8. A Cooperation Framework Linking the Four Countries and Japan

It is important not to allow cooperation with these four countries to remain merely a collection of individual projects, but to develop it into a mutually complementary network. By combining Indonesia's nickel, South Africa's platinum group metals and manganese, Brazil's lithium, graphite and rare earths, India's markets and manufacturing capacity, and Japan's technology, finance and

demand, it is possible to form a supply network of a certain scale that is not reliant on China alone. However, it is not necessary for all stages of the process to be completed within a single country. Processes should be divided according to each country's comparative advantages in terms of resources, electricity, technology, logistics and markets, and stable trade relationships should be established amongst multiple countries. Specifically, the following should be pursued.

- Firstly, carry out "mapping of critical minerals and industries" to jointly assess each country's resources, processing capacity and demand.
- Secondly, jointly identify promising projects in mining, smelting, processing and recycling, and pool public and private funding.
- Thirdly, combine off-take agreements not only with Japanese companies but also amongst companies from the four countries to avoid dependence on a single market.
- Fourthly, jointly design common principles regarding the environment, labour, local communities and traceability, taking into account each country's development goals, rather than imposing them as unilateral conditions set by developed nations.
- Fifthly, continuously carry out human resource development and joint research involving universities, research institutions and companies.

Of particular importance is a mechanism to ensure projects' survival even during market downturns. To withstand price competition with Chinese firms, it is necessary to consider long-term off-take agreements, minimum purchase volumes, public guarantees, stockpiling and the sharing of price fluctuation risks. At the same time, rather than relying solely on protectionism, competitiveness must be enhanced through energy conservation, digitalisation, by-product recovery and recycling. Evaluation criteria for joint projects should also encompass not only the volume of supply to Japan, but also local employment, skills transfer, tax revenue, environmental improvements, the participation of local businesses, and the diversification of export destinations.

9. Cooperation to Increase Options, Rather than "Decoupling from China"

The challenges surrounding critical minerals are multifaceted issues that require simultaneous solutions in the areas of decarbonisation, industrial competitiveness, economic security, development and the environment. China has built a high level of competitiveness through its long-term industrial policy and vast market, and its supply chains cannot be replaced in the short term. Furthermore, trade and investment with China will remain important for both the four countries and Japan. Therefore, it is not realistic to set the objective of cooperation as the exclusion of China or the formation of opposing blocs.

The aim should be to establish a structure in which each country can choose from multiple investors, technologies, processing centres and markets, so that their economies are not significantly damaged

by policy changes or supply disruptions in any single country. To achieve this, we must move beyond the traditional relationship in which resource-consuming countries seek only stable supplies, whilst resource-rich countries limit themselves to exporting raw materials. Industrial partnerships that share everything from on-site smelting and processing, infrastructure, human resources and technology to environmental management and end-product markets form the foundation for sustainable diversification.

Japan can play a role in linking the G7's capital, markets and technology with the resources, markets and industrialisation strategies of Indonesia, South Africa, Brazil and India. To achieve this, it is necessary to propose cooperation that enables these four countries to enhance their own industrial policies and strategic autonomy; it is desirable for Japan and the four countries to jointly explore concrete measures for mutually complementary joint projects, financing, demand guarantees and human resource development. It is important to transform cooperation on critical minerals from a competition for resource security into a new form of international industrial cooperation in which countries share both benefits and risks.

10. Linking Cooperation on Critical Minerals with Cooperation on the Energy Transition

Cooperation on critical minerals with the Global South—particularly Indonesia, South Africa, Brazil and India—must be conceived as an integral part of each country's energy transition policies, rather than being pursued in isolation from mine development, smelting and processing. This is because the mining, smelting and processing of critical minerals require large amounts of electricity, and the composition of the power sources used influences both the cost of the products and their carbon emissions. Furthermore, the pace of adoption of electric vehicles, storage batteries, power grids and renewable energy infrastructure—which generate demand for critical minerals—varies significantly depending on each country's electricity supply situation, industrial infrastructure and fiscal capacity.

Whilst reducing excessive dependence on China is necessary for economic security, it is likely to drive up the cost of clean energy technologies in the short to medium term. Thanks to its massive production capacity, industrial clusters and government support, China has supplied batteries, solar panels, EVs and critical mineral materials at low prices. If alternative supply chains are newly established under high environmental and labour standards, capital expenditure and operating costs will rise, and some of this will be reflected in electricity tariffs, battery prices and EV prices.

This issue is particularly significant for the Global South, which places great importance on affordable energy prices. Many energy transition scenarios have been based on the assumption that the costs of solar power, wind power, energy storage batteries and EVs will continue to fall. However, if the diversification of supply chains, the development of domestic industries and the tightening of envi-

ronmental standards lead to rising costs, there is a possibility that the transition pathways previously envisaged will need to be revised. For countries with limited fiscal capacity that must simultaneously expand access to electricity and promote industrialisation, rising energy transition costs will pose a major policy constraint.

Consequently, it cannot be ruled out that progress towards decarbonisation may lag behind initial projections. However, whilst decarbonisation is one of the key objectives of energy policy, it is not the sole objective that takes precedence over all others. Energy policy has multiple objectives, including security of supply, affordability, economic growth, industrial competitiveness, employment, energy access and environmental conservation. It is not realistic to apply a single transition pathway whilst ignoring the resource conditions, income levels, electricity demand and industrial structures of each country.

Accordingly, cooperation between Japan and the four countries should not be limited solely to the introduction of renewable energy and electric vehicles. Japan needs to present a wide range of options, including energy conservation, high-efficiency thermal power generation, the advanced utilisation of natural gas, the reduction of methane emissions, the cleaner use of fossil fuels (including CCUS), nuclear power, hydropower, geothermal energy, the strengthening of transmission and distribution networks, energy storage, and demand-side management. Rather than ruling out specific technologies in advance, we should jointly explore realistic combinations that improve stability of supply, economic viability and environmental performance, in accordance with the national circumstances and priorities of each partner country.

The circumstances of the four countries are not uniform. In Indonesia, the challenge lies in utilising geothermal, natural gas and renewable energy whilst reducing reliance on coal-fired power for nickel smelting. In South Africa, it is necessary to simultaneously address the modernisation of ageing electricity infrastructure, employment in coal-mining regions, and the securing of stable power sources, including nuclear and renewable energy. Brazil has the potential to become a low-carbon smelting and processing hub by utilising its abundant hydropower and renewable energy resources. In India, whilst meeting rapidly growing electricity demand, it is necessary to simultaneously expand the efficient use of coal, renewable energy, nuclear power, the transmission grid and energy storage.

Integrating cooperation on critical minerals with energy cooperation is not merely a matter of ensuring a stable supply of minerals. It is intended to support industrialisation in resource-rich countries through stable and affordable energy, reduce the environmental impact of smelting and processing, and produce products that are competitive on the international market. What Japan and the four partner countries should aim for is not a one-size-fits-all approach to cooperation based solely on decarbonisation targets, but a pragmatic partnership that simultaneously pursues each country's growth, energy security, industrial advancement and environmental improvement.

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Chapter 12: Japan and Global South Cooperation on Environmentally Sound E-waste Resource Circulation

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Key messages

- Evidence from four ASEAN Member States, together with related findings from Africa, suggests that the main challenge is not the absence of regulations or licensed facilities, but their incomplete connection with actual e-waste flows through collectors, repair businesses, and scrap traders.
- Cooperation between Japan and Global South partners should initially focus on domestically generated e-waste and on practical rules that connect collection and pre-processing with verified downstream treatment.
- Three priorities merit joint consideration: material classification and traceability; conditions for environmentally sound cross-border circulation of selected fractions; and the allocation of costs, benefits, and local capabilities, including a gradual transition for informal workers.
- A focused pilot, designed with local governments, existing collectors, and treatment operators, could provide the evidence needed to develop practical guidance.

1. Background

The growing volume of waste electrical and electronic equipment (e-waste) highlights the need for environmentally sound resource circulation. According to the Global E-waste Monitor 2024, jointly published by the United Nations Institute for Training and Research (UNITAR) and the International Telecommunication Union (ITU), global e-waste generation reached 62 million tonnes in 2022, an increase of 82% since 2010, and is projected to reach 82 million tonnes by 2030. However, only 22.3% of the e-waste generated in 2022 was documented as formally collected and recycled (Baldé et al., 2024). Southeast Asia is an important region for examining environmentally sound e-waste management in the context of continued economic growth, urbanisation, and increasing waste generation. Developing Southeast Asia is expected to maintain relatively strong economic growth (Asian Development Bank, 2026). At the same time, ASEAN countries face broader waste management challenges involving waste collection, treatment infrastructure, and resource recovery (United Nations Environment Programme, 2017; ASEAN Secretariat, 2023).

Table 1. E-waste Generation in Selected Global South Countries and Japan in 2022

Country	E-waste generation (million tonnes)	E-waste generation per capita (kg)
Global South countries considered in this brief (in order of G20 presidency, 2022–2025)		
Indonesia	1.886	6.9
India	4.137	2.9
Brazil	2.443	11.4
South Africa	0.527	8.8
Four ASEAN Member States (Malaysia, the Philippines, Thailand, and Viet Nam) examined in the authors' previous research (Hirata et al., 2026)		
Malaysia	0.411	12.2
Philippines	0.537	4.7
Thailand	0.753	10.5
Viet Nam	0.516	5.3
Comparison country		
Japan	2.638	21.2

Source: Compiled by the authors based on Baldé et al. (2024, Annex 2).

Table 1 illustrates differences between total and per capita e-waste generation in selected Global South countries and Japan in 2022. The four countries considered in this brief were selected as Global South members of the G20 that held its presidency consecutively from 2022 to 2025. The selection also reflects their geographical diversity and potential differences in the scale of e-waste generation, regulatory frameworks, and treatment capacities. Among the listed countries, India generated the largest total volume, while Japan recorded the highest per capita generation. Within the four ASEAN Member States examined in our previous research, Thailand generated the largest volume, whereas Malaysia had the highest per capita generation. These differences provide context for considering the scale of collection and treatment needs. However, the amount of the generation itself does not indicate how effectively e-waste is collected or whether recovered materials and residual waste are managed in an environmentally sound manner.

Environmentally sound resource circulation requires connections between collection, pre-processing, material recovery and refining, and the treatment of hazardous components and residual waste. This brief focuses on downstream activities, from pre-processing to recovery and residual waste treatment, while recognising their dependence on collection. Building on the authors' previous comparative research in Malaysia, the Philippines, Thailand, and Viet Nam (Hirata et al., 2026), this brief draws on findings that highlight gaps between existing regulatory frameworks and licensed treatment facilities, on the one hand, and actual e-waste flows, on the other. Licensed facilities may face insufficient or unstable material supplies, while household e-waste continues to circulate through existing collectors, repair businesses, and scrap traders with limited traceability. These findings provide an empirical

starting point for identifying practical challenges relevant to cooperation between Japan and Global South partners.

Related challenges have also been reported in other Global South countries. A report on e-waste management in Africa notes that 13 of the 54 countries in the continent have adopted e-waste related policies and that formal recyclers face difficulties in securing sufficient material supplies (Adu & Awuah, 2025). A study in South Africa also indicates that informal e-waste collectors undertake pre-processing activities, including dismantling and sorting, while many earn less than the minimum wage (Chitaka et al., 2025). These findings point to the importance of considering existing collection and processing activities, and the conditions under which those involved can participate in environmentally sound treatment.

Japan has also advanced policy initiatives to address resource circulation challenges. The Circular Economy Action Plan, adopted by the relevant ministerial council in April 2026, includes support for convenient separate collection systems for lithium-ion batteries by local governments and measures to address improperly operated scrap yards that can offer higher purchase prices by avoiding environmental protection costs. The plan also identifies cooperation with ASEAN countries and other partners as an area for international engagement (Cabinet Secretariat, 2026).

These findings provide a starting point for discussing cooperation between Japan and Global South partners. A key question is how technical cooperation can be combined with practical rules that connect collection and pre-processing to verified downstream treatment. Areas for joint consideration include material classification, record-keeping, treatment verification, and the allocation of responsibilities and costs. Cooperation should also strengthen local capabilities and ensure that participating countries benefit from resource recovery. The Southeast Asian findings are offered here as a basis for comparison and dialogue, rather than as evidence that the same conditions apply across all participating countries.

2. Priorities for Cooperation and Joint Rule Development

Participating Global South countries and Japan can strengthen downstream resource circulation by jointly developing practical arrangements that connect collection and pre-processing to environmentally sound treatment. Cooperation should reflect each country's regulatory framework, existing collection networks, and treatment capabilities. It should also consider the roles of local governments, consumer participation, and the livelihoods of people engaged in informal collection and processing.

Table 2 illustrates differences in e-waste management and extended producer responsibility (EPR) frameworks across the countries considered in this brief. These differences concern not only whether EPR is in place, but also the equipment covered, the responsibilities assigned to producers and other

actors, and the arrangements for financing collection and treatment. Shared operational arrangements would therefore need to accommodate national requirements and implementation conditions.

Table 2. E-waste Management and EPR Frameworks in Selected Global South Countries and Japan

Country	E-waste classification and waste management framework	Extended Producer Responsibility (EPR) framework for EEE
Indonesia	Government Regulation 27/2020 classifies unused electronic products as specific waste containing hazardous and toxic substances (B3).	A legal basis for producer waste reduction and take-back obligations exists, but an operational EEE-specific framework remains under development. A draft ministerial regulation on waste reduction by producers, replacing Regulation P.75/2019, was subject to public consultation in October 2026. National standards for household and office e-waste management were being prepared as of September 2026.
India	Governed by the E-Waste (Management) Rules, 2022, effective from April 2023, with subsequent amendments.	In force. Producers meet recycling targets, rising from 60% in 2023–24 to 80% from 2027–28, by purchasing EPR certificates from registered recyclers.
Brazil	The National Solid Waste Policy, Law 12,305/2010, requires reverse logistics for electrical and electronic products. Decree 10,240/2020 establishes arrangements for household EEE.	Mandatory reverse logistics is in force. Decree 10,240/2020 sets collection and appropriate disposal targets and requirements for collection points.
South Africa	Landfill disposal of hazardous WEEE is restricted under the National Environmental Management: Waste Act and associated standards, including Government Notice R636 of 2013, as amended.	In force under the EPR Regulations, 2020, and the EPR scheme for the EEE sector, with subsequent amendments. The scheme establishes take-back and recycling targets.
Malaysia	Treated as scheduled hazardous waste and regulated mainly under Environmental Quality (Scheduled Wastes) Regulations 2005	Planned, but not yet in place
Philippines	Governed by Republic Act (RA) 6969 and Department of Environment and Natural Resources (DENR) Administrative Order (DAO) 2013-22. Under DAO 2013-22, waste code M506 applies mainly to Waste EEE (WEEE) and e-scrap managed through formal treatment, storage and disposal (TSD) facilities, while waste code M507 covers household and residential special wastes, which may include household WEEE.	Not yet in place (only for plastic packaging) EPR is mentioned in the draft DENR Department Administrative Order (DAO) on "Environmentally Sound Management of WEEE" being finalised
Thailand	Existing laws (e.g., Hazardous Substance Act (1992) and relevant announcements by Ministry of Commerce (MOC) and Department of Industrial Works (DIW)) provide partial control but lack comprehensive e-waste-specific regulation	In preparation

Country	E-waste classification and waste management framework	Extended Producer Responsibility (EPR) framework for EEE
Viet Nam	Circular No. 02/2022/TT-BTNMT specifies types of EEE waste to be treated as hazardous. (Amended by Circular No. 07/2025/TT-BTNMT)	In force (Decree No. 110/2026/ND-CP, which repealed Chapter VI of Decree No. 08/2022/ND-CP for obligations from 2026 onward; obligations for 2025 and earlier remain under Decree No. 08/2022/ND-CP, as amended by Decree No. 05/2025/ND-CP)
Japan	The Waste Management Act regulates the storage and disposal of designated hazardous used equipment. Separately, revised regulations under Japan's Basel Act and criteria for determining whether e-waste falls within its scope have applied since January 2025, implementing the Basel Convention E-waste Amendments.	The Home Appliance Recycling Act assigns take-back responsibilities to retailers, recycling responsibilities to manufacturers, and fee payments to those discarding covered appliances. The Small Home Appliance Recycling Act provides a framework for municipal collection and recycling by certified operators.

Source: Adapted from Hirata et al. (2026) and compiled by the authors from the legislation and supporting materials cited in this brief.

Sources by country: Indonesia: Pemerintah Republik Indonesia (2020), Kementerian Lingkungan Hidup/Badan Pengendalian Lingkungan Hidup (2026a, 2026b), Putri (2024); India: Ministry of Environment, Forest and Climate Change (2022, 2024); Brazil: Presidência da República (2010, 2020, 2022); South Africa: Department of Environmental Affairs (2013), Department of Environment, Forestry and Fisheries (2020a, 2020b), Department of Forestry, Fisheries and the Environment (2024a, 2024b); Malaysia: Government of Malaysia (2005); the Philippines: Republic of the Philippines (1990), Department of Environment and Natural Resources (2013); Thailand: Kingdom of Thailand (1992); Viet Nam: Chính phủ (2022, 2025, 2026), Bộ Tài nguyên và Môi trường (2022, 2025); Japan: Ministry of the Environment, Japan (n.d.-a, n.d.-b, 2014, 2024).

Connecting collection and pre-processing to environmentally sound downstream treatment requires reliable information on materials and treatment pathways, clear responsibilities at each stage, and arrangements that cover necessary costs and enable continued participation. From this perspective, this brief identifies three areas for joint consideration: material classification and traceability, a framework for environmentally sound cross-border resource circulation, and the distribution of costs and benefits.

2.1. Material Classification and Traceability

A first priority is to improve the consistency of information across the resource circulation chain. Our research in selected ASEAN Member States suggests that existing collection networks and licensed treatment facilities are not sufficiently connected through traceable material flows (Hirata et al., 2026). Improving these connections requires attention to how materials are collected, transferred, and processed, as well as to the information recorded at each stage.

Participating authorities and businesses could jointly identify the information needed to determine whether equipment is intended for reuse or constitutes waste, and to characterise material fractions

obtained through pre-processing, including their composition, hazardous constituents, and intended recovery routes. Reusable equipment, remanufactured goods, and waste fractions should be distinguished according to their characteristics and applicable requirements.

The Basel Convention E-waste Amendments, effective from 1 January 2025, have increased the importance of these distinctions. Non-hazardous e-waste covered by the new entry Y49 is now subject to prior informed consent (PIC) procedures (Basel Convention, n.d.-a). The need for clear classification and documentation therefore extends to non-hazardous e-waste with potential resource value. Japan's published criteria for determining whether equipment and materials fall within regulated e-waste categories (Ministry of the Environment, Japan, 2024) could provide a reference when partners consider shared information requirements.

These arrangements should be developed with environmental authorities, customs officials, producers, collectors, and treatment operators. Shared information fields could improve communication across businesses and authorities while allowing procedures to reflect national requirements.

2.2. Building a Foundation for Environmentally Sound Cross-border Resource Circulation

Participating Global South countries and Japan could jointly develop practical conditions for the environmentally sound cross-border circulation of appropriately collected and pre-processed e-waste fractions. This would involve identifying their resource value, quality requirements, suitable receiving facilities, and responsibilities for recovery and residual waste treatment.

This approach shares elements with the "best of two worlds" discussion, which combines local manual dismantling with specialised facilities capable of treating hazardous and complex materials. Research on China and India identifies market scale, competition with informal operators, domestic legislation, collection systems, financing, and trust among businesses as important conditions for implementation (Wang et al., 2012). However, extending such arrangements to e-waste imported from advanced economies may reduce their benefits by transferring hazardous substances to developing countries (Manhart, 2011). The cooperation proposed here therefore focuses primarily on e-waste generated within participating countries.

Domestic collection and treatment should provide the foundation for such circulation. Where specialised recovery capacity is unavailable or insufficient domestically, clearly identified and traceable fractions could be connected to appropriate facilities abroad, subject to applicable international and national requirements. The division of processing activities should be determined jointly, taking account of environmental performance, technical needs, and local development priorities, and opportunities to strengthen local businesses and processing capabilities over time.

Japan's Circular Economy Action Plan identifies international circulation of dismantled and sorted e-scrap, together with institutional development, capacity building, and cooperation with Japanese businesses, particularly in major ASEAN countries (Cabinet Secretariat, 2026). The plan aims to

promote environmentally sound recovery and recycling through such cooperation, while enabling Japan and its partner countries to secure secondary resources, including critical minerals (Cabinet Secretariat, 2026). Cooperation is likely to be credible to partners only if access to specialised recovery in Japan is matched by commitments to strengthen processing capabilities and retain economic benefits in partner countries.

Responsibilities should be clear throughout the chain, from the verification of materials before shipment to evidence of treatment and residual waste management after receipt.

2.3. Implementation Costs, Benefits, and Local Capabilities

A third priority is to ensure that agreed rules are supported by the capabilities and incentives needed to implement them. Environmentally sound resource circulation entails costs for collection, transport, pollution control, worker protection, and residual waste treatment. Partners should examine who bears these costs, particularly where the value of recovered materials is insufficient to cover sound treatment, and how the benefits of resource recovery are distributed.

National financing arrangements differ. India uses an EPR certificate system through which producers meet recycling obligations, while Japan's Home Appliance Recycling Act requires those discarding covered appliances to pay recycling fees. These differences should inform discussion of how proposed cooperative arrangements would interact with domestic systems and how costs would be covered throughout the processing chain.

Implementation also depends on administrative capacity and the conditions under which businesses operate. Research on the Basel Convention and e-waste imports in ASEAN reports different effects across countries, indicating that international rules do not produce uniform outcomes (Lin et al., 2025). Research in Ghana likewise identifies challenges concerning treatment infrastructure, business registration and formalisation, and the sequencing of policy and regulatory measures, despite efforts to provide training for informal operators (Bimpong et al., 2024). Another study in Ghana highlights how informal e-waste activities sustain livelihoods while exposing workers and residents to environmental and health risks. The authors advocate an approach that recognises these livelihood functions while improving transparency, working conditions, and protection for existing informal workers (Finn et al., 2025).

Training, technical exchange, and support for equipment and operational improvements could strengthen local collection and pre-processing capacities. Earlier research on corporate environmental management in Thailand, although not focused on e-waste, highlights the importance of implementation costs, employee training, and business benefits (Hirata & Ialnazov, 2024). Joint rule development should therefore be accompanied by practical support and commercially workable arrangements. Assessment should consider technical recovery performance alongside pollution risks, emissions, working conditions, livelihood outcomes, and opportunities for local business development. Joint

research involving public authorities, researchers, businesses, and collection actors could help identify these conditions and refine cooperation through implementation experience.

3. Policy Recommendations

Global South partners and Japan could consider the following three actions to connect domestic collection and pre-processing with environmentally sound downstream treatment. Initial cooperation should focus primarily on domestically generated e-waste, with arrangements adapted to each country's regulatory framework and implementation capacities.

3.1. Jointly identify suitable material fractions and test the conditions for their circulation

Environmental authorities and local governments in participating countries, together with Japanese authorities and treatment operators, should establish a focused pilot using clearly identified e-waste fractions obtained through documented collection and appropriate pre-processing. The pilot design should include local governments, existing local collectors, repair businesses, and treatment operators to identify how materials can enter authorised treatment channels. It should also examine collection arrangements that are accessible to households and encourage consumers to return unwanted equipment through appropriate channels.

The pilot could test specifications for composition, hazardous constituents, and contamination, together with documentation and treatment verification. It should assess whether the proposed processing route enables environmentally sound recovery, including appropriate residual waste management. Evaluation should consider collection reliability, treatment costs, pollution risks, and local economic benefits, alongside technical recovery performance. Any cross-border movement should comply with applicable international and national requirements, including prior informed consent (PIC) procedures where required. Actors sending materials should verify their contents and documentation, while receiving operators should provide evidence of treatment and residual waste management. Japanese exporters and relevant authorities should contribute to prior verification when materials move from Japan to partner countries, and the same expectation of transparency should apply when selected fractions move to Japan or another destination for specialised recovery.

