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SCIENCE-DIPLOMACY INTERFACE

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The Science-Diplomacy Interface – Has It Changed?*

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In the last few years, science diplomacy has become a 'buzzword'. The concept has apparently undergone a degree of evolution – or has it? Certainly, the science-diplomacy interface's focus has recently become more explicitly pragmatic and transactional.[1] The issues that can and might be addressed via an effective interface have evolved. However, science and diplomacy have always been intertwined.

Understanding the science-diplomacy interface requires understanding the relationships between science and knowledge, knowledge and power, and between power and the advancement of state interests. Diplomacy, in the context used here, is a means of seeking to advance national interests in relationships between states. The science-diplomacy interface has always sat within this set of relationships.

Science, Patronage and Power

Patronage sits at the heart of understanding the science-knowledge and knowledge-power nexus. Science is an empirical form of enquiry that seeks to advance knowledge through enquiry, testing, and refining hypotheses. But scientific enquiry carries a cost. Science has therefore long attracted patrons. For much of recorded history, polities have relied on knowledge and the technologies that flow from it in one way or another as central to power, influence, and economic growth.

The nation-state has been modern science's primary patron for well over 150 years. That patronage has been motivated by the national benefits derived from science. However, national interests, the international advancement of science, and issues of the global commons are not mutually exclusive. They often reinforce one another. Indeed, for much of the post-Second World War period, significant progress has been made in addressing global challenges, and science, supported by national investments and international cooperation, has been integral to that progress.

However, recent events have highlighted the risks, including those of missing opportunities, if the focus of science diplomacy is reduced to promoting direct progress on issues of the global commons and giving inadequate attention to questions of how science diplomacy can pragmatically serve national interests. A longer-term perspective on how the science-diplomacy interface has developed over this time frame offers insights into the possibilities and limits of science diplomacy as the world confronts a new era of heightened instability.

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* The views expressed are those of the authors and are not necessarily those of the International Science Council.

Science, Diplomacy and National Interests

During the nineteenth and twentieth centuries, science was given increasing focus by many nation-states because of its interface with economic, defence, and security interests. The relationship between empires, power, and international law has been well documented.[2] While states were major patrons of science, during and after the Industrial Revolution, industries also invested heavily in knowledge-based innovation and technology. This has become particularly apparent in the past two decades.

In many cases, state-sponsored science and international goods aligned, providing fertile ground for science diplomacy. The late nineteenth and early twentieth centuries witnessed a plethora of examples of international cooperation across the practice of science, the adoption of international agreements informed by science, and the setting of standards to facilitate technological progress.[3] The international sanitary conferences (1851-1938), the establishment of the International Telegraph Union (1865), the series of conferences culminating in the International Meteorological Organisation's founding in 1873, and the *Convention du Mètre* (1875) offer a small number of well-known examples.

Interest in science's interface with defence and security accelerated with the Second World War, particularly in the United States of America. It has been well recognised that under the influence of Vannevar Bush and his report[4], *Science: the Endless Frontier*, science became more tightly linked in the minds of policymakers with economic growth.[5]

The post-1945 period is also seen by many modern practitioners as the time when science diplomacy emerged as a distinct practice.[1] The UN's establishment in 1945 ushered in an (imperfect) era of multilateral cooperation spanning significant periods of global challenge and change, including the Cold War, Decolonization processes, and rapid technological change with the rise of computing.

Science, technology, economic power, security and geostrategic interests remained linked across these periods. What has changed over the last century is how that linkage operates, as well as the focus and opportunities for science diplomacy.

Immediately after the Second World War, the focus was on building international organisations in a framework set by the victors (in particular, the USA). International science received increased focus with the establishment of UNESCO. Scientific activity and advice were embedded across other UN agencies, particularly in developmental aid agencies and in areas such as public health (World Health Organization), food security (Food and Agriculture Organization) and environmental stewardship (United Nations Environment Programme).

Science supported soft power projection during the Cold War. Nevertheless, international science working in partnership with diplomats could still have a major impact. Examples include the Antarctic Treaty (1959), the Montreal Protocol (1987), and the formation of the Intergovernmental Panel on Climate Change (1988). International scientific cooperation grew, although many countries across Asia, Africa, Latin America, and the Middle East remained peripheral participants, and the institutions and networks of science remained heavily concentrated in Europe and North America.

After the Cold War, the global order shifted again. While unequal representation persists, the geography of science has diversified. China and India invested heavily in science and experienced sustained economic growth. In the early part of the twenty-first century, science and diplomacy made significant advances in addressing issues of the global commons. In 2015, several landmark agreements were concluded: the Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction, and the Paris Accord on Climate Change.

And yet, over the past decade, the enthusiasm of that period has been replaced by more overt superpower competition, an increasingly multipolar world, weakened multilateral arrangements, and more cynicism towards the post-1945 rules-based world order.

A Challenging New Era for Science Diplomacy

The world has rapidly progressed to a new and worrisome phase. With good reason, uncertainty is high. It is a period characterised by fractured globalisation, multipolarity, and the emergence of non-state actors with a size and influence that is highly disruptive. These actors have an uncertain synergy with superpower interests, focusing middle and lesser powers into somewhat uncertain choices and direction. It is uncertain whether full technological sovereignty will remain possible in all but the most powerful nations.

Science-based technologies, especially in the digital space, have more clearly than ever demonstrated the linkages between science, technology, economics, security, and power. AI and quantum technologies have emerged rapidly and profoundly impacted superpower competition and economic strategies. Such technologies inevitably have defence applications, as seen in the use of autonomous weapons and drones in armed conflict.

We are seeing barriers being erected to knowledge sharing in science, both in the name of security and economic growth, especially