3.2. Strengthen local capabilities and agree on cost and value-sharing

Cooperation should strengthen local collection, sorting, and safe dismantling, while enabling access to specialised downstream recovery facilities. Governments and businesses should jointly identify training, equipment, and financing needs. Japanese authorities, businesses, and research institutions could contribute to the pilot through technical cooperation and treatment verification methods. Japan's technical cooperation has included support for institutionalising a household e-waste recycling fund management mechanism in Malaysia (Japan International Cooperation Agency, 2018). Basel Conven-

tion regional centres, such as those located in Indonesia and South Africa, could also serve as platforms for training and technology transfer (Basel Convention, n.d.-b).

Existing informal collectors and processors should help design a gradual transition that protects livelihoods and improves working conditions through training, registration support where needed, and links with authorised operators. Partners should agree on how to share recovered value and the costs of verification, transport, pollution control, and residual waste treatment, including where recovery revenues are insufficient. Arrangements should reflect domestic financing systems and support smaller operators and local business development.

3.3. Develop practical guidance through public-private dialogue and regulatory coordination

Environmental authorities, customs officials, local governments, producers, collectors, and treatment operators should use the pilot findings to develop practical guidance on material descriptions, quality requirements, documentation, treatment verification, receiving-facility capabilities, and responsibilities. Guidance should combine clear environmental requirements with workable procedures.

Experience from ASEAN-Japan public-private consultation, including cooperation through AMEICC, could provide practical lessons for organising this dialogue. For Asian partners, the Asian Network for Prevention of Illegal Transboundary Movement of Hazardous Wastes, proposed by Japan in 2003 and coordinated by Japan's Ministry of the Environment, offers an existing channel for cooperation among authorities on transboundary movements (Ministry of the Environment, Japan, n.d.-c). Partners could also examine how regional arrangements concerning circular economy activities and remanufactured goods relate to the proposed cooperation. Rules for reusable equipment, remanufactured goods, and waste fractions should reflect their different characteristics and applicable requirements.

Traceability tools, including battery passport systems where relevant, could be considered for selected material streams. Their use should be assessed against information needs, costs, and the ability of smaller operators to participate. Reporting should remain manageable for smaller operators, and training and practical support would be needed to help existing collection actors maintain records and connect with authorised treatment channels. Traceability arrangements should enable a gradual transition for actors whose activities are currently informal. Coordination should also address administrative obstacles to compliant cross-border circulation. Japan's Circular Economy Action Plan includes measures to digitalise PIC procedures and reduce processing time per case (Cabinet Secretariat, 2026), providing a reference for considering procedural improvements while maintaining environmental safeguards.

4. Issues for Further Discussion

Further dialogue between Global South partners and Japan could help refine the scope and implementation conditions of an initial pilot for environmentally sound e-waste resource circulation. Building on the challenges and policy priorities identified in this brief, the following questions merit joint examination:

1. Which domestically generated e-waste streams and pre-processed fractions would be suitable for an initial pilot, considering collection conditions, resource value, composition, and available treatment capabilities?

2. How can local governments, producers, collectors, and repair businesses improve household collection and sorting? What consumer practices and expectations need to be considered to encourage participation in appropriate collection channels?

3. How can informal collectors and processors participate in a gradual transition towards environmentally sound treatment without losing their livelihoods? What training, worker protection, financial support, and links with authorised operators would be needed?

4. How should processing activities, implementation costs, and recovered value be shared to strengthen local industrial capabilities and create benefits for participating countries? What evidence would be needed to assess pollution, emissions, working conditions, and livelihood outcomes alongside recovery performance?

Discussion of these questions can help identify an initial scope, potential participants, and evidence gaps. Joint research could support the pilot by examining technical performance together with environmental, industrial, and social outcomes. Findings should then be reviewed with participating authorities, businesses, local governments, and collection actors to refine the arrangements through implementation experience. This process would provide a stronger basis for a subsequent T20 policy contribution on cooperation between Japan and Global South partners in environmentally sound resource circulation.

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Part Ⅱ.

Sectoral Studies and Policy Recommendations

D. Advanced Technologies and New Business Creation

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Chapter 13: Industrialising Deep Tech and Co-Creation with the Global South: Japan's Growth Strategy and Policy Recommendations Centred on Fusion Energy

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1. Connecting Research to Industrial Growth

Of the 17 strategic growth fields designated by the Takaichi administration, quantum technology, fusion energy, AI and semiconductors, biotechnology and drug discovery, space, and others are positioned as "deep tech": fields that require long lead times and large amounts of capital to progress from research and development to practical application and commercialisation, and that carry a substantial risk of technical failure, but that, once successful, can profoundly transform industrial structures, national security, and the foundations of society.

When considering Japan's growth strategy and co-creation with the Global South, fostering deep-tech startups is a key challenge for generating new industries from research results and continuously returning the resulting added value to Japan. Even if the number of companies commercialising university-born technologies increases, this will not lead to a transformation of the industrial structure unless those companies reach the stage of continuously winning orders in global markets and making repeated investments in research and development and in facilities. The question going forward is how to achieve, in addition to a broad base of new ventures, the "height" of corporate growth and the "continuity" that links those achievements to the next challenge.

Considering this challenge from the perspective of international expansion, there are limits to viewing the relationship with the Global South solely as a destination for exports of finished Japanese products. Forming a new industry requires research, human resource development, component manufacturing, testing and evaluation, institutional development, and demand creation all at the same time. The ability of partner countries to participate in these processes and enhance their own industrial capabilities is a condition for sustaining cooperation. For Japan, too, joint development, expanded supply capacity, and designs that reflect local demand create opportunities to overcome constraints that are difficult to overcome domestically alone.

This paper discusses policy directions that link the industrialisation of deep tech with collaboration with the Global South, focusing on fusion energy. Fusion is a field in which Japan, with its accumulated strength in basic research, can expand its activities from equipment supply to system design and,

eventually, to power generation businesses. At the same time, it requires large-scale funding, long-term development, specialised human resources, and verification of safety and economic viability, and thus concentrates the challenges common to deep tech.

At the meeting of the Domestic Study Group on 28 August 2026, the author reported on the current state of Japan's deep-tech startups and their paths to success, focusing on the case of the fusion industry (Takeda 2026). This paper builds on the perspective presented there, which connects research, industry, and regional economies, and extends it to cooperation with Indonesia, India, Brazil, and South Africa. The central point of the discussion is not to introduce the same facilities in each country, but to create pathways for participation in industry formation that match each country's technological base and policy challenges.

What this paper proposes is a strategy in which Japan strengthens its capabilities in reactor design and in developing critical components while jointly pursuing testing and evaluation, human resource development, supply chains, and the study of future demand with partner countries. As the foundation for this, a "common knowledge base" will be built to share the state of technological achievement, evaluation methods, the handling of intellectual property, and benefit-sharing. This is not merely a mechanism for collecting information. It is an effort to establish the conditions under which research results can be compared, investment decisions made, and joint projects implemented across national and organisational boundaries.

2. The Height and Continuity Needed in Deep-Tech Policy

The number of university-launched ventures in Japan is steadily increasing. According to preliminary figures published by the Ministry of Economy, Trade and Industry (METI) in June 2026, there were 6,220 such companies as of October 2025, an increase of 1,146 from 5,074 the previous year (METI 2026). However, this figure covers all university-launched ventures, and not all of them are deep-tech companies conducting large-scale research and development. An increase in the number of companies cannot simply be read as an improvement in international competitiveness or as success in commercialisation.

In deep tech, it takes a long time to go from demonstrating scientific potential to finishing a product that customers can purchase. Even if a given performance is achieved once in the laboratory, the product cannot necessarily be manufactured repeatedly at the same quality. Only after long-duration operation, maintenance, stable procurement of raw materials, and integration with customers' equipment have been confirmed does it become viable as a business. The gap between the end of research funding and the start of business revenue creates the so-called "valley of death."

Accordingly, policy instruments need to differ between support for startup creation and support for growth. At the founding stage, identifying research seeds, connecting with management talent, and

organising intellectual property are important. At the growth stage, test facilities, preparation for mass production, long-term capital, and first customers are needed. If the number of startups founded is used as the main performance indicator, policy resources will be skewed towards the former and shortfalls in the latter will persist. Indicators such as deliveries to overseas customers, repeat orders, capital investment, and employment of R&D personnel should also be considered.

The significance of startups lies in their ability to advance research and business as one while taking on uncertainty. Researchers become actors who modify designs, bring together experts from different fields, and raise funds in order to deliver their own results to society. That said, not all research is suited to starting a company. Continuous public support for basic research is a prerequisite for generating future business opportunities and cannot be replaced by startup support.

For universities as well, mechanisms through which the results of commercialisation flow back to research and education are important. There are multiple pathways for such returns, including joint research, licensing income, the value of equity, and donations from alumni and founders. However, it is not appropriate to count on uncertain future equity income as a substitute for regular education and research budgets. In the long term, the goal is to nurture a cycle in which business success supports new research, and that research gives rise to the next business.

Cooperation with the Global South also needs to be built into this growth process. If overseas expansion is limited to sales activities after a product is completed, mismatches with local technical requirements and price conditions will only become apparent later. By having prospective customers and local companies participate from the joint research stage and confirming the required performance, operating environment, and maintenance arrangements, the direction of development can be corrected early. It is important to position international cooperation as industrial policy that creates outlets for research results.

3. The Position of Fusion in the Growth Strategy

Fusion is a technology that uses the energy generated by the fusion of light atomic nuclei. In the deuterium–tritium reaction, the representative approach under development, the energy of the neutrons produced by the reaction is extracted as heat, and fuel breeding using lithium is also essential. The wide availability of deuterium in seawater is an advantage in terms of resources, but building a power plant does not immediately make the fuel supply self-sufficient. A system must be established that includes securing the initial fuel, recovering and reusing tritium, breeding, and managing leakage.

In addition, although fusion does not use a fission chain reaction, that alone does not make a safety assessment of the facility as a whole unnecessary. Examinations specific to the approach and design are required, covering tritium management, activation of materials by neutrons, equipment failures, and radiation exposure during maintenance work. Accurately explaining the safety characteristics and

sharing the remaining challenges and how they will be managed is the starting point for building trust both in Japan and abroad.

The public-private investment roadmap decided by the Headquarters for Japan's Growth Strategy on 21 July 2026, sets out, for fusion, power generation demonstration in the 2030s, capturing approximately 30% of the global market over the medium to long term, and an expected public-private investment of approximately ¥3.1 trillion through FY2040 (Headquarters for Japan's Growth Strategy 2026). The investment amount here is a projection based on certain assumptions and does not mean that the full amount is a confirmed government budget. Achieving the targets will require technological progress and continued investment decisions.

The April 2026 report "Approaches to Initiatives towards the Social Implementation of Fusion Energy" emphasises the formation of entities that design, build, and operate entire plants, not just component technologies. It also distinguishes between power generation demonstration in the 2030s and the subsequent pre-commercial power generation demonstration (Expert Panel on Fusion Strategy for Promoting the Strengthening of Innovation Policy 2026). There is a gap between extracting electricity and supplying it stably over long periods at competitive prices. This difference must also be shared with partner countries in international cooperation.

When extending this policy direction to cooperation with the Global South, three time horizons should be kept in view. In the near term, joint development and order opportunities should be created for equipment for research facilities and for measurement and control technologies. In the next stage, capabilities in testing and evaluation, manufacturing, and quality assurance should be developed, and participation in the international supply chain supporting power generation demonstration should be advanced. Commercial deployment should be considered once the outlook for technology and costs has improved, with decisions made in light of the partner country's power plans and industrial demand.

This sequence has policy significance. Even if commercialisation is delayed, technologies and human resources in materials, vacuum, cryogenics, radio frequency, measurement, and other areas can be used in other industries and research infrastructure. Designing cooperation on fusion so that it does not stake everything on the future export of power plants, and so that results remain in each country even at intermediate stages, makes long-term participation possible.

On the other hand, investment in existing power sources, transmission grids, and energy efficiency should not be postponed on the grounds of expectations for fusion. Efforts to take on the challenge of future technologies and efforts to improve the current power supply must proceed in parallel on different time horizons.

4. Connecting Japan's Strengths to the Core of the Industry

Japan's strengths do not lie solely in the knowledge of plasma physics cultivated through many years of research. Through the design, manufacture, and operation of large-scale facilities, Japan has accumulated technologies spanning materials, superconductivity, heating, vacuum, precision machining, and plant engineering. The research facilities presented at the Domestic Study Group, such as JT-60SA (the superconducting tokamak of the National Institutes for Quantum Science and Technology [QST]), LHD (the Large Helical Device of the National Institute for Fusion Science), and GEKKO XII (the large laser facility of the Institute of Laser Engineering, Osaka University), symbolise the depth of research and engineering supporting different approaches (Takeda 2026).

Turning this technological base into industrial competitiveness requires both the capability to supply excellent components and the capability to make the entire system work. In the component market, it is relatively easy to capture demand common to different reactor concepts. On the other hand, the entities that manage reactor design, specification coordination between components, maintenance methods, and operating data influence the configuration of the entire supply chain. Even if Japan succeeds in improving the performance of individual components, its power to influence the distribution of added value will be limited if it cannot take part in design and procurement decisions.

The case of Kyoto Fusioneering, which the author co-founded, shows that technologies supporting fusion can become businesses even before power plants are commercialised (Takeda 2026). What matters is not to make the growth of any particular company a policy objective in itself, but to nurture multiple pathways for converting technologies accumulated through research into products and services that can meet customer requirements. An environment is needed in which companies that supply equipment and companies that integrate reactors and plants enhance their capabilities through both competition and cooperation.

Furthermore, international competition is not determined solely by when power generation is achieved. Even if the first facility can be built, an industry will not expand unless the next facilities can be built cheaply, reliably, and quickly. Design with mass production in mind, component configurations that facilitate replacement, long-term procurement contracts, and the training of maintenance personnel will determine competitiveness. These perspectives also need to be incorporated into the evaluation of technology demonstrations.

Cooperation with the Global South should be positioned within this industrialisation process. For example, one possible configuration is for Japanese companies to handle critical components and design integration, while companies in partner countries handle structures, auxiliary equipment, on-site construction, and maintenance under appropriate quality certification. However, fixing roles from the outset would narrow the scope for partner countries to advance technologically. A mechanism that allows the scope of responsibilities to expand in line with the results of joint development and the accumulation of skills is desirable.

In regions with energy resources, the development of those resources has promoted industrial agglomeration and urban formation. In fusion, the source of value may shift from underground resources to knowledge of technology, design, manufacturing, and operation. The perspective the author presented in a lecture, which reframes energy from "geo-politics" to "knowledge-politics," refers to this change. However, if benefits are concentrated only in the few countries that possess this knowledge, new relationships of dependence will arise. Reconciling the securing of technological competitiveness with capacity building in partner countries is a challenge for Japan's international strategy.

5. The International Division of Labour in Light of Economic Ripple Effects

In assessing the significance of industrialisation, it is necessary to capture not only expectations of market size but also which regions and industries investment flows to and how it generates income and employment. At the Domestic Study Group, the author presented estimates from a multi-country input–output analysis covering the construction and operation of a fusion power plant (Takeda 2026). This analysis does not guarantee a forecast of future outcomes; rather, it visualises economic linkages under assumed cost structures and procurement conditions.

The estimates were based on an existing cost model for CREST (Compact Reversed Shear Tokamak), a reactor concept proposed by the Central Research Institute of Electric Power Industry (CRIEPI), adjusted for prices and exchange rates, and set costs of ¥1.5940 trillion for equipment procurement, ¥1.4816 trillion for construction, and ¥0.7480 trillion for operation, for a total of ¥3.8236 trillion. Against this, induced production worldwide amounted to ¥9.4958 trillion, of which ¥7.8398 trillion was domestic. Induced value added was ¥4.3464 trillion worldwide and ¥3.8686 trillion domestically. As for employment, the materials show a cumulative effect over 20 years of approximately 460,000 persons in Japan.

Induced production represents the spread of production activity, including inter-firm transactions, and its full amount does not translate into an increase in GDP. Nor can the cumulative employment effect be read as the number of permanent jobs existing at any one time. These distinctions are essential when explaining the scale of investment for policy purposes. The investment projection in the government roadmap and these estimates are also separate figures with different target periods and cost items, and should not simply be added together or compared.

The lecture materials also compared procurement centred on domestic companies with procurement assuming an ITER (International Thermonuclear Experimental Reactor)-type international division of responsibilities. The results showed that the final share of benefits accruing to the host country fell from 77.9% in the former to 45.4% in the latter, while the economic effect worldwide increased (Takeda 2026). This analysis shows that the procurement structure determines the distribution of benefits.

However, the decline in the share alone does not warrant the conclusion that the amount of benefits to the host country decreases in the same proportion. Nor can these figures alone evaluate shortfalls in domestic production capacity or improvements in cost and construction schedules resulting from an international division of labour.

Japan's policy challenge is not to keep all processes within the country, but to create a structure in which research and development, design, advanced manufacturing, and income remain in Japan even as the international division of labour advances. Partner countries, for their part, also place importance on how much employment and technology remains in their own country. Reconciling the two requires evaluating not only the value of exports from Japan but also value added in the partner country, skills formation, and the participation of local companies.

Accordingly, this paper proposes that, when designing joint projects, procurement tables by country and by industry be prepared and scenarios such as domestic-production-centred, joint production, and expanded local production be compared. Evaluating not only construction costs but also operation and maintenance, component replacement, and reinvestment makes the relationship between short-term orders and long-term industrial development easier to see. Rather than applying the author's estimates directly to the four countries, analysing them jointly in line with each country's industrial structure and procurement capacity will be a concrete task for the common knowledge base.

6. Japan's Bottlenecks and Overcoming Them through Cooperation

The first bottleneck is that the timescales of research and development and of funding are difficult to align. In fusion, it takes a long time to build, test, and improve facilities. Even with technological progress, sustaining fundraising is difficult if it takes a long time to generate revenue. Public support should adopt a milestone-based approach that confirms scientific and engineering achievements and accumulates evidence that leads to subsequent private investment. International joint research can share the burden of development, but it does not in itself resolve the shortage of long-term capital on the Japanese side.

The second is a shortage of specialised human resources. What is needed is not only plasma researchers but also personnel in manufacturing, welding, electrical engineering, measurement, thermal engineering, project management, quality assurance, and safety assessment. Merely recruiting talent from overseas may compete with capacity building in partner countries. A mechanism is needed that combines joint supervision, corporate internships, short-term stays, and continued research after returning home, so that human resources circulate between bases in both countries. In addition to the number of people hired, it is necessary to track where the people trained are working and what capabilities they are exercising.

The third is access to testing and evaluation. Demonstrating the performance of new components requires facilities suited to the application, such as for high heat loads, vacuum, cryogenic temperatures, and radiation. It is difficult for startups to own all of these themselves. Organising information on existing facilities in Japan and abroad and sharing their terms of use and measurement methods can curb duplicative investment. However, differences in test environments must be made explicit. For example, materials evaluation using existing research reactors is not the same as demonstration in the neutron environment specific to fusion reactors.

The fourth is expanding supply chains. Moving from the stage of delivering one-off items to research facilities to the stage of stably supplying multiple plants requires the standardisation of manufacturing processes, inspection, records, and change management. Joint manufacturing with partner countries can contribute to expanding supply capacity and shortening delivery times. However, choosing manufacturing sites based solely on low labour costs overlooks the costs of defects, rework, transportation, and inspection. Evaluations should include total costs, quality, and substitutability in the event of supply disruptions.

The fifth is uncertainty in demand and institutions. Even if the technology is established, conditions allowing electric utilities and industrial customers to decide on adoption will not necessarily be in place. Tariffs, grid connection, operational responsibility, decommissioning, maintenance, and other matters need to be examined early. Inviting prospective customers in partner countries from the design stage enables the Japanese side to identify constraints it had not anticipated. International cooperation is a forum not only for transferring technology in one direction but also for the Japanese side to relearn the premises of its products and businesses.

What these forms of cooperation have in common is the need to clarify which parts are carried out jointly and which parts each country and each company is responsible for. In particular, the handling of initial fuel, critical design information, and business responsibility requires specific confirmation separate from general research exchange. Rather than vaguely expanding the scope of cooperation, selecting feasible tasks and expanding them step by step while verifying the results offers greater sustainability.

7. Current Status of the Four Priority Countries and Directions for Cooperation

7.1. Indonesia

Regarding Indonesia, BRIN (National Research and Innovation Agency, Badan Riset dan Inovasi Nasional), in an official communication introducing its technical cooperation with Thailand on cyclotrons, has expressed expectations for a future tokamak or plasma fusion facility (BRIN n.d.). While

this indicates interest in research capacity and human resource development, it does not mean that construction of a commercial fusion power plant has been decided. The starting point for cooperation should be translating expectations for introducing facilities into concrete human resource plans and research topics.

In cooperation with Japan, fields common to research facilities and other industries, such as vacuum technology, power supplies, measurement and control, and numerical analysis, will serve as entry points. Rather than completing training in Japan, facilities, teaching materials, and joint projects that returning researchers can work with locally should be prepared. Even when introducing necessary equipment, it is important to consider not only the purchase cost but also operating costs, component replacement, and the continued assignment of responsible staff as a whole.

In considering future demand, it is necessary to understand the scale of the power grid, industrial agglomeration, cooling conditions, and maintenance arrangements for each site. A large potential demand at the national level is different from having the conditions in place for deploying individual facilities. As near-term joint projects, this paper proposes prioritising surveys of research and industrial capabilities, educational programmes, and joint prototyping of auxiliary equipment and measurement instruments. The Japanese side can learn local technical requirements, while the partner country can accumulate capabilities usable across multiple fields.

7.2. India

India is not merely a future adopter but a partner that already has a track record in the international fusion supply chain. ITER-India is responsible for supplying equipment including the cryostat, cooling systems, cryogenic systems, heating systems, power supplies, and diagnostics (ITER-India n.d.). For the ITER cryostat, a large-scale international process combining manufacturing in India with on-site assembly has been carried out (ITER Organization n.d.). This is an important example of research participation leading to manufacturing capabilities and human resource development.

Therefore, rather than centring on basic technical guidance, cooperation between Japan and India should emphasise joint development that combines the track records of both countries and the formation of commercial projects. One possibility is to select specific targets, such as large structures, cryogenic and cooling systems, power supplies, and quality assurance, and to jointly design requirement specifications, prototyping, inspection, and post-delivery responsibilities. Joint proposals by companies from both countries for projects in third countries are also worth considering.

The challenge lies not only in whether technological capabilities exist but also in linking contracts with business operations. Unless responsibility for design changes, the use of intellectual property arising from joint development, the scope of warranties, and schedule management are clarified, the advantages of the division of labour will be lost. Moreover, Indian companies are competitors as well

as partners. On the premise of equal standing, areas should be selected where joint efforts can improve costs and development timelines.

7.3. Brazil

Brazil has accumulated expertise in plasma research centred on TCABR (Tokamak Chauffage Alfvén Brésilien), the tokamak at the University of São Paulo. The university's official description shows research using TCABR on high-temperature plasma confinement, basic physics, waves, and other topics (Universidade de São Paulo n.d.). This base provides a point of contact for concretely launching joint research and education. However, the existence of a research facility should not be taken as evidence that manufacturing and operational capabilities for commercial power generation are in place.

Possible entry points for cooperation include measurement, data analysis, control, and numerical simulation. Issues arising from Japan's large facilities would be linked with Brazil's research facilities and personnel to set common analysis tasks and comparative experiments. It is important that joint research not end as a one-sided provision of data, and that everything from formulating research plans to publishing results and handling intellectual property be designed on an equal footing.

Towards industrialisation, it is necessary to establish pathways through which university research results lead to product development by local companies. One possible framework is to start with prototyping small-scale measurement devices and control systems, with research institutions acting as customers to evaluate their performance. Regarding future demand for power generation facilities, combinations with existing power sources and industrial applications should be concretely compared, and the role expected of fusion should be defined together with local stakeholders. It is important not to confuse a track record of research exchange with the existence of industrial demand.

7.4. South Africa

In South Africa, the South African Nuclear Energy Corporation (Necsa) has accumulated experience at its SAFARI-1 research reactor in radioisotope production, irradiation services, and safety and quality management (Necsa n.d.). Although this is not a track record of fusion power demonstration, it is a useful adjacent base for considering the operation of radiation-utilisation facilities, materials evaluation, quality assurance, and human resource development. Judging the potential for cooperation solely by whether large dedicated fusion facilities exist would overlook such capabilities.

In cooperation with Japan, one option is to set joint tasks in materials characterisation, inspection procedures, facility maintenance, and quality control. Tests that can be conducted at existing facilities would be distinguished from those requiring additional confirmation in other environments, and the scope of applicability of the evaluation results would be clarified. Connecting experience in educating radiation-related engineers to training for fusion could also be considered.

A perspective is also needed that links the formation of new industries to the transformation of regional skills and employment. Rather than promising large-scale employment on the assumption of future power plant deployment, it should be examined which skills current engineers would need to add in order to participate in materials evaluation and equipment maintenance. If universities, research institutions, and companies in both countries jointly develop job-specific training, skills usable in other industries will remain even if progress in fusion is slower than expected.

What the four countries have in common is that the maturity of cooperation cannot be expressed in a single ranking. India's equipment supply, Brazil's plasma research, South Africa's irradiation and quality management, and Indonesia's interest in capacity building each offer different points of contact. Rather than allocating support uniformly by country, projects should be selected by confirming the tasks that individual institutions and companies can carry out, the resources for sustained operation, and the benefits for both sides.

8. The Common Knowledge Base and the Joint Formation of Rules

The first advantage of establishing a common knowledge base is that it can reduce gaps in understanding about technology. In fusion, plasma performance, demonstration of individual components, power generation, and commercial operation tend to be described with the same word, "realisation." What has been achieved differs depending on whether the facility's power consumption is included, how long operation lasted, and whether fuel was supplied externally. For decisions on joint research and investment, what has been confirmed and what remains must be recorded in a common format.

Specifically, the performance of facilities and components, test conditions, measurement accuracy, reproducibility, failure history, and technology readiness will be organised. For economic evaluations, the price year, currency, exchange rate, target period, procurement countries, and capacity factor will be recorded. When analysis results differ among countries, it should be possible to explain the reasons as differences in technology or industrial structure. Being able to trace the assumptions is more important than a database that merely lists figures.

The second advantage is that partner countries can participate in rule-making from an early stage. Merely presenting specifications and evaluation methods decided in Japan after they have been finalised may result in a mismatch with local operating environments, inspection facilities, and staffing. Considering common safety objectives, test methods, and record formats from the initial stage and clarifying the additional conditions required in each country would reduce later design changes and duplicate testing.

The order of harmonisation also matters. First, terminology and test data formats should be aligned; next, comparative tests should be conducted and the reproducibility of results confirmed. On that basis, the treatment of test reports and the mutual use of certification can be considered. Wholesale unifi-

cation of institutions and regulations should not be sought from the outset. Increasing the technical elements that can be shared, while respecting the decision-making authority of each country, is more feasible.

The third advantage is that it becomes easier for startups to participate in market formation as well. Standardisation and international meetings require specialised personnel, time, translation, and travel expenses. If discussions proceed only among large companies and research institutions, the practices of new approaches and small companies are less likely to be reflected. Support for startups' participation costs, technical and legal consultation, and administrative support for joint proposals should be provided, establishing a mechanism through which companies can submit views regardless of their size.

However, the common knowledge base is not a mechanism for disclosing all of a company's design information. It distinguishes between test methods that are made public, measurement data shared only among contract participants, and design information retained by each company. Before joint development begins, procedures for background intellectual property, new results, improvement inventions, and the publication of results must be established. It is precisely because the protection of information is clear that companies can participate in joint research.

As for the operating body, this paper proposes joint operation by universities and public research institutions, industry, and institutions responsible for regulatory and institutional frameworks in each country. A structure in which only Japan sets the agenda should be avoided, and partner countries should also be given opportunities to make proposals and conduct evaluations. It is also necessary to connect with existing international exchange frameworks such as those of the International Atomic Energy Agency (IAEA) and to avoid adding duplicative meetings and databases. Jointly charting a path to growth gives companies a clear outlook for their investments and human resources a clear outlook for their career paths.

9. A Policy Package for Achieving Mutual Benefit

9.1. A Joint Contact Point to Nurture Cooperation Projects

First, this paper proposes establishing a contact point that identifies cooperation projects between Japan and the four priority countries and supports them continuously from research to commercialisation. It would be desirable to make use of existing mechanisms for research exchange and business support and to connect bases in each country. The role of the contact point is not merely to hold networking events but to identify technical challenges and prospective customers, introduce appropriate partner institutions, support contracting, and track results.

In the first year, research facilities, corporate manufacturing capabilities, human resources, and potential demand in each country will be surveyed using a common format. On that basis, tasks will be selected for which the significance of working jointly, technical feasibility, and the partner country's capacity for continued operation have been confirmed. There is no need to create the same number of large-scale projects in each country. Efforts should start with small-scale projects for which a concrete implementing entity exists.

9.2. Seamless Support from Joint Research to Demonstration Procurement

Next, joint research grants should be linked with the purchase and evaluation of prototypes. Providing research funding alone does not sufficiently confirm whether a product meets the specifications customers require. A mechanism should be established whereby research institutions and demonstration operators purchase measurement instruments, power supplies, material test specimens, and the like for testing purposes and return the results to developers. This enables startups to build a track record of product use that they can explain to subsequent customers.

Funding will be provided in stages. Proof of concept, prototyping, third-party evaluation, and testing in the customer's environment will each serve as milestones, and progression to the next stage will depend on what has been achieved. Rather than committing to the construction of large facilities with a predetermined total budget, investment should be built up on the basis of technical and operational evidence. Even for projects that are not continued, the knowledge gained and the reasons for termination should be recorded and applied to the next projects.

9.3. Combining Shared Test Facilities with Supplier Development

Support for shared facilities through construction subsidies alone is insufficient. Only when usage fees, available time slots, technical support staff, and confidentiality of results are in place can companies incorporate these facilities into their development plans. Linking facilities in Japan and abroad and conducting comparative tests and mutual visits will increase confidence in measurement results. At the same time, support for quality assurance and records management should be provided so that companies that have undergone testing can improve their manufacturing processes.

In supplier development, there is no need to require full local manufacturing of finished equipment from the outset. Companies can participate starting with test specimens, machined parts, auxiliary equipment, and the like, and expand their scope of responsibility once performance and delivery times have been confirmed. For Japanese companies, this increases the options for suppliers; for companies in partner countries, it creates a pathway to move into higher-value-added processes.

9.4. Two-Way Human Resource Development and Formation of Regional Hubs

Graduate education and corporate internships should be combined to develop both researchers and practitioners. In addition to joint supervision, the treatment of credits, and support during stays,

linkages with research funding and positions after returning home should be designed. Opportunities should also be created for Japanese researchers and engineers to work in partner countries and learn local manufacturing and operating conditions. Ensuring that the movement of human resources is not one-way increases trust in the cooperation.

Regional hubs should not be considered solely in terms of power plant siting. Bringing together research, testing, education, manufacturing, and maintenance generates economic activity even before operation begins. The concept of fusion hubs presented at the Domestic Study Group should be extended to international cooperation, linking regions in Japan with research and industrial hubs in partner countries. It is also important for local governments, universities, and companies to examine the conditions for retaining human resources, including housing, education, and transportation.

9.5. Joint Evaluation with Customers and Long-Term Financing

Regarding future commercial deployment, the necessary price, capacity factor, maintenance periods, and siting conditions should be evaluated jointly with electric utilities and industrial customers. Power generation performance at the demonstration stage does not directly translate into the ability to fulfil commercial contracts. The appropriate type of funding differs between research and development with high technical risk and capital investment for which revenue prospects have been established. Institutional design is needed that considers R&D support for the former and loans, guarantees, and the like for the latter, without confusing the stages.

When deciding on specific financial support, the scope and business conditions of existing schemes should be checked case by case. Not excessively increasing the public burden in partner countries or the tariff burden on customers is also a condition for continuing cooperation. Projects should be selected in which Japan's export promotion and the partner country's industrial and energy policies can be achieved simultaneously.

10. Implementation Schedule and Measuring Results

This paper proposes that the policy package first set FY2027–FY2028 as a period for establishing the foundations of cooperation. Surveys of each country's capabilities and demand, selection of joint research topics, and preparation of contract templates and data formats will be advanced. The outcome of this stage should be not the number of memoranda of understanding but the launch of joint projects with assigned staff and secured operating resources. Work that can be carried out at existing facilities should be prioritised to build experience in joint work early on.

In FY2029–FY2030, efforts will move on to evaluation of prototypes, comparative testing, supplier development, and joint proposals. What should be evaluated, in addition to papers and the number of training participants, are performance confirmed by third parties, trial use by customers, repeat orders,

and quality improvements. A mechanism will also be established to feed knowledge gained from joint projects back into domestic development and discussions on standardisation.

The link to power generation demonstration in the 2030s and beyond will be determined according to technological progress. Not all partner countries need to build power plants at the same time. Various forms of participation are possible, including equipment supply, human resource development, testing and evaluation, and operation and maintenance. If moving towards commercial deployment, concrete verification should be required regarding net power generation performance, the fuel cycle, equipment durability, maintainability, and cost.

The outcomes of the policy as a whole need to be measured from both the Japanese side and the partner country side. On the Japanese side, the results of joint development, export and licensing revenue, supply capacity for critical components, and R&D employment will be examined. On the partner country side, local value added, the activities of trained personnel, the continued participation of local companies, and the capacity to evaluate technology independently will be examined. For joint projects as a whole, development timelines, testing costs, quality, and the continuity of investment will be evaluated.

It is appropriate to set numerical targets after establishing baselines through the first-year surveys. Setting the number of trainees or companies first without understanding the current situation risks skewing efforts towards easily achievable activities. In addition, what would remain in each country if the commercialisation of fusion were delayed should also be subject to evaluation. If technologies, human resources, and test methods applicable to other fields are accumulated, such cooperation has independent value.

Decisions on whether to continue support should be made using external evaluations by experts versed in both technology and business, with the relationships between evaluators and the companies being evaluated made clear. Rather than regarding every failure to meet a target as a failure, the causes must be identified. The appropriate response differs depending on whether a scientific limit has been revealed, project management was inadequate, or the demand assessment was wrong. International cooperation, too, requires management that can revise plans while learning.

11. Reconciling Japan's Growth with Capacity Building in Partner Countries

Fusion is an opportunity to link the science and technology Japan has accumulated to new industries and regional income. Its success hinges not only on the technical question of whether power generation can be achieved but also on the industrial question of who will design, manufacture, operate, and capture value. Deep-tech policy is required to answer both.

Cooperation with the Global South is not a supplementary measure for delivering Japanese technology overseas. By jointly building supply capacity, human resources, evaluation infrastructure, and future demand, it is a strategy for improving the very conditions for Japan's industrialisation. At the same time, partner countries acquiring the capacity to understand, choose, and improve technologies on their own provides the basis for long-term cooperation.

To this end, the areas in which Japan protects its advantages and the areas in which value is increased jointly must be concretely designed. While securing critical intellectual property and design capabilities, cooperation should be expanded in test methods, education, quality assurance, and local business operations. It is necessary to make visible the benefits generated by the international division of labour and to embed in contracts and policies the conditions under which both sides can grow.

Indonesia, India, Brazil, and South Africa each have different pathways for participation. Rather than Japan presenting a single development model and asking others to follow it, it is important to select feasible work based on existing capabilities and build up results. The common knowledge base provides the technical and institutional foundation for this.

What Japan's growth strategy should aim for is to connect research results to new ventures, to grow those ventures into sustainable industries, and to increase the number of international partners in that process. The long period leading up to the realisation of fusion should be turned not into a mere wait for power generation but into a period for nurturing technologies, human resources, companies, and regions. That accumulation will simultaneously underpin Japan's competitiveness and capacity building in the Global South.

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Chapter 14: Does the Circular Economy Make the World Better Off? Global Impacts of Using Domestic Recycled Materials in Japan, India, Indonesia, Brazil and South Africa

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Key messages

- Domestic use of recycled materials that are already collected reduced world GHG emissions in eight of the nine country–material cases examined, by approximately 28.7 Mt CO_2e per year in total; cement in India accounted for 70% of this reduction.
- Clinker substitution with slag and fly ash reduced world emissions in all five countries, with little offsetting in other countries in the main case.
- For steel scrap, the result depends on how former importing countries respond: for Japan, world emissions increase by 0.27 Mt CO_2e if they compensate with ore-based iron, but decrease by 9.88 Mt CO_2e if they do not.
- In the main case, domestic value added did not decrease in any case, whereas domestic employment decreased in eight of the nine cases, mainly in industries supplying primary materials. These findings point to shared measurement of global net impacts, coordination of scrap policies along trade routes and support for affected workers.

1. Introduction

1.1. Circularity Indicators and Global Outcomes

The circular economy has become a common policy framework across the G20. Japan, India, Indonesia, Brazil and South Africa have each adopted targets or strategies to increase the use of recycled steel, supplementary cementitious materials and recycled plastics. Progress towards these goals is typically monitored with circularity indicators, such as recycling rates, the scrap share of steelmaking inputs and the clinker content of cement. These indicators quantify the volume of material in circulation, but they do not indicate whether the associated environmental and socio-economic outcomes improve at the global scale.

Circularity indicators and global outcomes can diverge for two reasons. First, the environmental benefit of a recycled material depends on the quantity of primary production that it actually displaces,

rather than on the quantity collected (Zink and Geyer 2017). Second, many recycled materials are internationally traded and available only in limited quantities. Steel scrap is a prominent example: when one country retains its scrap for domestic use, former importing countries must compensate for the shortfall, frequently through ore-based ironmaking. Consequently, a measure that reduces emissions in one country may increase emissions elsewhere, and an assessment confined to national boundaries may misjudge not only the magnitude but also the sign of the net effect.

These cross-border effects are particularly relevant to the Global South. India, Indonesia, Brazil and South Africa are simultaneously major producers of basic materials, importers or exporters of scrap, and suppliers of iron ore, coal and other raw materials to the global economy. A circular-economy measure adopted in one G20 economy can therefore alter mining activity, water consumption, land use and labour conditions in these countries through international supply chains. National circularity indicators do not capture such spillovers.

1.2. Policy Context: National Strategies for Recycled Materials

All five countries have adopted, or are developing, policies that would increase the use of recycled materials. India's National Steel Policy 2017 sets the long-term direction of its steel sector, and its Steel Scrap Recycling Policy aims to expand domestic scrap collection and processing (Ministry of Steel 2017, 2019). Japan's Plastic Resource Circulation Strategy targets a doubling of recycled plastics use by 2030 (Ministry of the Environment of Japan 2019), and the long-term vision of the Japan Cement Association envisages a lower clinker ratio (Japan Cement Association 2022). The Brazilian cement industry has published a technology roadmap that likewise reduces the clinker ratio (SNIC and ABCP 2019), and South Africa restricts scrap exports through a price preference system intended to secure scrap for domestic industry (ITAC 2020).

Achieving these goals will in many cases require more than the domestic use of materials that are already collected, including expanded collection, improved sorting and international trade in recycled materials, each of which involves partner countries. The scenario examined in this study, the full domestic use of recycled materials that are already collected, represents a first step that each country can take unilaterally. Its cross-border effects are therefore relevant to the design of subsequent, more ambitious measures.

1.3. Research Questions

In this study, we investigated whether the domestic use of recycled materials improves outcomes for the world as a whole, rather than only for the country that adopts the measure. Specifically, we addressed three research questions:

RQ1. If each of the five countries used all the recycled materials that it already collects domestically, would global greenhouse gas (GHG) emissions decrease, and to what extent would domestic reductions be offset by increases in other countries?

RQ2. Where do the environmental and social side effects of these measures, namely water consumption, cropland use, iron ore extraction, air pollution and human rights risks, occur: in the country adopting the measure or in its trading partners?

RQ3. How do value added and employment change in the adopting country and in the rest of the world?

To answer these questions, we coupled country-level material-flow data with a global multi-regional input–output (MRIO) model covering three materials (steel, cement and plastics) in five countries. Our objective was not to rank countries, but to identify which circular-economy measures yield global net benefits, where the associated burdens arise, and what forms of cooperation between Japan and its Global South partners could make such measures beneficial for all parties.

This paper is organised as follows. In Section 2, we describe the data and methods used in this study. In Sections 3–7, we present the overall results and the effects on climate, cross-border emissions, environmental and social indicators, and the economy. In Sections 8 and 9, we discuss the implications for each country and for policy, respectively. Section 10 describes the limitations of this study, and Section 11 concludes.

2. Data and Methods

2.1. Scope and Scenario

This study covers the four Global South countries that held the G20 presidency consecutively from 2022 to 2025 (Indonesia, India, Brazil and South Africa), together with Japan. We selected three materials because they account for a substantial share of industrial emissions and because their circular pathways differ. In steel, scrap melted in electric arc furnaces substitutes for iron produced from ore and coal in blast furnaces at a ratio close to one. In cement, industrial by-products such as granulated blast-furnace slag and coal fly ash substitute for clinker, the production of which releases process CO_2 from limestone calcination. In plastics, recycled resin substitutes for virgin resin produced from fossil feedstock; however, collection frequently relies on informal workers, and data availability is most limited.

Throughout this paper, the term “recycled materials” refers to steel scrap, recycled plastic resin, and the slag and fly ash used in cement. It should be noted that slag and fly ash are, strictly speaking, by-products of other industries rather than recycled products; we treated them together because they perform the same function of displacing primary inputs.

We analysed a single scenario in which each country uses domestically all recycled materials that are already collected but not used within the country. These comprise the net exports of scrap, slag, fly ash and plastic waste in 2019, together with fly ash that was generated but not utilised. We did not assume

any new collection systems, imports or technologies. Table 1 presents the corresponding quantities. Of the 15 country–material combinations, plastics in India and Indonesia were excluded because primary data on recycled resin were unavailable, and plastics in South Africa cannot be represented because the MRIO model has no separate recycling sector for South Africa. Of the remaining 12 combinations, nine involve a change in practice. The other three involve no surplus material: India and Indonesia are net importers of steel scrap, and Brazil was a net importer of plastic waste in 2019 (Table 1); South Africa was likewise a net importer of plastic waste.

Table 1. Recycled materials used domestically in the scenario (million tonnes per year, 2019 basis)

Material (displaced input)	Japan	India	Indonesia	Brazil	South Africa
Steel: scrap (iron ore and coal)	7.55	0	0	0.54	0.40
Cement: slag and fly ash (clinker)	10.62	37.28	2.32	0.51	0.31
Plastics: recycled resin (virgin resin)	0.88	n.a.	n.a.	0	0

Note: 0 indicates that no unused domestic material is available; n.a., data not available. For cement in India, the clinker ratio was not reduced below 0.60, which was adopted as a technical lower limit. Sources: UN Comtrade, worldsteel, Japan Iron Source Association, Andrew (2024), Japan Cement Association, Plastic Waste Management Institute, PICPlast and Plastics SA.

2.2. Data and Indicators

In this study, we used the full-resolution Eora MRIO database for 2021, which describes inter-industry transactions among 14,839 sectors in 190 countries and regions (Lenzen et al. 2012, 2013). Physical data for 2019 on production, scrap use, clinker ratios and plastics recycling were compiled from public statistics and industry reports, including worldsteel (2020), the Japan Iron Source Association (2020), Andrew (2024), the Japan Cement Association, the Plastic Waste Management Institute (2020), ABIPLAST (2021) and Plastics SA (2020). International trade in scrap and other recycled materials was obtained from UN Comtrade (2019).

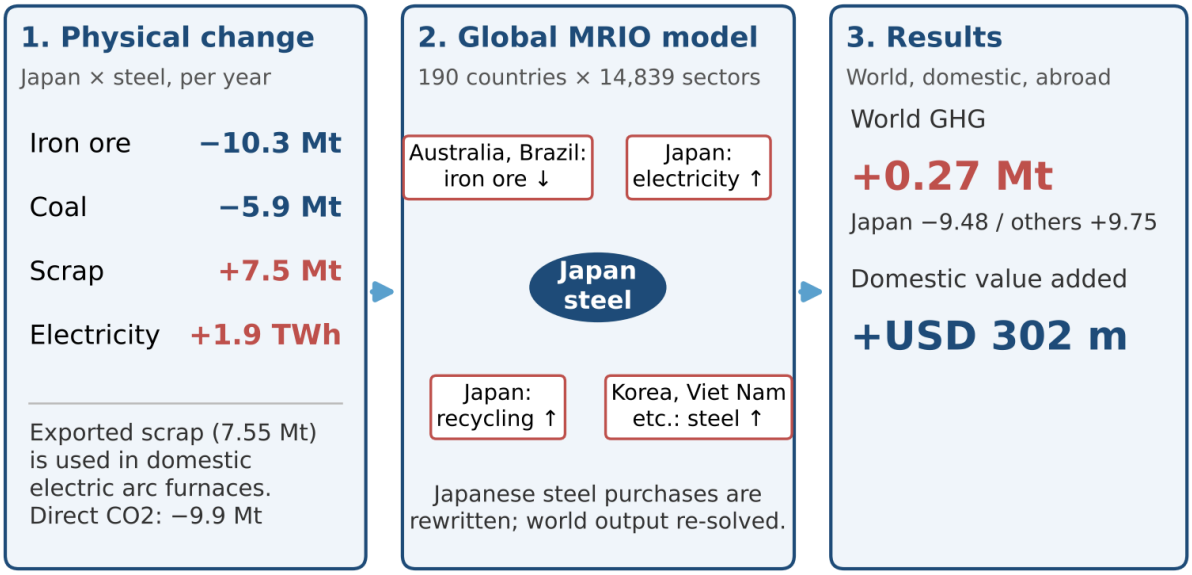
We used twelve indicators. GHG emissions are taken from the PRIMAP-hist dataset (version 2.4; Kyoto gases, excluding land use, land-use change and forestry) (Gütschow et al. 2016; Gütschow and Pflüger 2022). For steel and cement, we calculated changes in direct emissions at plants from physical data rather than from the sectoral emission intensities of the MRIO model. The allocation of national emissions to sectors follows the satellite accounts of the Eora database. The physically calculated changes in direct emissions were added to the steel or cement sector of the country concerned, and the emissions from additional electricity use were replaced by the change in electricity consumption multiplied by the national grid emission factor for 2019. The economic indicators are value added and employment. The environmental indicators are blue water consumption, grey water, cropland use, iron ore extraction and SO_2 emissions. The human rights indicators, derived from the Social Hotspots Database (SHDB;

Social Hotspots Database 2022), are the risks of child labour, forced labour, occupational injury and violation of indigenous rights. Each risk is expressed in risk-weighted working hours, in which every hour of work in a given country and sector is weighted according to the risk level assessed in the SHDB. The weights were set in this study as 0.02 for low, 0.07 for medium, 0.15 for high and 0.25 for very high risk, and zero for very low risk and where no data were available. These weights are not derived from the SHDB itself; the human rights results are therefore used for relative comparison only and not for the overall assessment.

2.3. Model

The analysis consists of three steps, as illustrated in Figure 1 for steel in Japan.

Figure 1. The three steps of the analysis, illustrated with steel in Japan



In the first step, we quantified the physical change. In 2019, Japan's net exports of steel scrap amounted to 7.55 million tonnes. Using this scrap in domestic electric arc furnaces raises the electric arc furnace share of Japanese crude steel production from 24.5% to 33.1%, reduces iron ore consumption by 10.3 million tonnes and coal consumption by 5.9 million tonnes, and increases electricity consumption by 1.9 TWh. Direct CO_2 emissions from Japanese steelworks decline by 9.9 million tonnes. We assumed substitution ratios of 0.95 for scrap relative to primary iron (range 0.90–1.00), reflecting yield losses in electric arc furnaces (Japan Iron Source Association 2020); 0.75 for recycled relative to virgin resin, the midpoint of a range of 0.5–1.0, because recycled resin is often downcycled and does not displace virgin resin one-for-one (Zink and Geyer 2017); and 1.0 for slag and fly ash relative to clinker, a design assumption that follows the mass-based substitution in blended cement standards.

In the second step, we translated the physical change into changes in the input coefficients of the MRIO model. For steel in Japan, we modified the input structure of the Japanese steel sector to reflect lower purchases of iron ore and coal, higher purchases of scrap and electricity, and a lower direct emission intensity. Holding final demand y constant, we computed total output after the change as

$$x' = (I - A')^{-1} y, \tag{1}$$

where A′ is the modified matrix of input coefficients and I is the identity matrix. The change in indicator F is then

$$\Delta F = E' x' - E x, \tag{2}$$

where E and E′ denote the matrices of indicator intensities per unit of output before and after the change, and $x = (I - A)^{-1} y$ denotes the baseline total output. In the main case, we assumed that countries that previously imported Japanese scrap compensate for the shortfall through ore-based ironmaking, which emits approximately 1.16 tonnes of CO_2 per tonne of scrap replaced, that is, the difference in direct CO_2 intensity between blast furnace–basic oxygen furnace steel (1.2 t per tonne) and scrap-based electric arc furnace steel (0.04 t per tonne) (IEA 2020). Section 5 examines an alternative case in which they do not.

In the third step, we decomposed the change in each indicator into the change in the world, in the country adopting the measure and in all other countries combined. Because final demand is held constant, the analysis is comparative-static: it compares two states of the same year, with and without the circular measure, and does not constitute a forecast.

3. Overall Results

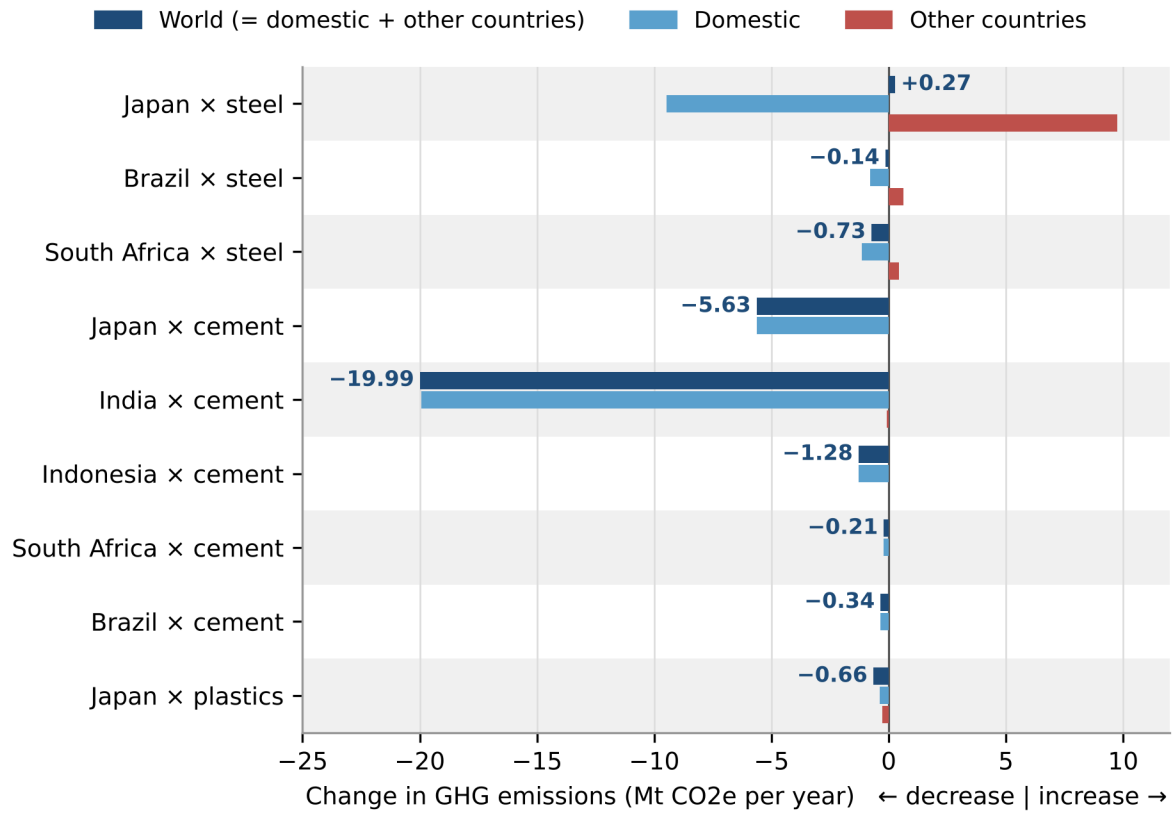
Table 2 and Figure 2 summarise the results for the nine cases that involve a change. We found that world GHG emissions decreased in eight of the nine cases, while domestic value added did not decrease in any case under the main assumption that savings on material costs accrue to producing firms (Section 7). The exception is steel in Japan, for which world emissions increase slightly. If all nine measures were implemented, world GHG emissions would decrease by approximately 28.7 million tonnes CO_2-equivalent (Mt CO_2e) per year. Cement accounts for 96% of this reduction, and cement in India alone for 70%.

Table 2. Main results of the domestic use of recycled materials

Country × material	World GHG (Mt CO_2e)	Domestic GHG	Other countries' GHG	Domestic value added (USD m)	Domestic employment (thousand)
Japan × steel	+0.27	−9.48	+9.75	+302	+8.0
Brazil × steel	−0.14	−0.78	+0.64	+3.9	−3.0
South Africa × steel	−0.73	−1.15	+0.42	+151	−11.1
Japan × cement	−5.63	−5.63	−0.005	+12.8	−0.6
India × cement	−19.99	−19.92	−0.07	+183	−56.3
Indonesia × cement	−1.28	−1.28	−0.002	+7.8	−8.5
South Africa × cement	−0.21	−0.21	−0.0002	+0.5	−0.01
Brazil × cement	−0.34	−0.34	−0.0002	+0.4	−0.02
Japan × plastics	−0.66	−0.39	−0.26	+479	−8.3

Note: Annual changes, main case. Value added is measured at basic prices in current 2021 US dollars and assumes that savings on material costs accrue to producing firms. Cases without change (steel in India and Indonesia; plastics in Brazil) and plastics in South Africa, for which the MRIO model has no separate recycling sector, are omitted.

Figure 2. Change in GHG emissions in the world, in the adopting country and in other countries (main case)



These results indicate that the effect of a circular-economy measure depends strongly on the combination of country, material and location of use. Measures of the same type can yield a substantial global benefit in one setting and a negligible or even negative effect in another. Sections 4 to 7 examine climate effects, side effects and economic effects in turn.

4. Climate Effects of Clinker Substitution

Clinker substitution reduces world GHG emissions in all five countries, and almost the entire reduction occurs within the adopting country. In India, the use of 37.3 million tonnes of slag and fly ash lowers the clinker ratio from 0.71 to 0.60 and reduces world emissions by 20.0 Mt CO_2e per year, while emissions in other countries also decrease slightly (by 0.07 Mt CO_2e). Japan and Indonesia reduce world emissions by 5.6 and 1.3 Mt CO_2e, respectively.

This robustness can be attributed to the fact that, unlike steel scrap, slag and fly ash are not scarce inputs on which other countries depend; their domestic use therefore does not induce substitution by more emission-intensive alternatives elsewhere. The reduction derives primarily from avoided process emissions from limestone calcination, which cannot be abated by decarbonising energy supply. Within the scope of this analysis, clinker substitution thus combines a large reduction potential with negligible leakage.

Plastics in Japan also reduce world emissions, by 0.66 Mt CO_2e, of which approximately 40% occurs outside Japan as a result of reduced petrochemical feedstock production. Steel in South Africa and Brazil yields net global reductions of 0.73 and 0.14 Mt CO_2e, respectively; however, increases abroad offset approximately 37% of the domestic reduction in South Africa and more than 80% in Brazil.

5. Cross-Border Offsetting in Steel

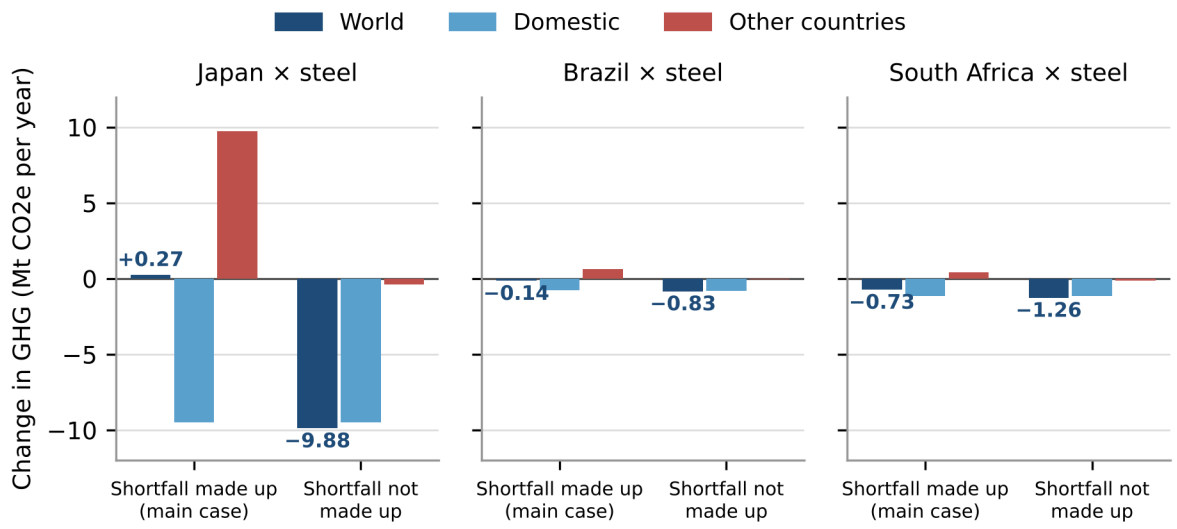
Steel in Japan demonstrates the necessity of a global assessment. The domestic use of 7.55 million tonnes of scrap reduces Japan's emissions by 9.48 Mt CO_2e. However, former importers of this scrap, predominantly steelmakers in East and Southeast Asia, compensate for the shortfall through ore-based ironmaking, increasing their emissions by 9.75 Mt CO_2e. World emissions consequently increase by 0.27 Mt CO_2e; that is, the increase abroad exceeds the entire domestic reduction. The domestic reduction comprises 9.92 Mt in direct emissions at steelworks, an increase of 0.99 Mt from additional electricity generation and a further reduction of 0.56 Mt in other domestic sectors. The increase abroad comprises 8.75 Mt from additional ore-based ironmaking (7.55 Mt × 1.16), a reduction of 0.90 Mt in electricity use and an increase of 1.90 Mt in upstream and other sectors captured by the MRIO model.

The additional electricity demand of electric arc furnaces does not account for this result. At Japan's 2019 grid emission factor of approximately 528 g CO_2 per kWh, the additional 1.9 TWh corresponds

to about 1.0 Mt CO_2, roughly one-tenth of the reduction at steelworks. The determining factor is the response of the countries that lose access to the scrap.

Figure 3 compares the main case with an alternative case in which importing countries do not compensate for the shortfall with ore-based iron, for example because they procure scrap from other sources or reduce output. In this case, world emissions for steel in Japan decrease by 9.88 Mt CO_2e instead of increasing by 0.27 Mt CO_2e. Brazil and South Africa exhibit the same pattern on a smaller scale. The assumed response of trading partners therefore determines not only the magnitude but also the sign of the net effect. Employment responds analogously: in the main case, employment abroad increases by approximately 129,000 owing to expanded mining and steelmaking, whereas in the alternative case it decreases by approximately 17,000.

Figure 3. Change in GHG emissions for steel under two assumptions regarding the response of scrap-importing countries



These findings do not imply that scrap should not be used in Japan. Rather, they indicate that the climate benefit of scrap use depends on where the scrap is used and on how the rest of the system responds. If importing countries substituted Japanese scrap with lower-emission iron, such as natural gas-based or, in the future, hydrogen-based direct reduced iron, the outcome would approach that of the alternative case. Empirical evidence on how scrap-importing countries adjust is currently lacking; such evidence should be shared among trading partners before national scrap policies are adopted.

6. Side Effects on Water, Land, Resources and Human Rights

Table 3 reports the side effects for three representative cases, together with the number of cases in which the world total decreases. In most cases, the side effects move in the same direction as GHG

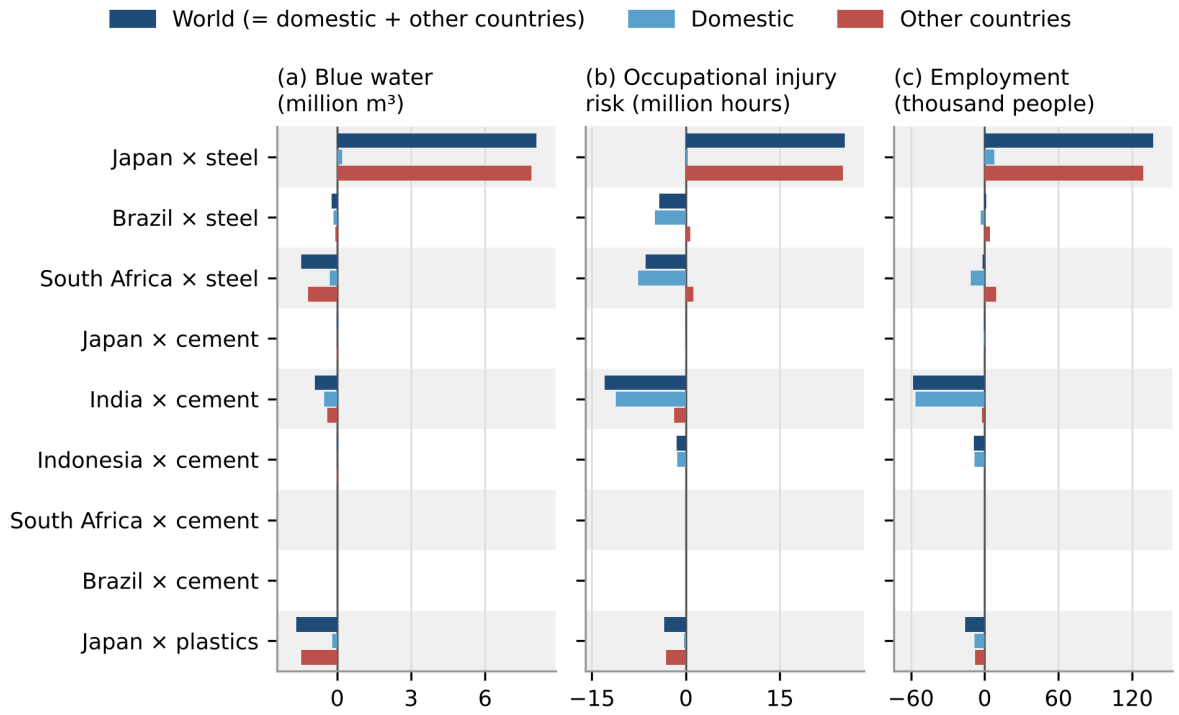
emissions and decrease when world emissions decrease. Steel in Japan is the principal exception, and its side effects arise almost entirely outside Japan. Figure 4 presents two of these indicators, together with employment, for all nine cases.

Table 3. Selected side effects: change in the world and in other countries

Indicator (unit per year)	Japan × steel		India × cement		Japan × plastics		Cases with world decrease (of 9)
	World	of which other countries	World	of which other countries	World	of which other countries	
Blue water (million m³)	+8.08	+7.88	−0.92	−0.40	−1.67	−1.46	8
Grey water (million m³)	+34.5	+33.3	−4.38	−0.67	−3.97	−2.72	8
Cropland (ha)	+5,693	+5,674	−560	−425	−1,905	−1,893	8
Iron ore extraction (kt)	+6,330	+6,330	−164	−164	−20	−20	6
SO_2 emissions (kt)	+28.7	+26.2	−1.65	−0.45	−3.46	−1.12	7
Child labour risk (million h)	+30.4	+30.1	−13.8	−1.6	−3.3	−3.0	7
Forced labour risk (million h)	+24.7	+23.6	−20.1	−1.5	−4.1	−3.0	7
Occupational injury risk (million h)	+25.3	+25.0	−13.0	−1.9	−3.5	−3.2	8
Indigenous rights risk (million h)	+22.1	+20.9	−11.0	−0.9	−3.3	−2.2	7

Note: Main case. Blue water denotes surface water and groundwater withdrawn and not returned; grey water denotes the volume required to dilute pollutants to ambient water quality standards. Human rights risks are expressed in risk-weighted working hours based on the SHDB (2022 edition) and should be interpreted as relative measures.

Figure 4. Change in (a) blue water consumption, (b) occupational injury risk and (c) employment in the world, in the adopting country and in other countries



Water and land effects are transmitted through supply chains. Blue water consumption decreases in eight of the nine cases, for example by 1.67 million m³ for plastics in Japan and 1.47 million m³ for steel in South Africa, whereas for steel in Japan it increases by 8.08 million m³, of which 7.88 million m³ occurs abroad. Grey water exhibits the same pattern. Cropland use increases by approximately 5,700 ha for steel in Japan, again almost entirely abroad, and decreases by approximately 1,900 ha for plastics in Japan and 1,800 ha for steel in South Africa. Although these changes are small relative to global totals, they identify where additional pressures arise.

Resource extraction shows the most pronounced cross-border effect. All three steel cases increase iron ore extraction in other countries: by 6.3 million tonnes for steel in Japan, and by 0.7 and 0.8 million tonnes for Brazil and South Africa, respectively. For steel in Japan, the additional ore-based ironmaking abroad requires approximately 10.3 million tonnes of iron ore (1.37 tonnes per tonne of scrap replaced); the net increase is smaller because the MRIO model also registers lower ore purchases by Japan, although Japan's iron ore inputs in the model are smaller than its imports in trade statistics. This increase constitutes the physical counterpart of the emission offsetting described in Section 5 and is directly relevant to ore-exporting countries, including Brazil and South Africa, for which mining generates both income and environmental and social pressures.

Human rights risks display a similar structure. For cement in India, the risks of child labour, forced labour, occupational injury and violation of indigenous rights all decrease substantially, reflecting

reduced activity in upstream industries such as mining and quarrying. For steel in Japan, by contrast, these risks increase by 22–30 million risk-weighted hours, almost entirely in other countries, including Viet Nam, India and Brazil, where additional mining and steelmaking take place. Steel in South Africa reduces the domestic risk of child labour by 2.1 million hours but increases it abroad by a comparable amount.

These results imply that a circular-economy measure that appears beneficial from a national perspective can shift environmental and social burdens to supplier countries in the Global South. Such spillovers should therefore be incorporated into policy assessment, consistent with the value-chain approach of the Taskforce on Nature-related Financial Disclosures (TNFD 2023) and the Global Reporting Initiative (GRI) standards (GRI 2021).

7. Value Added and Employment

Domestic value added does not decrease in any of the nine cases in the main case. The largest increases occur for plastics in Japan (USD 479 million per year), steel in Japan (USD 302 million), cement in India (USD 183 million) and steel in South Africa (USD 151 million). These gains derive mainly from reduced purchases of primary materials.

It should be noted that this result is sensitive to the distribution of cost savings. The main case assumes that savings on materials accrue to producing firms as profit. If firms instead pass the savings on to customers through lower prices, such that the value-added ratio of each sector remains unchanged, the results change considerably, and in some cases the gains become negative. Under this alternative assumption, domestic value added for plastics in Japan decreases by USD 564 million, because reduced sales by the domestic petrochemical industry are no longer offset. For steel in Japan, the alternative assumption yields a larger gain (USD 577 million), because the steel sector purchases more scrap and electricity than before. The actual outcome is likely to lie between the two estimates, depending on market conditions.

Employment exhibits a different pattern (Figure 4c). Domestic employment decreases in eight of the nine cases. The largest decrease occurs for cement in India (approximately 56,000 jobs), mainly in upstream industries that supply primary materials. Indonesia loses approximately 8,500 jobs in cement, Japan approximately 8,300 in plastics and South Africa approximately 11,100 in steel. The only exception is steel in Japan, for which domestic employment increases by approximately 8,000 and employment abroad by approximately 129,000 in the main case.

The coexistence of increasing value added and decreasing employment is characteristic of structural change and implies that circular-economy policies have distributional consequences that require management. Workers and regions dependent on mining and primary material production bear the costs, even when the country as a whole benefits. This concern is central in Global South countries,

where mining and materials industries are important sources of formal employment. The results further suggest that unilateral measures may relocate employment across countries rather than create it. Because each case was analysed separately, the employment effects of coordinated action by several countries remain to be quantified.

8. Implications for Each Country

8.1. India

India has by far the largest potential among the cases examined. The domestic use of slag and fly ash that are already generated would reduce world emissions by approximately 20 Mt CO_2e per year without leakage, increase domestic value added and reduce human rights risks in mining. These findings are consistent with the direction of India's cement decarbonisation roadmap (IEA and WBCSD 2013). The principal challenges are practical: the quality, logistics and standards of blended cement, and the transition of approximately 56,000 workers in upstream industries. Steel scrap is not available in surplus, as India is a net importer, and the Steel Scrap Recycling Policy focuses on expanding domestic collection. Data on plastics recycling were insufficient for the analysis.

8.2. Indonesia

Clinker substitution in Indonesia reduces world emissions by approximately 1.3 Mt CO_2e per year using domestic by-products, with a modest gain in value added and a loss of approximately 8,500 jobs. As a net importer of steel scrap (net imports of 2.6 million tonnes in 2019; UN Comtrade 2019, HS 7204), Indonesia has no surplus scrap, and the scenario therefore implies no change in steel. For plastics, the absence of consistent data on recycled resin precluded assessment, although plastic leakage into rivers and coastal waters is a recognised concern (World Bank 2021). Improved material-flow data would be a prerequisite for evaluating circular options in Indonesia.

8.3. Brazil

Brazil's plastics recycling rate was approximately 24% in 2019, measured as the share of post-consumer plastic generated that was recycled (ABIPLAST 2021), and its cement industry has adopted a technology roadmap (SNIC and ABCP 2019). The domestic use of scrap that Brazil currently exports reduces world emissions only marginally, because more than 80% of the domestic reduction is offset abroad. As a major supplier of iron ore, Brazil is also affected by circular steel policies in other countries, which can alter demand for ore and the associated environmental and social pressures. Brazil therefore has a direct interest in the international coordination of scrap policies.

8.4. South Africa

For steel in South Africa, the domestic use of 0.40 million tonnes of formerly exported scrap reduces world emissions by 0.73 Mt CO_2e and increases domestic value added by USD 151 million. This result

is consistent with South Africa's policy of retaining scrap for domestic use (ITAC 2020). However, domestic employment decreases by approximately 11,100, while employment abroad increases by approximately 9,500, and part of the human rights risks and iron ore extraction is shifted abroad. For plastics, the MRIO model does not include a separate recycling sector for South Africa, and the effect could therefore not be assessed; this reflects a data limitation rather than a finding.

8.5. Japan

The results for Japan are mixed. Clinker substitution and plastics recycling reduce world emissions by approximately 6.3 Mt CO_2e per year in total. For steel, however, world emissions increase: domestic scrap use reduces Japanese emissions but increases emissions, resource extraction and human rights risks in former importing countries. This implies that Japan's circular-economy policy for steel should be designed jointly with its trading partners, many of which are in the Global South, rather than as a purely national measure.

9. Policy Implications for Co-Creation with the Global South

9.1. Assessing Circular-Economy Policies by Their Global Net Impact

Circularity rates remain useful as process indicators, but the performance of circular-economy policies should be assessed by their global net impact, that is, the change in world emissions together with the changes in domestic and foreign value added, employment, environmental pressures and human rights risks. The five countries participating in the Global Five Epistemic Caucus (G5EC) could agree on a common set of indicators covering GHG emissions, water, land, human rights and employment, and apply a global net impact assessment to major national measures using shared MRIO-based tools. Linking these indicators to existing frameworks for measurement, reporting and verification (MRV), such as the Joint Crediting Mechanism (JCM) and the Asia Zero Emission Community (AZEC), would enable consistent assessment and crediting of circular-economy projects and make visible the cross-border effects that are most relevant to Global South partners. These frameworks do not, however, cover all five countries: India and Indonesia are JCM partner countries, whereas Brazil and South Africa are not, and among the four Global South partners only Indonesia participates in AZEC (Global Environment Centre Foundation n.d.; METI n.d.). Cooperation with Brazil and South Africa would therefore require other arrangements.

9.2. Prioritising Supplementary Cementitious Materials

Clinker substitution with slag and fly ash reduces world emissions in all five countries, involves negligible leakage and reduces human rights risks in mining. It is therefore a suitable early priority for cooperation. Cooperation could include joint pilot projects with the four Global South partners, the harmonisation of standards and quality certification for blended cements, and logistics for transporting fly ash and slag from power plants and steelworks to cement plants, beginning in India and

Indonesia, where the potential is largest. Local firms, industry associations and service providers could contribute by matching by-product suppliers with cement producers and by supporting the MRV that such projects require. Japan's experience with blended cement and by-product utilisation is relevant, provided that the design reflects local construction practices and demand.

9.3. Coordinating Scrap Policies along Trade Routes

Because steel scrap is traded and limited in supply, national scrap policies directly affect partner countries. Japan and its Asian trading partners, together with ore-exporting countries such as Brazil and South Africa, could establish a regular dialogue on scrap flows to share projections of scrap generation, trade and use, and to assess the global effects of proposed measures prior to their adoption. Domestic scrap use in one country could be combined with support for lower-emission ironmaking, such as direct reduced iron, in the countries that would otherwise compensate with blast furnaces. Figure 3 indicates that, if importing countries did not compensate with ore-based iron, the outcome for steel in Japan would shift from a small global increase to a substantial global reduction; the effect of supporting lower-emission ironmaking itself was not quantified in this study.

9.4. Integrating a Just Transition into Circular-Economy Plans

Domestic employment decreases in eight of the nine cases, predominantly in industries that supply primary materials. Circular-economy plans should therefore include measures for workers and regions dependent on mining, limestone quarrying and petrochemicals, such as retraining, support for emerging local industries in recycling, by-product processing and construction, and the monitoring of regional employment. Because employment may shift across borders, these measures also warrant international cooperation; joint reskilling programmes and shared human rights due diligence along supply chains would help to prevent transition burdens from simply being transferred between countries.

9.5. Developing Shared Data and Measurement Infrastructure

Several limitations identified in this study stem from data gaps: recycled plastics in India and Indonesia, the absence of a separate recycling sector for South Africa in the MRIO model, country-specific scrap collection rates, and the response of importing countries to changes in scrap supply. Informal collection, which is substantial in many Global South countries, is not captured in current statistics. A shared material-flow data infrastructure, developed jointly by Japan and its partner countries, would enable each country to evaluate its options with consistent methods. Such an infrastructure aligns with the common knowledge base envisaged in the G5EC process and could be supported by universities, statistical offices and industry associations. The measurement of global impacts, which combines large-scale data, modelling and verification, is itself a knowledge-intensive activity; sustained public support could help research institutions in Japan and partner countries build the capacity it requires.

10. Limitations

Several limitations should be noted. First, the analysis is comparative-static, contrasting two states of a single year (physical data for 2019 and the MRIO model for 2021), and does not constitute a forecast. Second, the response of countries that lose access to imported scrap is assumed rather than observed, and Section 5 shows that the results for steel depend on this assumption. In addition, the main case assumes that former importing countries compensate for the loss of exported steel scrap, but not for the loss of exported slag, fly ash or plastic waste; the small effects on other countries reported for cement and plastics should be interpreted in light of this assumption. Third, informal recycling activities are not represented in the MRIO model, and the results for plastics are likely to be conservative. Fourth, the value-added results depend on whether savings on materials accrue to firms. Fifth, human rights indicators are based on SHDB risk-weighted working hours and depend on the risk characterisation of that database and on the weights set in this study; they should therefore be interpreted as relative rather than absolute measures. Finally, each case was analysed separately, and the effects of simultaneous action by several countries were not assessed.

11. Conclusion

In this study, we assessed the global effects of the domestic use of recycled materials in five countries using a multi-regional input–output model. We found that world GHG emissions decreased in eight of the nine cases examined, without a decrease in domestic value added in the main case. Clinker substitution, in particular, achieves large reductions in world emissions without leakage, with the largest potential in India. At the same time, our results showed that circular-economy measures can shift emissions, resource extraction, water consumption and human rights risks across borders, and that they tend to reduce employment in industries supplying primary materials. The effect of the circular economy thus depends on which country uses which recycled material, and where.

For co-creation between Japan and the Global South, these findings point to three directions: prioritising measures with robust global benefits, such as supplementary cementitious materials; coordinating measures for traded materials, such as scrap, along trade routes; and supporting affected workers and regions. Above all, they call for a shared approach to measuring global outcomes, so that circular-economy policies adopted in one country are designed with due consideration of their effects on partner countries.

Data availability: The processed data supporting the findings of this study are available from the authors upon reasonable request.

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Chapter 15: Co-Creation with the Global South in the Aviation and Space Sectors: Policy Recommendations

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About This Paper

This paper sets out a practical policy pathway for cooperation with countries of the Global South — cooperation that Japan will need if it is to meet the aviation and space targets in its Growth Strategy. We use the term "Global South" in the sense used in Japanese policy, while recognising that each partner country sets its own priorities. The authors are with Solafune, Inc., a Japanese satellite-data company; the views expressed are their own and do not represent the position of the Government of Japan or METI.

We use "co-creation" in the sense defined in Japan's Development Cooperation Charter, which identifies the co-creation of social value through dialogue and collaboration with partner countries as one of its basic principles: diverse actors bring their respective strengths to a shared goal and develop solutions together.

The paper focuses on four countries: India, Brazil, Indonesia and South Africa. Each is a natural starting point for wider uptake in its region, and each already participates in international frameworks for Earth observation (EO). An accompanying presentation sets out the argument in outline; this paper provides the evidence, figures and precedents behind it.

Where this paper touches on security, it refers to disaster resilience, maritime domain awareness, infrastructure monitoring and economic security, and it distinguishes between Official Development Assistance (ODA) and Official Security Assistance (OSA). ODA remains subject to the non-military principle of the Development Cooperation Charter, while OSA operates under a separate framework for security cooperation.

1. Targets and Means

1.1. What the Government of Japan Has Committed To

The Growth Strategy commits Japan, by the early 2030s, to deploying at least 30 new major communication and satellite-data services worldwide and building at least five satellite systems by Japanese companies; to capturing a global market of about ¥12 trillion by 2040; and to raising launch demand to as much as ¥300 billion by 2040 (Cabinet Secretariat 2026a, 2026b). In adjacent fields, it aims to extend

Japan's maritime domain awareness (MDA) services to around eight countries by the early 2030s, and to double overseas sales of disaster-management solutions from about ¥1 trillion in 2024 to about ¥2 trillion in 2030 (Cabinet Secretariat 2026a, 2026b).

None of these targets can be met from the domestic market alone.

1.2. The Domestic Market: Size and Make-Up

Japan's satellite-data services market is estimated at ¥18.2 billion in FY2023 and ¥20.2 billion in FY2024, and is projected to reach ¥34.0 billion by FY2030 (Yano Research Institute 2025). The Growth Strategy itself cites a global market of about ¥150 trillion in the 2030s (Cabinet Secretariat 2026a, 2026b). Japan's ¥12 trillion target is therefore roughly 8% of the world market — a gap that can only be closed abroad.

The make-up of the market matters as much as its size. Public-sector demand accounts for close to 90% of the market in FY2024 and is still expected to be around 80% in FY2030 (Yano Research Institute 2025). Disaster management, infrastructure monitoring, maritime surveillance and property-tax registers are essential to society, yet rarely viable as stand-alone businesses. Demand of this kind becomes a market only when the public sector deliberately structures it through procurement and institutional design.

Building overseas demand and structuring domestic public-sector demand are therefore one issue, not two. The real question is whether the models Japan builds for domestic public-sector use are built so that they can also be deployed abroad.

2. Where Japan Stands

2.1. The Policy Language Exists; Implementation Does Not

The Public-Private Investment Roadmap, in its international-cooperation entry for satellites and services, already speaks of securing latent demand in the Global South by using ODA and Official Security Assistance (OSA) as catalysts. The Cabinet-approved Growth Strategy, however, describes the means for this field only in general terms — supporting overseas market development, including through cooperation with international organisations and foreign governments (Cabinet Secretariat 2026a, 2026b).

The one place where the Strategy pairs a target with a concrete means is MDA, in the ocean chapter: it commits to deploying Japan's MDA services to around eight countries by the early 2030s through public-private partnership and ODA/OSA. No other chapter names ODA and OSA as instruments for capturing overseas demand (Cabinet Secretariat 2026a, 2026b).

So far, not a single OSA project has involved space. Projects adopted between FY2023 and FY2025 covered air-traffic-control equipment, high-speed patrol boats, coastal surveillance radar and surveillance equipment; none included a satellite component. OSA is a grant-aid framework separate from

ODA that supports the security capabilities of like-minded countries. It is implemented in accordance with Japan's Three Principles on Transfer of Defense Equipment and Technology; among the four partner countries considered here, Indonesia is the only one that has so far received OSA.

2.2. The Market Environment

The global commercial EO market was worth US$5.4 billion in 2024, of which value-added services accounted for US$3.2 billion; more than 60% of data demand comes from security and defence users (Novaspace 2024). Measured by the value it enables across the economy, Earth observation is far larger: the World Economic Forum estimates US$266 billion in 2023, rising to US$703 billion in 2030, with the fastest growth in Africa and South America (World Economic Forum 2024).

Other providers — China in particular — offer frameworks rather than finished products. China financed a satellite for Egypt and an assembly, integration and test (AIT) centre alongside it. Building on that infrastructure, the Egyptian Space Agency, with Egypt's development-partnership agency and Italian support, has trained 71 engineers from 34 African countries since 2021 (Space in Africa 2025). China reports that seventeen countries and international organisations have signed up to the lunar research framework it leads. Partner countries therefore weigh several different packages, and Japan's aim is to add to their options rather than to ask them to choose. Appendix A (Table A-3) compares what different providers offer.

2.3. Japan's Capabilities

Between 2015 and 2024, about half of Japanese satellites were launched from Japan, short of the Growth Strategy's target of 60–80% or more over 2030–2040 (Cabinet Office 2025a). The average masks a sharp divide: from 2013 to 2022, 29 of 31 government satellites were launched on Japanese launch vehicles, while none of 27 commercial satellites were. The Working Group's own diagnosis also points to gaps in aircraft integration, mass production, engagement with certification and standards bodies, and analysis and operations talent (Cabinet Office 2025a). Practitioner experience adds two points: there is no established route for Japan to help shape standards in new fields, and partner countries face the same talent shortage (author's first-hand information). The two perspectives are set side by side in Appendix A (Table A-1).

2.4. Three Pieces of Evidence

(1) A broken value chain

Across the five layers — satellite operations, data processing, analytics, solutions and end demand — the links between successive layers are not functioning along the private-demand pathway. Projects that do reach implementation depend on public-sector demand, consistent with the fact that the public sector accounts for close to 90% of the domestic market.

(2) More institutions, the same disconnect — and some ground lost

In October 2017, a Ministry of Economy, Trade and Industry (METI) study group published a report on access to government satellite data. It found that pilots rarely reached deployment, that data procurement was expensive, that public procurement was fragmented across administrative silos and constrained to single fiscal years, that specialists were scarce, and that public data was not open enough. Since then, substantial institutional infrastructure has been put in place: a national data platform, the Space Strategy Fund, Small Business Innovation Research (SBIR) Phase 3, the designation of satellite and rocket components as specified critical products under the Economic Security Promotion Act, a public-private framework on international standards, and a programme to accelerate government adoption.

What has not changed is the mechanism that carries pilots into deployment; in some areas, capabilities have even receded. A system that had monitored tropical-forest change in 78 countries roughly every 45 days was cut back to a single country in March 2024 as its equipment aged. A government satellite-data platform, launched as an R&D project, was transferred to its contractor, spun off in 2024, and became independent through a management buyout in August 2026. Two platforms built over a decade have both been scaled back or privatised.

(3) The same gap in national security

For the Information Gathering Satellites, the Cabinet Satellite Intelligence Center analyses imagery for policymaking, national security and diplomacy, and a ten-satellite constellation is planned — two optical and two radar core satellites, plus four time-diversity and two data-relay satellites. Three issues nonetheless remain from an operational perspective: data acquisition relies on purchases from the United States and Europe; private use cases are not growing, so analytical technology has stalled; and public-sector demand is skewed towards science and technology and disaster management rather than security. In 2011, lacking sufficient domestic capacity, Japan had to rely on more than 5,700 scenes from 27 foreign satellites operated by 14 countries and regions (Appendix A, Table A-2). The Ministry of Defense's Space Domain Defense Guidelines (28 July 2025) explicitly call for considering flexible use of commercial communications constellations and commercial services, creating an opportunity for institutional design.

2.5. Data Infrastructure: The Difference Is Law, Not Budget

In the EU, Copernicus EO data are required by regulation to be provided on a free, full and open basis. There are no restrictions on use or users, a free version must always be available on the distribution platforms, and the data may be used worldwide without time limit; users need only acknowledge the source and flag any modification.

Japan also publishes a free synthetic aperture radar (SAR) normalised-backscatter product that complies with the international Analysis Ready Data specification and is listed in an external open-data registry. However, some products are restricted to non-commercial use, continuity of provision is not

guaranteed by law, and the distribution platform was unavailable from October 2024 to February 2025, requiring interim arrangements. Appendix A (Table A-4) compares the two regimes item by item.

The gap is not one of budget. It lies in whether free and open access is written into law, whether commercial use is allowed, and whether continuity of supply is guaranteed.

2.6. Four Issues

This analysis points to four issues. First, the link between targets and means is not established in the top-level policy documents. Second, the design of public-sector demand does not anticipate overseas deployment. Third, partner countries have no single route into cooperation with Japan that starts from the problems they need to solve. Fourth, Japan has no defined route for contributing to the development of verification and certification frameworks in emerging fields.

3. The Partner Countries

3.1. Their Place in the Wider World — and What They Are Aiming For

Seen from outside Japan, the four countries are not newcomers waiting to be invited in. Between 2022 and 2025 they held the G20 presidency in succession and kept a consistent development agenda across their terms. Space came onto that agenda through the Space Economy Leaders' Meeting, which each of them hosted during its term and where South Africa proposed in 2025 that it become a formal working group. India has proposed a G20 satellite for environment and climate observation whose data would be shared with other developing countries, and has agreed with Mauritius to develop a joint satellite. All four are members of BRICS, whose 2021 remote-sensing constellation agreement is now being discussed for expansion. India also hosts the Information Fusion Centre for the Indian Ocean Region (IFC-IOR), where 17 countries, including Japan and, since July 2026, Indonesia, post liaison officers. Each country works across several frameworks at once. They have helped shape the agenda; what is still missing is the means to implement it. (European Parliamentary Research Service 2025; South African National Space Agency 2025b; Prime Minister's Office of India 2025; Government of India 2026; Indian Navy n.d.)

All four countries state in their space policies that they intend to move from being users of space technology to developers of it. Their policy direction is not simply to purchase finished products, but to build industries and public infrastructure that are economically sustainable at home. They already hold chair or co-chair positions in the international coordination framework for EO satellites, and all four are members of the international body that shapes rules for unmanned aircraft. Some have written the procurement of high-resolution data into law; others operate resolution-based data distribution policies.

3.2. Country Snapshots

India. The Indian Space Policy 2023 aims to enhance space capabilities, build a commercial presence, use space as a driver of technology development, and pursue international relations. Data at a ground resolution of 5 m or coarser are free and open; finer data are free to government agencies and offered to others at a fair and transparent price. In August 2025 a private consortium won a public-private partnership to deploy a 12-satellite national EO system within four to five years, stating that it would strengthen data sovereignty and reduce reliance on foreign imagery. Japan and India have held three rounds of their Space Dialogue (2019, 2021 and 2025) and are cooperating on lunar polar exploration (LUPEX), but no flagship bilateral Earth-observation mission has yet emerged (Ministry of Foreign Affairs 2025c).

Brazil. The National Program of Space Activities 2022–2031 envisions a leading position in the South American space market and names EO as one of five strategic areas. National forest monitoring is fully operational, and deforestation in 2025 fell to its lowest level in 11 years. The Earth-resources satellite series has comprised six satellites since the first launch in 1999. A resource-monitoring satellite due in 2027 uses a domestically developed platform, while one due in 2028 will carry a SAR instrument supplied by another country, with costs and technology shared. A bilateral action plan provides for cooperation on advanced radar satellites and AI to curb illegal logging, and on measuring greenhouse-gas (GHG) emissions in rural areas. Brazil's maritime and environmental priorities broaden the opportunity beyond forests. Brazil's Blue Amazon Management System (SisGAAz) provides a national maritime-surveillance context, and research on the 2019 oil spill off north-eastern Brazil concluded that sustained satellite monitoring of Brazilian waters is needed; regional cooperation can be explored through the South Atlantic Peace and Cooperation Zone (ZOPACAS); and the Tropical Forest Forever Facility (TFFF) creates a separate opportunity to co-develop transparent forest-monitoring methods. The Japan–Brazil Action Plan for 2025–2030 already links cooperation on minerals, sustainable fuels, forests and peaceful space activities (Anais da Academia Brasileira de Ciências 2022; COP30 Presidency 2025; Ministry of Foreign Affairs 2025a).

Indonesia. The Space Law assigns a single agency sole responsibility for procuring high-resolution remote-sensing data for central and local government. After the 2021 consolidation of research agencies, this function passed to the data and information unit of the national research agency, which now acts as national data custodian and runs the national remote-sensing data bank. Indonesia plans to launch a satellite with over 60% local content in 2027, which the agency's head has described as a milestone towards mastering the full satellite technology chain, and in October 2025 it agreed with another country to set up a joint remote-sensing centre. The immediate challenge is keeping the system supplied with new data: requests for data fell from 520 in 2024 to 266 in 2025 (according to secondary press reports). For Indonesia, the next step should be to connect national data procurement with operational users. Japan's support for naval patrol boats through OSA and for a BAKAMLA patrol vessel through grant aid offers two distinct starting points for exploring satellite-assisted maritime

awareness, with separate eligibility, end-use and information-sharing controls. Fisheries, agriculture, energy and critical-mineral cooperation provide civilian demand for these capabilities alongside Indonesia's space-sector ambitions (Ministry of Foreign Affairs / JICA 2026).

South Africa. The National Space Strategy aims to move the country from being mainly an end user of space technology to a developer of its own systems and capabilities. Its capacity building has delivered results: between 2019 and 2025 the national space agency supported 149 postgraduate students, leading to 123 degrees. The South African National Space Agency (SANSA) also runs an operational ocean information system: SANSA acquires weekly RADARSAT-2 imagery over South Africa's exclusive economic zone, which feeds a national vessel-tracking tool used to detect illegal fishing and oil spills (South African National Space Agency 2025a). Progress on hardware has been more difficult — an EO satellite was not delivered despite an investment of about R300 million, and development was suspended between FY2018 and FY2023. In March 2026, South Africa's own parliamentary oversight committee identified fragmentation across governance, funding and institutional mandates as a serious strategic risk and asked for a report within nine months. Nevertheless, South Africa has an operating maritime-data base on which to build. Under Operation Phakisa, the national Oceans and Coastal Information Management System (OCIMS) integrates satellite imagery into maritime decision support. Japan should explore complementary SAR coverage, data fusion and local analytical capacity, connecting South Africa's Indian Ocean and South Atlantic interests without displacing its existing systems.

3.3. Which Layers Should Be Built Together?

Table 1. Status by layer

Layer	Partner countries	Japan	Character
Launch	Some have it, some do not	Has it	Can be supplied from outside
National EO satellites	Owned or planned	Has them	As above
Ground stations / test facilities	Mostly in place	Has them	As above
National data provision	Rules exist; implementation varies	Track record of free release, but no legal permanence	Requires institutional design
Analytics / value-added services	Private firms emerging	Firms exist, but public-sector demand accounts for 90% of the market	As above
Public-sector demand / procurement	Set in law in some cases, but implementation lags	Scheme decided, but no overseas-deployment requirement	As above
Verification / certification standards	Hold positions in frameworks, but no compliant products	Has passed the procedures, but does not write the standards	Incomplete on both sides
Analysis and operations talent	Still being developed	Persistent shortage	Incomplete on both sides

Source: by author, compiled from public materials of the governments and agencies concerned (2025–2026).

Three conclusions follow. First, the top three layers can be supplied from outside, but supply alone leaves no capability behind in the partner country. The model described in Section 2.2 — financing satellites and facilities as a package, which the host agency then uses for training — addresses these layers directly.

Second, the middle three layers call for institutional design in Japan and the partner countries alike. Japan has a record of releasing data free of charge, but without legal permanence; partner countries have written procurement into law, but implementation has not followed. The shared challenge is less the creation of institutions than their sustained operation. Recommendation 2 addresses these layers.

Third, neither side has completed the bottom two layers. On verification and certification, Japan has been through the procedures but does not write the standards, while partner countries hold positions in the frameworks but have not been through the procedures. Relevant talent is scarce on both sides. These two layers are what should be co-created. Recommendations 4 and 5 address them.

3.4. The Window Ahead and the Shared Gaps

All four countries plan to launch EO satellites within the next three to five years, and that window will decide whether standards are in place in time. In several areas, no established international standard yet exists: later SAR analysis-ready product categories, validation of AI and machine-learning outputs, and hyperspectral analysis-ready data. For GHG measurement, reporting and verification (MRV), an international roadmap targets operational use by 2028, but no standard procedure yet exists. In aviation, type certification of new categories of aircraft may fall outside the scope of existing bilateral aviation safety agreements, and five national aviation authorities published a joint roadmap in 2025 toward harmonised certification of these aircraft; neither Japan nor any of the partner countries is among them (NAA Network 2025).

3.5. Opportunities by Sea Basin

At sea, the need is clear: satellite analysis suggests that an estimated 72–76% of the world's industrial fishing vessels are not publicly tracked, with much of that activity around South Asia, Southeast Asia and Africa (Paolo et al. 2024).

Indian Ocean. Maritime information-sharing in the Indian Ocean is already anchored in the region. Besides IFC-IOR in India (Section 3.1), the western Indian Ocean has a Regional Maritime Information Fusion Centre in Madagascar and a Regional Coordination Operations Centre in Seychelles (Indian Navy n.d.). The Quad's Indo-Pacific Partnership for Maritime Domain Awareness (IPMDA) now runs its Indian Ocean programme through IFC-IOR, and in May 2026 the Quad launched the Indo-Pacific Maritime Surveillance Collaboration (IPMSC), initially in the Indian Ocean. For Japan, whose MDA target and Free and Open Indo-Pacific (FOIP) vision both point to this basin, these are channels to work through rather than structures to build; the Indian Ocean–Africa Economic Zone Initiative announced at TICAD 9 (Ministry of Foreign Affairs 2025b) could add an Earth-observation component for maritime activity, resources and logistics.

South Atlantic. A 2025 policy brief identifies the absence of a dedicated basin-wide MDA centre, while recognising existing national and subregional capabilities, and proposes regional leadership that could include Brazil and South Africa (Bueger 2025). Brazil's assumption of the ZOPACAS presidency at the ninth ministerial meeting in Rio de Janeiro in April 2026 provides a diplomatic entry point, although it is not evidence that a regional centre has been established (Agência Brasil 2026).

4. Recommendations

4.1. Overview

The partner countries' space agencies already participate in international coordination frameworks, some as chairs or co-chairs, and their space policies commit them to moving from users to developers of

technology. Yet where high-resolution data procurement has been written into law, implementation is still catching up, and sustained publication of products that meet the analysis-ready data specification remains an open goal.

Japan faces a similar gap. Its policy documents mention cooperation with the Global South, yet this has produced pilots rather than sustained projects; it has obtained international validation for its products, yet has not extended them to partner countries; and it has helped run a regional framework for more than 30 years without giving it a project-formation function. In short, both sides participate in the frameworks, but implementation has not kept pace. This is not a one-way transfer of capability: both sides face comparable implementation gaps. The partner countries have already helped shape the international agenda on space and Earth observation, from the G20 to regional maritime cooperation. Japan's role is not to bring a framework of its own, but to build the means of implementation with them, within the agendas they have helped set. The five recommendations below start from this recognition.

Table 2. Four issues and five recommendations

#	Issue	Recommendation
①	Targets and means are not linked in the top-level policy documents	R1
②	The design of public-sector demand does not anticipate overseas deployment	R2
③	Partners have no single route into cooperation with Japan that starts from their problems	R3
④	No defined route for contributing to verification and certification frameworks in emerging fields	R4 (space), R5 (aviation)

Note: R1 underpins the other four. R2 and R3 build the market; R4 and R5 are where co-creation takes place.

4.2. R1: Link Targets to Means in the Policy Documents

The Public-Private Investment Roadmap already refers to using ODA and OSA to secure demand in the Global South for satellites and services, but the Growth Strategy leaves the means abstract, and no OSA project has yet involved space. Experience already shows that stating the intention is necessary but not sufficient.

The MDA section of the ocean chapter provides the template: a target paired with its means. The aviation and space chapter sets a similarly concrete target, but leaves the means of implementation abstract. We therefore recommend, first, that the aviation and space chapter describe satellites and services in the same way as the ocean chapter does; and second, that a route for turning that language into projects be designated within existing programmes. That route need not be new. Japan's cooperation with the partner countries already covers areas such as critical minerals, decarbonisation and the maritime economy, through the Japan–India Economic Security Initiative, the Japan–Brazil Action Plan for 2025–2030 and cooperation with Indonesia under the Asia Zero Emission Community (AZEC).

Each depends on exploration, monitoring or verification that Earth observation can provide. Naming Earth observation as an instrument within these existing programmes is the most direct way to turn language into projects (Ministry of Foreign Affairs 2025a, 2025c; Prime Minister's Office of Japan 2025).

Those who need this language are the companies that develop and structure projects and the implementing agencies: it provides the basis for budget requests and for the explanations that embassies and agencies give to partner countries. Without it, companies must develop each market independently. Partner countries, in turn, would be able to see from published documents what forms cooperation with Japan can take. Revising the documents requires no new budget.

4.3. R2: Share How Public-Sector Demand Is Designed

The know-how of building satellite data into day-to-day government work has accumulated in local governments and companies. For property-tax registers, municipalities commission satellite-image analysis under multi-year contracts, and the contractors have designed the interpretation criteria and update frequency. For infrastructure deformation monitoring, the Geospatial Information Authority of Japan has issued a survey manual under the public-survey standards, and companies carry out the work as public surveys. The government provides the institutional framework; operational know-how resides with the companies. Because these systems were designed around Japan's public-finance rules, however, simply exporting the specifications will not work.

Creating an institution and sustaining it are also two different things. In one partner country, the procurement of high-resolution data for the government has been centralised by law in a single agency, and the function survived an institutional merger — yet new data acquisition has stalled and data requests halved within a year. The legal framework and responsible office remain in place, yet the system is not functioning in practice. Japan has seen the same: the tropical-forest monitoring system shrank from 78 countries to one, and a data platform launched as a national project was transferred to private operation.

What should be shared, therefore, is not a finished system but the reasoning behind its design and the evidence from running it: why the contract was set for that duration, how the acceptance criteria were defined, and how much additional tax revenue was generated over what period. Those who know this are the municipalities and contractors, not the central government. We recommend that the Government of Japan collect this reasoning and evidence from those who implemented the systems, put it into a form partner countries can use, and provide a forum for doing so. Handing over documents is not enough: partner countries need practitioners who understand the design choices and can adapt them to their own institutions, and the forum should also serve as a venue where those practitioners build expertise alongside their Japanese counterparts. The design itself remains in the hands of the partner governments and companies; Japan does not design on their behalf.

We further recommend that overseas-deployment requirements be built into the domestic anchor-tenancy scheme that has already been decided. It is companies that will use the scheme, and building these requirements at the design stage costs far less than retrofitting them later (Cabinet Secretariat 2026a, 2026b).

4.4. R3: One Entry Point, Organised Around the Partner's Problem

From a partner-country perspective, Japan's support is organised by institution, with no single route through which the elements can be assembled into a package around a specific problem. METI itself has asked whether, in some regions, Japan needs to offer packages spanning surveys, matchmaking, capacity building and space-equipment exports.

An entry point does already exist. Since its founding in 1993, the Asia-Pacific Regional Space Agency Forum (APRSAF) has brought together more than 40 countries and regions and has run a regional disaster-monitoring framework. APRSAF is not treaty-based; participation is voluntary, and it has neither membership contributions nor legal personality. This light structure has broadened participation, but it was not designed to carry projects through to implementation. Treaty-based organisations have assessed contributions and a permanent secretariat, but far fewer members. The two reflect different design philosophies; neither is superior.

We therefore do not propose changing this structure. What we propose is to make an explicit two-tier division of labour: consensus-building with partner agencies takes place in existing forums, while project formation, procurement and financing are handled by existing programmes. These forums include APRSAF and venues where the partner countries are already engaged, such as the G20 Space Economy Leaders' Meeting when it convenes, GEOGLAM's Asian rice-monitoring component, which JAXA leads with Indian and Indonesian agencies, and IFC-IOR, where Japan already posts a liaison officer (GEOGLAM Asia-RiCE 2024; Indian Navy n.d.). What needs to be bundled is not only government agencies. Companies operate at every layer — satellite operations, data processing, analytics and solutions — and the right combination depends on the partner's problem; bundling government bodies alone cannot deliver the solution a partner is looking for. Companies should be able to participate at every layer. Neither a new agency nor a merger of mandates is needed — only a clear statement of who does what among existing bodies. Partners would no longer need to source satellites, ground stations, analytics and training separately and design the package themselves; they could start from the problem they need to solve. These venues differ in mandate, membership and legal status, and none of them is a financing mechanism. For each problem agreed there, the Japanese entry point should assign an eligible instrument for project formation, procurement and finance, with a named lead, a local counterpart and an operating budget.

The sea-basin opportunities in Section 3.5 show how this entry point would work at sea. In the Indian Ocean, Japan could offer validated SAR-derived vessel detections and analytical services for workflows agreed through IFC-IOR and IPMDA, with access for partners outside the Quad arranged explicitly. In

the South Atlantic, Japan could propose a Brazil–South Africa–Japan scoping dialogue on EO-enabled maritime cooperation, starting with interoperability, shared alert protocols and analyst training rather than a new institution. A first pilot could combine Japanese SAR and optical imagery with national AIS and coastal observations to detect oil spills and vessels not visible in public tracking data, building on Brazil's SisGAAz and South Africa's OCIMS. Its procurement should specify coverage, latency, detection performance, local validation and the authority responsible for acting on an alert; a satellite detection is a basis for further investigation, not in itself proof of illegal fishing.

Civilian work at sea — fisheries management, pollution response, search and rescue and marine-environment monitoring — should be considered for ODA where its purpose, implementing arrangements and end use comply with the Development Cooperation Charter. Support for naval capabilities belongs under OSA and its transfer and end-use rules. Keeping procurement, access controls and audit trails separate ensures that each strand of cooperation stays within its declared purpose.

4.5. R4: Work Through Existing International Procedures

An international procedure for validating satellite data already exists: the Analysis Ready Data specification of the Committee on Earth Observation Satellites (CEOS-ARD). Providers first conduct a self-assessment, which is then peer-reviewed by the CEOS Working Group on Calibration and Validation. Japan has chaired CEOS and its Strategic Implementation Team and currently co-chairs several working groups, and both a government satellite and a private SAR operator have completed the process. Japan therefore has standing in the framework and practical experience with the process, but has not itself been in the position of drafting the specifications.

The partner countries' agencies also hold chair or co-chair positions in CEOS working groups and similar bodies. Few, however, distribute compliant products on a sustained basis; some have only submitted self-assessments. A gap remains between their standing and their implementation.

Japan should not, therefore, set up a certification scheme of its own. Where an international procedure is already working, a separate Japanese label would compete with it and could be perceived by partner countries as an externally imposed standard. Instead, we recommend two things. First, work through the existing procedure together with partner agencies, including technical cooperation that enables them to take part in self-assessment and peer review. Second, jointly propose specifications for areas not yet covered. Such proposals are made through the relevant CEOS Virtual Constellation, which is open to actors outside CEOS, and there is a precedent: Japanese, Indian and African agencies jointly drafted one specification. The proposers should be agencies and companies, not the government directly, and the scope should be limited to new areas, leaving existing international certification regimes intact.

India's proposed G20 satellite for environment and climate observation, planned to carry instruments for carbon dioxide, methane and nitrous oxide, offers a near-term opening: Japan could discuss joint

calibration and validation, reference measurements, uncertainty reporting and analysis-ready products with the Indian Space Research Organisation (ISRO) and participating agencies, helping make its data usable across the Global South. For partner agencies, this approach turns standing in the frameworks into a sustained supply of internationally recognised data, and a voice in specifications that have not yet been written.

Joint specifications for GHG measurement, reporting and verification should be designed so that the same satellite-derived evidence can serve several instruments the partner countries already use or help shape: the Joint Crediting Mechanism (with Indonesia and India), AZEC's work on robust MRV, the satellite-based forest monitoring that underpins the Tropical Forest Forever Facility, and land-use verification in biofuel and sustainable aviation fuel certification, such as ISCC CORSIA and Brazil's RenovaBio. CEOS-ARD compliance addresses data usability and quality; it is not, by itself, certification of a carbon credit or proof of fuel sustainability (Ministry of the Environment 2026; ISCC 2022; COP30 Presidency 2025).

There are three routes to implementation. First, the Space Strategy Fund already has a window for developing methods to evaluate satellite-data quality and to calibrate and validate sensors; this should be linked to international co-development. Second, technical cooperation that enables partner agencies to take part in self-assessment and peer review can become concrete projects under the route designated in R1. Third, these areas have not been developed as formal standards, so aviation and space should be added to the scope of the public-private framework on international standards.

4.6. R5: Aviation Certification, and Talent Through Joint Development

Aviation. Cross-border acceptance of type certificates for new aircraft categories depends on the scope of the applicable bilateral arrangements and the receiving authority's validation requirements: a type certificate does not confer automatic worldwide recognition. The National Aviation Authorities (NAA) Network comprises the authorities of Australia, Canada, New Zealand, the United Kingdom and the United States. Its April 2025 roadmap addresses advanced air mobility certification and validation (NAA Network 2025). Japan and the four partner countries are not among those five authorities. Japan should work with partner regulators to build common safety evidence, certification capacity and pathways toward mutual recognition, while maintaining compatibility with established international requirements rather than creating a competing safety regime.

Sustainable aviation fuel. Aviation cooperation should also cover industrial decarbonisation, particularly feedstock traceability, land-use safeguards and lifecycle-emissions evidence for sustainable aviation fuel (SAF). The Japan–Brazil Action Plan connects sustainable fuels and next-generation aircraft through ISFM and identifies Brazil as a founding member of the Global Biofuels Alliance and Japan as an observer (Ministry of Foreign Affairs 2025a). Japan should use this connection, alongside engagement with India and South Africa, to develop commercially useful evidence and skills. EO can complement, but not replace, fuel testing and certification.

Talent. Joint development of small satellites, led by universities with JAXA's support, has involved 13 countries and produced more than 17 satellites, giving at least nine countries their first national satellite. Some participating students have gone on to lead development of the next satellite at universities in their home countries. This model — the partner country builds its own satellite — fits squarely with the direction partner countries set out in their own policies. It has so far reached only a limited number of countries and should be expanded.

Country guides. Existing knowledge on procurement rules and fiscal years, treatment of data and intellectual property, counterpart agencies, lessons from past projects, and standard MoU clauses should be compiled and shared across government and industry. This knowledge resides with the companies and implementing agencies that have worked on projects. The compilation should involve Japanese embassies, the Japan International Cooperation Agency (JICA), the Japan Bank for International Cooperation (JBIC) and JAXA, as well as existing regional frameworks that connect directly with partner agencies.

4.7. Why Action at the National Level Is Needed

(1) Access to resources

Supply of critical minerals is concentrated in a few countries, and demand will keep rising towards 2040. Satellite data is used for exploration, operational monitoring and environmental-impact assessment at mine sites. These are needs that resource-rich countries themselves face in managing their own resources, and areas in which Japan's capabilities can be of practical value.

Table 3. Concentration in critical minerals

Mineral	Mining	Refining
Cobalt	Democratic Republic of the Congo (DRC) supplies about two-thirds of world output (2024)	Chinese companies over 75%
Lithium	—	China expected to supply over 60% of refining in 2035
Copper	Chile leads with about 25%; DRC second	China 45% of global capacity (2024), rising to 50% by 2040
Graphite	—	China about 90%; still about 80% of battery grade in 2035
Manganese	—	China 95% of high-purity manganese sulfate for batteries

Note: Under the Stated Policies Scenario, demand to 2040 rises about fivefold for lithium, doubles for graphite and nickel, grows 50–60% for cobalt and rare earths, and 30% for copper. Sources: IEA, Global Critical Minerals Outlook 2025; USGS, Mineral Commodity Summaries 2025.

(2) The lesson of an earlier withdrawal

In 1968, eight Japanese companies set up a local company in the Congo, holding an 80% stake, to develop a copper mine. Between 1972 and March 1983 it produced 330,000 metric tons of copper, all shipped to Japan. In June 1983, however, the partners decided to liquidate their stake, and all had withdrawn by December 1984; of ¥60 billion in investment and loans, ¥53 billion was written off. One cause was the transport route: civil war in 1975 closed the railway, and the haul to port lengthened from 2,199 km to, eventually, 3,372 km. Holding the mining rights is not enough to secure access to resources. Without the means to monitor surrounding conditions and secure alternative routes, invested capital cannot be recovered — and satellite monitoring is precisely such a means.

(3) What cooperation builds over time

The two points above concern what Japan stands to gain directly. Cooperation also yields benefits that accumulate over time. First is the long-term value of trained people. Engineers who have taken part in joint development will be involved in decision-making in their national agencies ten years from now. Japan remains limited in scale: since 2021, Japan's ODA-funded space training has reached 40 short-term and 15 long-term participants, whereas one other country's education centre had hosted 465 people from 40 developing countries by September 2025, and another of its programmes has produced 220 degree holders. Second is standing in multilateral forums. New standards ultimately need the backing of the agencies that take part in these forums. The four partner countries hold chair or co-chair positions in the EO coordination framework and are all members of the unmanned-aircraft rule-making body; new specifications will carry weight only if they are shaped with, and backed by, these agencies. Third is institutional durability. Satellite data is used in land administration, resource mapping, disaster management, maritime affairs and taxation — domains over which states retain enduring responsibility. Once embedded, such systems tend to remain in place for decades.

(4) A narrowing window for partnership

The current trend runs the other way. The tropical-forest monitoring system was cut back to a single country in March 2024; the government satellite-data platform became an independent private business in August 2026; no OSA project involves space; and no flagship EO project has emerged with one of the partner countries. Over the same period, other providers have expanded their engagement: a China-financed satellite and test centre in Egypt now anchors a training programme the Egyptian Space Agency runs for engineers from across Africa (Space in Africa 2025), and another provider has agreed with Indonesia to set up a joint remote-sensing centre. The case for acting is not only commercial. Partnerships Japan helped build over two decades are at risk of lapsing.

5. The Shared Knowledge Platform and Talent

The shared knowledge platform envisaged by this study group — a framework for building up, together with partner countries, the knowledge needed for policymaking — already partly exists in aviation and space (MIGA n.d.). APRSAF has convened more than 40 countries and regions since 1993, and

CEOS-ARD specifications include one jointly drafted by Japanese, Indian and African agencies. R4 and R5 ask that these existing venues be used; no new framework is needed. Nor is standard-setting in new fields the preserve of incumbents or governments: a Japanese private SAR operator has obtained CEOS-ARD compliance, and in India a private consortium is building the national EO satellite system, with all satellites to be manufactured in-country.

Co-creation is also not a new concept. It is already defined in Japan's Development Cooperation Charter, which describes offer-type cooperation as proactively proposing cooperation goals and support packages through policy dialogue and collaboration with partner countries, combining hardware and software. In the approach proposed here, each proposal starts from priorities the partner country has set. Aviation and space, however, need a clearer cross-sectoral implementation pathway in external cooperation policy. Individual projects have already been selected under Global South co-creation support, including Synspective's SAR-based mining monitoring demonstration in Brazil and SkymatiX's remote-sensing project in Indonesia (METI 2026). These selections establish that relevant projects exist; they do not, by themselves, establish a durable pathway from demonstration to recurring procurement, local operations and regional replication. That is the implementation gap R1 and R3 should address.

There is a shortage of analysis and operations specialists in Japan and the partner countries alike. In Japan, the specialist shortage identified in 2017 persists; in partner countries, institutions with standing in international frameworks have yet to develop sufficient numbers of people with first-hand experience of the procedures. Because neither side has this talent in sufficient depth, it is a natural area to develop together — joint development in which the partner builds its own satellite is one such model. A separate recommendation on human resources has been presented to this study group; this paper addresses concrete formats specific to aviation and space and does not replace the education and research functions proposed there.

6. Beyond the Four Countries, and Conclusions

6.1. The Gap Between Participation and Implementation

The pattern observed in the four countries holds across much of the Global South. Countries take part in international frameworks and commit in their policies to moving from users to developers of technology, yet legally established systems can fail to function when new data acquisition stalls, and positions in international frameworks do not translate into a steady flow of compliant products. In Africa, 18 countries have launched 69 satellites, and more than 20 national space agencies have been established, yet no national agency has been identified as independently producing and supplying data that meets international specifications. A continental framework for such data exists, but it is funded by governments and foundations outside the region, and its compliance derives from upstream

European and US products. This gap will not be closed by more assistance, because participation is already there. What is needed is a pathway to implementation.

6.2. A Shared Approach, Not Individual Contracts

One after another, countries across the Global South face the same question: now that we have a space agency, what should it do? Some providers answer by financing a satellite and an assembly and test facility as a package; in Egypt, the host agency has since turned such a facility into a regional training hub. Japan's aim should not be to pursue individual contracts. Instead, it can work with each country to apply its own experience of creating and sustaining institutions, including lessons from areas where implementation has fallen short. R2 shares that experience; R4 builds standards jointly. Both can be applied well beyond any single country.

6.3. Regional Spillover

Verification and procurement models proven in one country can spread through regional frameworks, and each of the four partner countries is a natural starting point in its region. How effectively they spread depends on the region: Africa has a continental space agency and a free-trade area, while in South America a track record of joint development has accumulated within bilateral frameworks. The route to regional uptake should be tailored to the nature of each regional framework.

6.4. Co-Creation Country by Country

Table 4. Co-creation perspectives by country

Country	Stated goal	Already in place	Not yet implemented	What can be co-created
India	Commercial presence and international engagement	Resolution-based data policy; 12-satellite PPP; chair roles in the coordination framework	Published compliant products; bilateral EO projects	Joint specification drafting (precedent of joint contribution)
Brazil	Leadership in the South American space market	Operational national forest monitoring; GHG measurement in a bilateral action plan	Published compliant products	GHG measurement, reporting and verification; forest monitoring that meets the requirements of the Tropical Forest Forever Facility
Indonesia	Mastery of the full satellite technology chain	Law centralising procurement; national satellite planned for 2027	Implementation (still in transition after the 2021 agency consolidation)	Designing for continuity; a route to make the system work
South Africa	From end user to developer	Vice-chair role in the coordination framework; continental space agency framework	Satellite launch; integrated governance	Designing regional spillover
Common	From technology user to developer	Participation and standing in international frameworks	Compliant products, delivery capacity, analytics talent	Joint standard-setting; talent through joint development

Note: Stated goals are from each country's policy documents; the last column follows from the gap between the two preceding columns. Source: by author, based on public materials of the governments and agencies concerned (2025–2026).

Industry-facing priorities complement Table 4: critical-mineral and maritime services with India; resource-processing safeguards, food security and resilient infrastructure with Indonesia; minerals, hydrogen-linked industry and oceans services with South Africa; and sustainable fuels, forests and off-shore environmental monitoring with Brazil. These should become jointly selected service portfolios with a responsible procurer and an operating plan, rather than an unrelated collection of technology demonstrations.

6.5. Conclusions

R1 is the foundation; R2 and R3 build the market, and R4 and R5 are where co-creation takes place. The key points are these.

First, the Government of Japan has already set quantitative targets whose achievement depends on demand in the Global South. What is needed is not new targets but to elevate the existing language into top-level policy documents and designate a route to implementation. Revising the documents requires no new budget.

Second, the domestic market stands at only ¥20.2 billion, with public-sector demand accounting for nearly 90% — not for lack of demand, but because the core uses are essential to society yet rarely viable on their own. Such demand becomes a market only when public procurement and institutional design give it structure.

Third, where Japan lags is not in assets but in how well its offer is integrated. The actors to be brought together already exist; what is needed is not a new organisation but a clear division of roles. The Indian Ocean and the South Atlantic are the first places to show how such an integrated offer would work.

Fourth, verification and certification are unfinished for Japan and the partner countries alike. Japan has been through the procedures; the partners hold standing in the frameworks. These strengths currently sit apart; their value lies in combining them.

Fifth, Japan's industrial growth and the partner countries' build-up of sovereign capability can be achieved together through the same demonstration projects. The design itself makes this achievable. These partnerships serve Japan's interests as well as those of its partners, and that shared stake is what makes them durable.

7. What Implementation Requires

The five recommendations fall into three groups according to the policy resources they require. First are document and scheme revisions: elevating the relevant language (R1), incorporating requirements into scheme design (R2), and clarifying the division of roles (R3). These fit within existing review cycles and need no new budget. Second is the reallocation of existing budgets: turning R1 into concrete projects and linking R4 to joint standards development. The Space Strategy Fund already has windows for calibration and validation methods and for overseas demonstration; these should be broadened rather than new ones created. Third is ongoing implementation: technical cooperation under R4, maritime pilots under R3, and the expansion of joint development and preparation of country guides under R5.

R2 is particularly time-sensitive: the domestic scheme is being designed now, and retrofitting the requirement later would cost more. We therefore recommend an early start. The international calendar also matters. India chairs BRICS in 2026, Brazil has held the ZOPACAS presidency since April 2026 (Section 3.5), and the United Kingdom holds the G20 presidency in 2027; Japan can work with the partner countries to carry the G20 space track forward under that presidency (Government of India 2026; UK Government 2026).

Appendix A: Supporting Tables

The tables below expand on points summarised in the main text.

Table A-1. Japan's capabilities: the Working Group's self-assessment and an operator's view

Area	Working Group self-assessment (Cabinet Office 2025a)	Operator's view (author's first-hand information)
Aircraft integration	Japan lacks the capability to integrate commercial passenger aircraft	—
Launch	Share of domestic launches is below target	Commercial satellites are not launched on Japanese vehicles
Mass production	A gap remains with competitor countries	—
Certification and standards	Engagement with the relevant bodies is insufficient	There is no defined route for contributing to standards-setting in emerging fields
Talent	Analysis and operations specialists are in short supply	Partner countries face the same shortage

Source: public proceedings and secretariat briefing of the Aviation and Space Working Group (1st meeting), and the presenter's practical experience.

Table A-2. What happened when capacity and continuity were missing

Event	Consequence
Domestic observation capacity fell short during the 2011 disaster	Japan obtained more than 5,700 scenes with the help of 27 foreign satellites from 14 countries and regions
Three years passed between the end of one observation satellite's operations and the launch of its successor	Continuous observation was interrupted

Source: JAXA Earth Observation Research Center public materials.

Table A-3. What a partner country can draw on, by provider

Offering	China	US	Europe	Japan
Launch services	○	○	○	○
Satellite donation / joint development	○	△	○	○
Ground stations / receiving facilities	○	△	○	△
Free and open data	△	○	○	△
Analytics / value-added services	△	○	△	○
Participation in standards and certification development (space)	○	○	○	○
Participation in standards and certification development (aviation)	○	○	○	△
Capacity building	○	△	○	○
Finance (loans / investment)	○	△	△	△
Single point of contact for the whole package	○	△	○	△

Note: ○ = generally offered; △ = offered in part. China has analytical capability, but under its package model the analytical layer does not necessarily remain in the partner country (authors' assessment). India, Brazil and South Africa also draw on the BRICS Remote Sensing Satellite Constellation (agreement 2021; amendment under discussion in 2026), a framework for sharing data from members' existing national satellites rather than a new dedicated fleet. Indonesia became a full BRICS member in January 2025, but BRICS membership does not in itself mean accession to this satellite agreement. For Japan, financing instruments exist, but there is no established model for forming space or satellite-data projects; agency-to-agency cooperation and training programmes exist, but they have no project-formation or procurement function. Source: by author, compiled from public materials of the governments and agencies concerned (2025–2026).

Table A-4. Data infrastructure compared

Item	Japan	European Union
Legal basis	None (operational decision)	Regulation (EU) 2021/696 and Delegated Regulation (EU) No 1159/2013
Commercial use	Some products non-commercial only	Unrestricted (stated in regulation)
Eligible users	Unrestricted	Unrestricted, inside or outside the EU
Guarantee of duration	None	Use without time limit, set in law
Distribution platform	Unavailable Oct 2024–Feb 2025; interim provision	Continuous availability of a free version guaranteed
Data quality	Compliant with international ARD specification	Set per service

Source: Official Journal of the European Union; Japan Aerospace Exploration Agency (JAXA) public materials.

Appendix B: Abbreviations

Abbreviation	Meaning	Abbreviation	Meaning
AIS	Automatic Identification System	ISRO	Indian Space Research Organisation
AIT	Assembly, integration and test	JAXA	Japan Aerospace Exploration Agency
APRSAF	Asia-Pacific Regional Space Agency Forum	JBIC	Japan Bank for International Cooperation
ARD	Analysis Ready Data	JICA	Japan International Cooperation Agency
AZEC	Asia Zero Emission Community	MDA	Maritime domain awareness
BAKAMLA	Maritime Security Agency of Indonesia	METI	Ministry of Economy, Trade and Industry
CEOS	Committee on Earth Observation Satellites	MOFA	Ministry of Foreign Affairs
CEOS-ARD	CEOS Analysis Ready Data (specifications and assessment framework)	MRV	Measurement, reporting and verification
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation	OCIMS	Oceans and Coastal Information Management System (South Africa)
DRC	Democratic Republic of the Congo	ODA	Official Development Assistance
EO	Earth observation	OSA	Official Security Assistance
FOIP	Free and Open Indo-Pacific	PPP	Public-private partnership
GEOGLAM	GEO Global Agricultural Monitoring initiative	R1–R5	Recommendations 1 to 5 of this paper
GHG	Greenhouse gas	SAF	Sustainable aviation fuel
IFC-IOR	Information Fusion Centre – Indian Ocean Region	SANSA	South African National Space Agency
IPMDA	Indo-Pacific Partnership for Maritime Domain Awareness	SAR	Synthetic aperture radar
IPMSC	Indo-Pacific Maritime Surveillance Collaboration	SBIR	Small Business Innovation Research
ISCC	International Sustainability and Carbon Certification	TFFF	Tropical Forest Forever Facility
ISFM	Initiative for Sustainable Fuels and Mobility	TICAD	Tokyo International Conference on African Development

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Annexes

Annex 1: Record of Discussion, Global Five Epistemic Caucus (G5EC) Strategic Workshop in Tokyo, 15–16 October 2026 ..... *p. 274*
Prepared by Musashino Institute for Global Affairs (MIGA), Musashino University, Japan.

Annex 2: Thematic Record of Interventions, G5EC Final Session, NEXUS Japan-GS Forum, Tokyo, 19 October 2026 ..... *p. 286*
Prepared by Musashino Institute for Global Affairs (MIGA), Musashino University, Japan.

Annex 1: Record of Discussion, Global Five Epistemic Caucus (G5EC) Strategic Workshop in Tokyo, 15–16 October 2026

Prepared by Musashino Institute for Global Affairs (MIGA), Musashino University, Japan.

1. Day One — 15 October 2026

1.1. Session 1 — AI, Semiconductors, and Industrial Development

The first session examined semiconductor development and the Japanese proposal to use AI to strengthen both intellectual assets and human capabilities. The process-by-process analysis of semiconductor value chains was welcomed as a useful framework for identifying opportunities for cooperation. However, participants noted that having a large market or abundant natural resources does not automatically create a competitive semiconductor industry. They stressed the need to understand each country's actual industrial capabilities and identify commercially feasible areas of cooperation.

Regarding AI, considerable interest was expressed in transforming practical knowledge accumulated in factories and businesses into lasting intellectual assets, while developing human capabilities at the same time. This was described as a shift from simply adopting AI to using AI to develop knowledge and people. However, participants pointed out that industrial structures, technological capabilities, and national AI strategies differ considerably, and that cooperation should therefore be based on realistic, country-specific approaches.

An important message was that AI should also contribute to solving social challenges, including youth unemployment, poverty, and inequality. Human dignity, equity, accountability, and ethical governance were emphasised, particularly against the background of global polarisation, corruption, illicit financial flows, and slow progress towards the Sustainable Development Goals.

Another important question concerned international AI governance: participants asked how the G5EC should engage with emerging United Nations initiatives and other global frameworks, while ensuring that Global South countries participate in shaping international AI rules.

Further issues included critical minerals, the circular economy, quantum technologies, and public–private partnerships. The potential to connect industrial cooperation with wider regional markets, particularly the African Continental Free Trade Area, was also highlighted. A new proposal was the establishment of a G20 Implementation Dialogue Series, linking policy discussions with continued practical implementation.

Overall, the first session emphasised the importance of connecting technological development with industrial capabilities, social priorities, and international cooperation.

1.2. Session 2 — Common Knowledge Infrastructure and Human Capital

The second session focused on common knowledge infrastructure and its relationship with education, research, and capacity building. The proposal was welcomed as ambitious and timely. A central idea was the continuous cycle of implementation. It was observed that, too often, knowledge, experience, and human networks disappear when individual development projects come to an end. Participants therefore emphasised the need for a process in which practical experience generates knowledge, knowledge develops people, and people undertake new activities that create further knowledge.

Another important concept was epistemic justice. Participants stressed that Global South countries are not simply recipients of knowledge from advanced economies, and that every society possesses its own knowledge, culture, history, and institutional experience. Co-creation should therefore involve mutual respect and the joint development of new knowledge and values, including perspectives that emphasise coexistence with nature.

Several concrete institutional proposals emerged. First, joint master's and doctoral programmes could be developed through networks of existing universities, drawing inspiration from the European Erasmus model. These programmes could focus on shared policy challenges emerging from the G20 and T20 processes. Rather than constructing new institutions, cooperation could begin with scholarships, joint research, and academic exchanges.

Second, it was argued that practical education should be combined with strong academic foundations. Competency-based education and project-based learning are important, but theoretical research should not be neglected. Joint policy research involving academics, practitioners, businesses, and policymakers could help bridge the gap between theory and practice.

Third, participants noted that genuine co-creation requires human capital, intellectual property arrangements, research infrastructure, access to finance, appropriate regulations, and ethical safeguards, and that solutions should be locally relevant, affordable, and capable of producing real social benefits. Another proposal was to explore partnerships with existing international institutions, including the United Nations University, rather than creating entirely new structures. This could also extend cooperation beyond the five participating countries.

The importance of involving younger generations was repeatedly emphasised. Participants added that institutions need to learn, evaluate themselves, and evolve as circumstances change. Frequent changes in senior government leadership can also undermine continuity; knowledge and institutional capacity therefore need to be developed across different levels of government and society. The contribution of small and medium-sized enterprises to employment and local economies was another important consideration.

Taken together, the second session suggested that common knowledge infrastructure should be more than an information-sharing platform. It should connect education, research, industry, and public administration, while preserving and continuously developing knowledge.

1.3. Session 3 — Regional Development and Innovative Finance

The third session addressed river basin development and start-up finance, with particular attention to implementation. The Basin OS concept was welcomed as an integrated approach connecting water management, agriculture, land use, urban development, industry, and disaster resilience.

A new proposal was to develop cooperation among the five countries on flood prevention, drought management, water security, and joint disaster response. This could include shared information, expert networks, and coordinated response planning.

However, participants noted that agricultural structures, technological capabilities, and local institutions differ greatly across countries and regions; food, water, and environmental security should all be considered, and local governments, farmers, younger generations, and communities should be involved. Other concerns included cultural diversity, indigenous communities, public trust in digital technologies, AI transparency, urban planning, disaster prevention, and infrastructure financing.

The financial discussion was particularly substantial. The Japanese proposal to address not only start-up financing at the entry stage, but also the lack of investment exit opportunities, was welcomed. The development of secondary markets was recognised as an important issue. Drawing on experience in development finance, participants noted that selling existing equity and bond investments is essential for recycling capital into new projects.

A further proposal concerned the use of exchange-traded funds, or ETFs, to broaden investor participation and support financial market development.

However, significant concerns were raised about currency risk: when local currencies depreciate sharply, foreign investors may face substantial losses. It was also noted that blockchain technology may improve transparency and traceability, but it cannot by itself resolve information asymmetry or ensure investor protection. Anti-money-laundering requirements, market authorisation, financial regulation, the operating institution, and the applicable legal framework all require careful consideration.

Another important issue was first-loss funding. Participants suggested that, before public resources are used to absorb initial losses, it is necessary to understand why exit markets are not functioning, since public funding alone may not address the underlying structural problems. Where information asymmetry is a major obstacle, financial support should be linked to better disclosure.

Local-currency financing was also discussed from two perspectives. On the one hand, it may expose investors to exchange-rate risks. On the other hand, local businesses may grow substantially in

domestic terms while appearing less successful when measured in US dollars. This led to a discussion of developing domestic capital markets and mobilising local institutional investors, including pension funds and sovereign investment institutions. The potential for low-cost financial infrastructure using digital technologies was also considered, together with the need for gradual implementation and improvement through practical experience.

Overall, the third session suggested that technology and finance need to be supported by appropriate institutions, reliable information, public trust, and workable arrangements for sharing risks.

1.4. Day One — Closing Reflections

The closing reflections noted that the most significant outcome of the first day's discussions was that a clearer picture of the G5EC as a common knowledge infrastructure had begun to emerge. The G5EC was described as not simply another mechanism for supporting individual projects; its distinctive value would lie in bringing together different development paths, industrial experiences, scientific knowledge, financial expertise, and local knowledge to generate possibilities that would not emerge from these activities separately. Businesses will continue to develop their own strategies and pursue their own opportunities; what the G5EC can add is a new dimension of connectivity, enabling these independent initiatives to evolve into more advanced industrial activities and new forms of cooperation.

At the same time, universities, research institutions, governments, financial institutions, and local communities contribute to, and benefit from, this process of knowledge creation. Through Path Diversity and Co-creation, knowledge generated in one activity can become a resource for others, creating a continuing process of innovation, industrial development, and institutional learning. The first day's discussions began to indicate how the G5EC could become a common knowledge infrastructure that creates new possibilities beyond the boundaries of individual projects, organisations, and countries. How this might be achieved emerged as a significant theme of the first day's discussion.

2. Day Two — 16 October 2026

2.1. Session 4 — Energy, Critical Minerals and Circular Industrialisation

2.1.1. Responses to the paper on energy cooperation

The discussant welcomed the paper's comparative information on the countries' different stages of energy transition as useful for practical cooperation. The discussant also urged that energy policy be connected to ecological transformation, new industrialisation and inclusive development. Drawing on the experience of a country with a relatively clean electricity mix but continued fossil-fuel challenges, the contribution asked how new energy opportunities could help build domestic industrial capacity rather than perpetuate exports of commodities and imports of manufactures. The proposed direction

was “shared development,” not a single common development model imposed on differing national situations.

A separate intervention drew attention to differences in the meaning of energy security. For many developing countries, vulnerability concerns imports of both energy and food, whereas Japanese supply-chain discussions often emphasise semiconductors, minerals and other industrial inputs. Japan’s experience since the 1973 oil crisis was proposed as a source of practical lessons in three areas: preparing before a shock, responding during a shock and strengthening long-term resilience. The speaker expressly described Japanese policy experience as a record of trial and error, rather than a ready-made template.

2.1.2. Responses to the paper on critical minerals

The critical-minerals discussant asked how mineral wealth could support a new development model through local suppliers, engineering, processing, technology and employment rather than extraction alone. Long-term purchasing and offtake agreements were welcomed as potential support for investment, though their financial credibility, enforceability and fit with local industrial development remained unresolved. A participant linked the paper to South Africa’s G20 emphasis on beneficiation at source: mineral-producing countries should share in processing, manufacturing, technology and employment.

A question challenged the limited treatment of mineral-chain governance, citing transparency initiatives, illicit financial flows and international tax cooperation. Private finance and domestic industrial-policy instruments, rather than multilateral development-bank financing alone, were urged for climate-related investment.

In direct questioning, a participant characterised the proposed five-step roadmap for mineral partnerships as extremely important for matching finance, markets and productive capacity, but asked who would implement it and under what governance structure. The question itself was framed as a challenge of organisational innovation. In response, the presentation side proposed using existing bilateral mechanisms between Japan and partner countries as a practical starting point, gradually opening them to other countries as relevant projects and supply chains expanded. “Start small” was the institutional advice given.

2.1.3. Responses to the paper on electronic waste and circular industrialisation

The electronic-waste discussant welcomed the view of waste as a secondary resource, but stressed that recycling requires municipal collection, sorting, industrial capacity and realistic regulation, not processing technology alone.

Particular concern was expressed about vulnerable people earning livelihoods through informal waste collection. The discussant argued that such workers cannot simply be displaced by rapid industrialisation of recycling. Skills development, safer treatment, gradual transition and protection of livelihoods

should be part of practical cooperation. The three papers, considered together, were seen as an opportunity for joint research linking technical capacities, emissions, local development, pollution, vulnerable populations, public policy and private enterprise.

An additional intervention drew on ASEAN–Japan AMEICC cooperation, explaining how public–private consultation and regulatory coordination could support circular industrial practices. The intervention identified the upgraded ASEAN Trade in Goods Agreement (ATIGA), including circular-economy and remanufactured-goods provisions, as a relevant institutional opening. It nevertheless warned that resource circulation remains heavily informal in parts of ASEAN and that strict regulation could undermine livelihoods. A gradual rule-based approach was suggested: battery traceability and passport systems; common quality and process standards for remanufactured goods; and implementation through policy dialogue and capacity building. Experience from Malaysia, Thailand and Japanese firms was cited to illustrate possible starting points, with potential for broader Global South cooperation.

A participant added that circular consumption, including consumer behaviour and social expectations, must accompany circular production.

2.1.4. Additional interventions and closing observations

One participant questioned whether international institutions were meeting their mandates, recalling South Africa's democratic transition and subsequent state capture. The coordinator called for country-specific starting-point papers and practical accounts of Japanese policy and industrial experience to support real action.

2.2. Session 5 — Deep Tech, Supply-Chain ESG and Space-Based Businesses

The chair reflected on BRICS cooperation in the area of space and Earth observation, noting that four of the G5EC countries are members. This reflection was intended to provide an understanding of what these nations have jointly articulated in the areas of start-ups, commercial aerospace, and Earth observation, thereby helping to identify their existing appetite, gaps, and challenges in order to determine new opportunities.

2.2.1. Responses to the Live Deep-Tech Presentation and the Advanced Fusion Paper

The chair questioned why disruptive research impact appeared to diminish despite increasing funding and publications.

The prepared commentary proposed futures literacy, prospective scenarios and anticipatory governance: alternative hypotheses about uncertain futures should inform present choices. The question is not only what technology will be possible, but what desirable futures partners wish to build and which capacities they must develop now. It was argued that deep-tech policy should sustain the entire sequence from research, prototypes and testing through manufacturing, certification, first customers, repeat orders and reinvestment, not merely the initial breakthrough or creation of start-ups.

Regarding fusion, the discussant asked how scientific strengths could lead to systems integration, scalable manufacturing and lasting industry. Global South partners should join research, testing, demonstrations, skills, supply chains, standards and demand-setting before Japanese technology is completed for export: "Co-creation is not localisation after innovation." The discussant argued that fusion and space revealed a "missing middle" between research and implementation. International agreements alone do not create projects, markets or capabilities. Universities, laboratories, start-ups, established businesses, governments, finance, regulation, standards, procurement and customers must be connected.

Drawing on information from Brazil's National Nuclear Energy Commission, the discussant distinguished Brazil's fusion research ecosystem (including tokamak work and possible national-laboratory development) from an established fusion industry. The issue was where Brazil could enter the emerging global industrial network. Potential areas for Brazilian participation included measurement, data analysis, controls, simulation, prototypes, testing and specialist services. The discussant also proposed connecting knowledge, projects, finance, industrialisation and evaluation, with interoperable ESG data as one possible element.

The discussant called for measures beyond numbers of start-ups, projects or agreements: capacity building, technology absorption, domestic value added, employment, international industrial integration and repeat orders. The timing of Global South participation was as important as the resulting outputs.

The chair reiterated that Global South partners should help shape desired technological futures, not serve only as product markets.

The presenter strongly endorsed concrete Brazilian involvement and noted that fusion has developed through international cooperation, citing ITER. Neither scientific discovery nor finance alone is enough: markets, institutions, governance, standards and industrial partners must emerge together. The presenter questioned national efforts to internalise entire fusion supply chains: like aerospace, fusion contains too many technologies and components for any one country or company. Brazilian contributions were presented as a way forward for the global fusion community. Global South partners can invent and produce, not only import; co-creation means jointly developing technology, finance and markets on equal terms.

2.2.2. Responses to the Global Supply-Chain ESG Modelling Presentation

The chair praised the visualisation of global supply chains, including the steel case, and asked how regional differences entered the analysis. The discussant proposed linking existing institutional datasets to support policy, project appraisal and practical learning. Another intervention requested geographically specific evidence to evaluate policies over time, including Brazilian industrial policy, project appraisal and sectoral scenarios.

The presenter acknowledged inventory discrepancies, missing observations and the complementary potential of finer satellite measurements. Language differences and incompatible national datasets were recognised as obstacles requiring cleaning, reconciliation and cross-country exchange.

The exchange also connected the steel and automobile examples to policy evaluation. Questions were directed to the geographical distribution of consequences: whether an apparent improvement within one country can be accompanied by additional effects elsewhere, and how a comparison can preserve differences between regions. A practical suggestion was to use this evidence when assessing investment and industrial policy, not only when producing retrospective ESG indicators.

2.2.3. Responses to the Space and Earth-Observation Presentation

The chair asked how space projects could begin with jointly defined problems, connect to G20 priorities and strengthen partners' ability to develop technology. A participant saw possibilities for collaboration in start-ups, commercialisation, marketing and standards. The discussant emphasised that space agreements cannot themselves create local capability or customers; firms, finance, regulation and procurement matter. The presenter supported jointly defined goals and rules, with viable start-up models rather than agreements alone.

2.2.4. Additional Perspectives, Independent Comments and New Proposals

Brazilian start-up experience was used to distinguish exceptional platform success from the challenge of scaling innovation into industrial capacity. A participant proposed a shared social compact with defined responsibilities, timelines and accountability.

2.3. Session 6 — Reflections from Four Successive Global South G20 Presidencies

2.3.1. Indonesia: Four Areas of Continuity and the Lessons of Implementation

The intervention distinguished four overlapping priorities emerging from the successive Global South G20 presidencies. The first was inclusive digital transformation: connectivity, digital skills, digital public infrastructure, AI and opportunities for small businesses. Technology was valued for productivity, employment and market access, but the participant warned that inadequate access, skills and data protection can deepen exclusion. Equitable distribution of benefits and sound governance therefore matter as much as technology adoption. The intervention connected digital productivity with Indonesia's economic growth ambitions.

Second, the energy transition was framed as energy security and industrial competitiveness. The participant noted that Indonesia's electricity plan envisaged approximately 76% of added capacity from renewables, but that coal retirement, grid development and investment remain difficult.

Third, affordable climate finance, now covering adaptation as well as mitigation, was identified as a continuing priority. The Just Energy Transition Partnership was cited as a specific caution. Although announced with a USD 20 billion package and reported disbursements of USD 3.9 billion by September 2026, the participant judged that it had not delivered transformative results, especially in accelerated

coal retirement. The stated obstacles included insufficient concessional finance, contractual and regulatory problems, a shortage of bankable projects, and inconsistencies with domestic energy policy. These were proposed as implementation lessons for future G5EC initiatives, not as reasons to abandon cooperation.

Fourth, green industrial development and international rules were considered together. Solar panels, batteries, storage and minerals processing could support industrial upgrading and downstreaming, but minerals processed with coal-powered electricity, together with mining impacts, may undermine sustainability. Environmental performance, competitiveness and international cooperation must therefore be assessed together. The concluding proposal was to use the G5EC to deepen and carry forward these four streams of work rather than restart each agenda with every G20 presidency. The intervention treated these four themes as possible areas for further joint examination, not as a predetermined G5EC work programme.

2.3.2. India: Continuity, Economic Security and Co-Creation Rather Than Transfer

The intervention first noted that several priorities had already been raised by the Indonesian contribution and were not peculiar to either country. The central question was why four consecutive Global South G20 presidencies should lead to continuing cooperation. Presidencies change, but problems facing the Global South do not disappear when the chair passes to another country. A priority introduced in one presidency should therefore be carried forward rather than announced and forgotten. This continuity was considered particularly important under an uncertain emerging world order. The speaker described the proposed forum as potentially useful for sharing knowledge, working together, and sustaining collaboration beyond one-off initiatives.

Economic security was identified as a shared priority for many Global South countries and Japan alike. Particular fields mentioned were the resilience of supply chains, critical minerals, semiconductors, space and satellite technology, infrastructure and connectivity. India's experience added digital public infrastructure and financial inclusion, while the wider concerns of the Global South included food security, agriculture and amplifying countries' voices in international discussions. AI governance, emerging technologies and a knowledge society were also raised. These were presented neither as an exclusively Indian agenda nor as a settled work programme for the G5EC, but as areas in which several countries face related challenges and might identify specific cooperative undertakings.

The contribution cautioned against defining cooperation simply as a request for technology transfer: "Come together, work together as a partner" was the point. Co-creation should address demands identified together and extend the benefits beyond the five initial countries. The RIS DAKSHIN centre, introduced during the 2023 Voice of Global South Summit, was offered as an experience in mutual learning, demand-driven problem-solving and possible trilateral cooperation.

The speaker also stressed that the value of the initiative would become clearer through continuing practical work; a full programme should not be presumed settled already.

2.3.3. Additional Perspective: Lessons from AMEICC and ASEAN–Japan Cooperation

An independent additional comment presented AMEICC's ASEAN–Japan experience in joint research and policy–industry coordination as adaptable learning, not a prescribed G5EC institutional model.

2.3.4. Brazilian Reflection and Additional Perspectives

The intervention stressed that four consecutive Global South G20 presidencies had brought development issues more firmly into the G20, with relevance to advanced economies too. Specific examples were health sustainability, universal health coverage, social inclusion, inequality and debt. The discussion pointed out that debt might be more acute for African countries than for Brazil, but continuity required one presidency to take seriously priorities raised by another. Inequality carried from the Brazilian to the South African agenda was an example; the concentration of new wealth among the top one per cent was cited as incompatible with genuine, shared development.

Think tanks could sustain cooperation even when governments disagree, building evidence and strengthening sovereign policymaking. Research networks should support trust and continuity, not merely one-off meetings. Decades of Brazil–Japan cooperation, including agriculture and steel, were invoked as evidence that partnerships can evolve into more advanced industrial collaboration.

A central institutional point concerned shared ownership and the distribution of benefits. All partners should help determine the agenda, not simply receive knowledge or completed technologies. Trust developed between think tanks might help build confidence across governments and other partners. If jointly pooled data lead to an innovation and a patent, the fruits of that innovation should not accrue only to one country: sharing the fruits, including benefits reaching enterprises and public authorities, was presented as essential to genuinely shared development. No detailed intellectual-property arrangement was agreed.

In a separate additional intervention, opportunities were raised in sustainable aviation fuel and cleaner maritime shipping, including biofuels and ethanol, with reference to the substantial share of global trade carried by sea. The speaker also identified forest protection, the Amazon Fund and REDD+ as matters for cooperation. In response, the chair noted differences in national energy-use structures and suggested that those differences could create opportunities for co-creation and investment. These are additional views raised after the main Brazilian reflection, not statements attributable to it or agreements reached by the session.

2.3.5. South African Contributions: National Reflection and Subsequent Discussion

The intervention referred to the report presented at the start of the session and returned to a priority discussed during South Africa's G20 presidency: beneficiation at source. Critical-mineral-producing countries should gain value through processing and related industrial activity, rather than being confined to the extraction and export of raw materials. The participant also noted that South Africa had faced difficulties participating in the current G20 process, but argued that the underlying issues could continue to find resonance.

The participant described the inequality agenda as an important issue carried forward from Brazil. South Africa's inequality panel was cited as an example of how concerns first advanced through the Global South presidencies could continue into United Nations processes. Debt and the high cost of capital, including the risk premium affecting Africa, were identified as obstacles to attracting investment. The contribution therefore linked policy continuity to practical financing constraints.

The same participant noted common concerns across the four former G20 presidencies and asked how work undertaken through both the formal G20 and T20 could be carried forward through the G5EC. Think-tank research normally addresses policymakers, but the workshop had demonstrated the need to align it more closely with industry and take joint and individual research directly to relevant sectors. Stronger engagement with the B20 and businesses was described as a critical missing link, alongside trust among the actors involved.

After a separate intervention asking what a common knowledge platform might mean, another participant speaking from the South African and wider African experience argued that a lack of ideas was not the main problem. Research is often disconnected from market demand, innovation ecosystems are insufficiently developed, and local industry has limited capacity to absorb technology.

Agriculture was cited as an example, including gaps in post-harvest and fertiliser solutions and dependence on imports. The speaker emphasised the need to turn knowledge into economically viable projects. Feasibility studies could make investment more predictable; attention to local capacities could reduce risk, while foresight could help anticipate and address investors' perceptions of risk.

The later discussion reiterated that T20 research should inform B20 businesses, translating Global South priorities into continuing industrial and policy activity.

2.3.6. Further Cross-Cutting Interventions: Practical Value and Open Questions

An additional contribution stressed that cooperation must meet business and investor needs; an exclusively academic knowledge platform would not suffice. A participant asked what a common knowledge platform would mean in practice; no specific structure was adopted.

2.4. Session 7 — Concluding Discussion and Proposals

2.4.1. International Cooperation: G20, G7 and BRICS

The opening contribution argued that G5EC should reach beyond its five initiating countries through existing Global South research networks and undertake practical, interactive cooperation. G5EC was urged to examine empirically how it might operate alongside and through the G20, comparing the strengths and limits of G7 and BRICS on development, climate, AI and poverty. Bridging these constituencies was proposed, not agreed as an institutional mandate.

The G20's responses to the financial crisis, the Paris climate agreement and pandemic debt problems were recalled alongside its limitations. Macroeconomic stability and private-sector growth were

described as important but should not eclipse inequality, health, debt, minerals, climate and social exclusion carried forward by Global South presidencies. AI was identified as a transformative issue across sectors, requiring continued evidence and policy proposals beyond earlier debates about internet access.

2.4.2. Assessment of the Workshop Papers and the Need for a Meeting Summary

Participants considered whether the discussion papers, prepared for the workshop and not publicly released, could be shared appropriately while respecting contributors' wishes and the Chatham House Rule. The papers were appreciated as a useful account of emerging ideas, but were distinct from a record of the actual discussion. Participants expressly requested a concise Day Two reflection modelled on the Day One account. Together these could form an Executive Summary of participants' questions, criticisms and proposals.

2.4.3. Possible Governance and Institutional Connections

Existing university and research networks, including the United Nations University, were suggested as possible partners. Rotating leadership and a Global South location for any eventual secretariat were raised as options, not decisions.

2.4.4. Different Routes from Research to Business and Policy

A participant distinguished policy institutes working through ministries and regulation from organisations collaborating directly with companies. The proper channel for business engagement depends on institutional roles, including in Brazil. In reply, the workshop approach was described as bridging academia and business, with company-authored contributions and commercial proposals as well as research papers.

2.4.5. A Concrete Proposal to Carry Forward G20 Outcomes

A participant cited a South African public-dialogue initiative involving the presidency, the UN, universities and civil society to implement the National Development Plan amid problems of state capture. A new proposal would connect universities across countries to implement G20 outcomes and reflect T20 and B20 contributions. The idea was welcomed as a possible first G5EC activity, building on initiatives already underway rather than recreating them.

3. Closing Perspectives

Closing remarks affirmed that G5EC should be jointly owned and developed by participants across the five countries.

Annex 2: Thematic Record of Interventions, G5EC Final Session, NEXUS Japan-GS Forum, Tokyo, 19 October 2026

Prepared by Musashino Institute for Global Affairs (MIGA), Musashino University, Japan.

1. Opening and Purpose of the Final Session

Hidetoshi Nishimura (MIGA, Musashino University)

Ladies and gentlemen, good evening. This is the final session. I'd like to introduce my colleagues. First, Yose Rizal Damuri, Executive Director of the Centre for Strategic and International Studies (CSIS), Indonesia; Luciana Mendes Santos Servo, President of the Institute for Applied Economic Research (IPEA), Brazil; Sachin Kumar Sharma, Director General of the Research and Information System for Developing Countries (RIS), India; and Elizabeth Sidiropoulos, Chief Executive of the South African Institute of International Affairs (SAIIA). First, I'd like to briefly explain what the G5EC is. The Global Five Epistemic Caucus is an emerging joint initiative involving Indonesia, India, Brazil, South Africa and Japan. What is significant about this combination? These four countries held successive G20 presidencies: Indonesia in 2022, India in 2023, Brazil in 2024 and South Africa in 2025. Ladies and gentlemen, these colleagues played leading roles in discussions under those four successive G20 presidencies.

This is an extraordinary development here in Japan. Before today's symposium, we held two full days of intensive G5EC strategic workshops on 15 and 16 October. We discussed a wide range of themes across seven sessions: AI, semiconductors, industrial development, common knowledge infrastructure, human capital, regional development, innovative finance, energy, critical minerals, circular industrialisation, deep tech, supply chains, ESG and space-based businesses. We discussed all these items intensively. We would now like our colleagues to enrich our understanding and help us form a clearer picture of what we aim to create through the Global Five Epistemic Caucus. In this first round, we would like to hear from each colleague. Today's excellent symposium has brought business and project development into the discussion, and we have also held two days of intensive discussions about the G5EC. On top of that, we would like to hear their views and insights, drawing on the achievements of their respective G20 presidencies. Please, Yose.

Luciana Mendes Santos Servo (IPEA)

First of all, good afternoon, distinguished guests. Thank you very much, Professor Nishimura-san, for inviting us and organising this event. I would first like to express my condolences on the passing of Professor Anbu, who was supposed to attend this event and was very important in organising it. I

would also like to thank METI, JETRO, JICA, JBIC and the other organisations that supported this important event.

2. G20 Presidency Legacies and Their Continuity

Yose Rizal Damuri (CSIS)

Thank you very much, Nishimura Sensei. Good evening, ladies and gentlemen. Since we are discussing the Global Five Epistemic Caucus, which is based on the G20 presidencies of developing countries, it would be useful to briefly consider what those presidencies have already contributed through their commitments. If we look at the four developing-country G20 presidencies (Indonesia, India, Brazil and South Africa), we can identify at least four legacy areas of cooperation: inclusive and transformative digitalisation, energy transition, affordable and participatory climate finance, and green industrial development. These four areas of cooperation have been central to the economic agenda of the four consecutive developing-country G20 presidencies. With those three recommendations, I believe that the legacy of the developing-country G20 presidencies can not only survive the current global uncertainty but also contribute to progress in overcoming future challenges. Thank you very much.

Sachin Kumar Sharma (RIS)

Thank you very much, Professor Nishimura. I will be very specific and highlight six points. First, we have had many sessions today, and we are talking about co-creation. For co-creation, we need to identify the projects and areas where there is demand. How do we identify them? Four successive G20 presidencies have already generated substantial knowledge. Those countries have already identified their priorities.

The third point I would like to highlight is that we are not starting from scratch. As we saw in the previous session, Japan and the Global South are already working together. One example is Suzuki's work with rural India on biogas projects. India has one of the largest cattle populations in the world. Using cattle dung to produce biogas is important, as is understanding how this can contribute to rural transformation. That is a key point I would like to highlight. In this context, our Prime Minister presented a concept with five elements: trade, technology, capacity building, lines of credit and grants. These five elements are important for development cooperation. Finally, I would highlight that I head the Research and Information System for Developing Countries (RIS), where we have a platform called DAKSHIN. It was launched in 2023 during the Voice of Global South Summit.

Luciana Mendes Santos Servo (IPEA)

I would like to leave three important messages in this first round. The first is that the Global South, including Brazil, and Japan have been building partnerships for a long time. They have created knowledge, strengthened local capacities and sought to build shared benefits for sustainable, inclusive

development. We have heard examples here in Japan. We have an opportunity to connect research with economically viable projects in value-added chains, and to link them to measurable, inclusive and sustainable development outcomes.

Elizabeth Sidiropoulos (SAIIA)

I will be very brief. First, it is very important to have cooperation across the Global North and Global South. In the current geopolitical context, these divisions can be negative and counterproductive. Fostering understanding is important. Finally, knowledge can be generated by the Global South and co-created between the Global South and Global North.

3. National Ownership, Co-creation and Established Partnerships

Yose Rizal Damuri (CSIS)

But it should be more than a long shopping list of projects. Projects should be coherent and comprehensive so as to achieve shared prosperity, with the strengths of all five countries, including Japan, reinforcing one another. Earlier this afternoon, Dean Bambang Brodjonegoro made an important point about coordinating business relationships with development aid to ensure the effectiveness of cooperation. I think this is a very good approach to the cooperation envisaged under the Global Five Epistemic Caucus. But we also need to prevent security concerns from leading to demands for geopolitical alignment, which could threaten the effectiveness of cooperation. This is particularly important for Indonesia and other developing countries, because many of us want to maintain economic partnerships with a broad range of partners. This will help safeguard our future cooperation.

Sachin Kumar Sharma (RIS)

This should benefit businesses, whether Japanese, Indian or from elsewhere in the Global South, as well as local populations. Another point I would highlight is the need for bilateral cooperation. Japanese and Indian businesspeople have worked together for many years to create specific projects. There are several examples. There are also trilateral opportunities, where India and Japan come together to address challenges in other Global South countries, especially African countries.

Luciana Mendes Santos Servo (IPEA)

Second, from Brazil's perspective, I would like to give just two of many examples of long-standing cooperation. The first is technical cooperation between Brazil and Japan, dating back to the 1950s, when Japanese experts travelled for 36 hours, as we do today, to reach Brazil, which is 12 hours behind Japan, and helped Brazilians begin production in the Cerrado region. The Cerrado was not productive at the time. That was one of the first projects to develop production in that area. This is long-standing cooperation. Let me turn to another area of great interest today that also has a long history of cooperation: Brazil's mining and minerals sectors. In the 1950s and 1960s, there was a partnership involving a

Brazilian company and financing for a new steel-producing company in Brazil, whose name is unclear in the transcript, which would export steel worldwide. Brazil has a long tradition in steelmaking, and that cooperation was important.

Research could really help with this, but research could also help us evaluate and monitor our results. We heard some examples here this afternoon. I remember representatives from India saying that when Suzuki came to India to develop biofuels, they tried a model that was not co-creation. It was a model of bringing Japanese companies and their technology there, and it did not work. Based on that failure, they started co-creation projects: going to local communities, understanding how they work and how they relate to government, and now they are co-creating projects with local communities, with financing and support from the government and with private-sector participation in biofuel production. The same applies to all the projects we have heard about here. We have heard about cooperation between a Japanese international development bank and our national development bank on biofuels and energy in Brazil. That is how we see this G5EC project: as co-creation. Co-creation means cooperation, understanding the local context and shared development. It means everyone developing together: business, research, think tanks and development banks, all working within the local context. We have seen many opportunities demonstrated here, and many others could be brought into this kind of discussion. From the workshop and today's event, I see room for long-standing cooperation, even in very challenging geopolitical times. Thank you.

Elizabeth Sidiropoulos (SAIIA)

Good morning from South Africa. It is very good to join you, although I would have very much liked to be with you in Japan and take part in the discussions. I have, however, benefited from briefings by colleagues and by you, Nishimura-san. Let me begin by thanking METI for its ongoing support for this initiative, as well as MIGA and Nishimura-san. As I think Pamla said earlier, cooperation between Africa, including South Africa, and Japan has been long-standing. I think the TICAD process itself has been a very important vehicle and mechanism. I want to pick up on a couple of points colleagues have made, build on them and offer some suggestions. First, from an African or South African perspective, Africa is the continent of the future.

One of the major challenges African countries face is how to scale up these innovations. How do we take homegrown ideas that address local problems and roll them out effectively? Part of the answer lies in co-creation and identifying mutual benefit. All of these are crucial for us to really be able to realise the objectives that have been set out, both regionally through SADC in the Southern African case, but also continentally through the African Continental Free Trade Area. The partnerships we are creating through the T20 (Think20), the G20 and the G5EC can, I believe, help galvanise efforts to address these challenges.

4. Knowledge, Research Institutions and International Policy

Sachin Kumar Sharma (RIS)

So we already have a framework; we are not starting from scratch. We have the knowledge products, but how do we turn them into economic opportunities? I would especially like to congratulate this forum on bringing researchers, policymakers, government and the business community together. Turning knowledge products into economic opportunities is key. In this context, I also congratulate and thank Professor Nishimura for bringing the G5EC framework to bear on finding solutions to the challenges of the Global South.

Luciana Mendes Santos Servo (IPEA)

Now we are talking about this kind of cooperation in the mining and minerals sectors, bringing together knowledge from both sides (and, we believe, from at least five countries) to build knowledge partnerships. This brings me to my second message: knowledge is essential for business. Producing evidence that businesses can be efficient and profitable while contributing to development in each country is part of what we are trying to do through this five-country G5EC partnership, working with businesses and ministries in each country and combining knowledge generation with evidence. Let me suggest three priority areas of cooperation. First, invest in joint innovation. Innovation is key to entering and organising new markets.

I work in a government think tank that is sixty-two years old and has provided evidence and support to the Brazilian government throughout that period. We work with ministries, including the Ministry of Finance, and we know the value of co-creation with governments. From the perspective of this report, I think this co-creation can help ensure that we do not get lost in translation. We can bring our knowledge together, share it and help our companies and governments cooperate, even in challenging geopolitical times. One more thing: I heard from the grandmother of a Japanese friend of mine that the only thing she wants to hear is peace. Peace is built through cooperation. The more we cooperate, the more we may be able to bring peace to younger and older people in our countries. Thank you.

Elizabeth Sidiropoulos (SAIIA)

I see this observation as part of a value chain that we should also recognise as an epistemic community. A great deal of evidence has been produced through research. But sometimes the biggest constraint, in developing and developed countries alike, is not knowing what solutions are needed, but knowing how to make them happen. That requires us (and I see the G5EC playing a critical role here) to focus on the system rather than on narrow, individual initiatives and issues. We need to see how these initiatives can contribute to the broader ecosystem of economic growth and development. So, besides producing evidence, it is important to reflect on what this ultimately comes down to: implementation.

I think that interface, that nexus, is very important. It is a three-way exchange, not just a two-way exchange. Recommendations to policymakers must be rooted not only in research but also in industry and the private sector. At the end of the day, development, economic growth and innovation in response to today's complex challenges depend on people on the ground who create jobs and build sectors. I think it is important to speak about local, bilateral and trilateral cooperation. It is also important, picking up on what Yose was saying, to look at how this epistemic community can press for changes in global governance. Such interventions can be powerful because of the knowledge created by this epistemic community.

5. Project Formation, Business and Investment

Yose Rizal Damuri (CSIS)

But going forward, under the G5EC, we need to move from commitments to implementation. I think that is one of the messages we are trying to convey in today's discussion. Allow me to make three recommendations to continue the legacy of those four G20 presidencies under the proposed G5EC. First, economic cooperation should focus on concrete projects and initiatives that benefit everyone. We should move from broad commitments to specific projects.

Sachin Kumar Sharma (RIS)

That is a good example of how we can co-create a project. Second, Japan and India can come together to work in Africa. Examples involving Nigeria and Angola were given, including critical minerals and other areas. We are already working on many of these issues. What we need is a common knowledge platform through which we can identify specific sectors and projects and determine how to co-create initiatives that lead to shared prosperity for all stakeholders, including businesspeople. Through DAKSHIN, we have memoranda of understanding with more than 163 think tanks across 92 countries. We follow a demand-driven approach: we identify demand and then help implement projects. The challenges in the Global South are substantial, so we need this platform and collaboration with Professor Nishimura. We would be pleased to contribute whatever we can to addressing these challenges. Thank you very much.

Luciana Mendes Santos Servo (IPEA)

Twenty years later, Brazil established Embrapa, the Brazilian Agricultural Research Corporation, which helped develop agribusiness in Brazil. The area where we began the partnership in the 1950s, in the country's central-western region, is now Brazil's main agribusiness region. It was a long-standing partnership with very fruitful results. That cooperation did not end there. More recently, in 2025, Japanese companies and Embrapa began cooperating again to help small and medium-sized businesses in agriculture develop machinery, technologies, software and AI to increase their productivity.

Elizabeth Sidiropoulos (SAIIA)

Let us consider how to build foreign investment that works with local companies and local opportunities, so that critical minerals benefit development on the continent. Fundamentally, that should be the goal. That was the perspective through which our respective G20 presidencies approached the issue. Economic growth is not an end in itself; it must be inclusive. We must move from commitments and ideas to implementation and consider how to make that happen. Another important dimension of the G5EC initiative and the past three working days in Japan is bringing policymakers, knowledge producers and providers together with the private sector, business and industry. Sometimes we sit, not always in ivory towers, but in places that are not sufficiently connected to what is happening on the ground. I think this nexus of business, the private sector and government is one of the most powerful ways to realise many of these opportunities.

6. Technology, Industrialisation and Regional Development

Yose Rizal Damuri (CSIS)

My second recommendation is that these initiatives should create shared value, shared responsibility and shared benefits among the parties. Cooperation under the Global Five Epistemic Caucus should involve all parties proportionately, according to their capacity to contribute and their ability to implement. One example is circular-based green industrial development. People already talk about green industrial development, but we need to move towards circular-based green industrial development that becomes increasingly sustainable, not only in products themselves, but also in production and manufacturing processes. We can try to develop new industrial networks. My third point, which is also related to today's discussion, is that we must acknowledge current global dynamics, in which geopolitics and security have dominated global initiatives.

Elizabeth Sidiropoulos (SAIIA)

Africa is the continent of the future not only in terms of demographic growth, but also in terms of significant economic and development opportunities, including innovation. Across the continent there are examples of innovations and ideas connected to the discussions held on Thursday and Friday about new frontier sectors that will be crucial for economic growth and development in the twenty-first century. Here I want to echo what Luciana said: it is important to build integrated value chains that support small and medium-sized enterprises. Reflecting briefly on South Africa's G20 presidency, one of its most important aspects for South Africa and many other African countries was the opportunity to use the continent's significant deposits of critical minerals for the green transition. These resources can help rebuild existing industries and create new ones, rather than perpetuate the cycles of extraction that have characterised much of Africa's economic development.

In the South African context, there are many opportunities to work together through this caucus, building not only on South Africa's new industrial policy but also on regional initiatives concerning industrialisation and critical minerals, which were among the outcomes of the G20 last year. These connect to the opportunities offered by the African Continental Free Trade Area, which encourages regional value chains across national borders rather than in a single country. When we talk about digitalisation, it must be inclusive. When we talk about artificial intelligence, it must be inclusive. Specific opportunities in this new era of sectoral development include green hydrogen in South Africa and the wider region, new-energy vehicles, the automotive sector and clean-technology supply chains, including linkages among critical minerals, energy and logistics.

Sachin Kumar Sharma (RIS)

If we really want to make an impact, we must break out of our institutional silos and bring think tanks, government and business together. This forum and the G5EC can play important roles. At RIS, we are also working in this direction. That is the first point. Second, to succeed, we need to identify a pipeline of projects, including both bilateral and trilateral cooperation. Finally, we must work together transparently to transform the world towards shared prosperity. Thank you.

7. Knowledge and Influence on International Decisions

Participant (speaker attribution to be confirmed)

I have worked in research and knowledge for about thirty years. I think there is an important distinction between knowledge accumulated for its own sake and knowledge that can shape international decisions. I believe exercises such as the G5EC can generate greater influence over international decision-making and cooperation in the future. I thank METI for supporting this kind of exercise. I believe it should be repeated in the future. Through a strong presence and a common platform, we five G5EC countries can exert greater influence on economic policy and the global agenda. Thank you very much.

8. Chair's Substantive Interventions and Closing

Hidetoshi Nishimura (MIGA, Musashino University)

Thank you very much. This is an important opportunity for concrete cooperation. Japanese businesses are modest and very careful about investment. RIS has invited us: 'Please join our platform. Let us go to Africa through cooperation between India and Japan.' I found that invitation very interesting.

Yes, remarkable. 'Epistemic' is a difficult word. What does it mean? It concerns fundamental insight and questions of beauty and truth, extending beyond economics and politics to wider relationships.

This new type of connectivity is symbolised by the word ‘epistemic.’ Luciana has demonstrated her own understanding of what the G5EC is. Thank you very much. Luciana created this, not us. That is a fundamental example of the Global Five Epistemic Caucus’s co-creation from the outset.

We have little time left. We would like to hear more about the project described as involving approximately three billion. A major development is underway. How do you evaluate these developments, and what do you expect from these activities? Luciana, please.

Thank you very much. Ladies and gentlemen, you are witnesses: ownership of the Global Five Epistemic Caucus belongs to all of us. It is not a Japanese project. The G5EC is a framework for cooperation among five countries. Thank you very much.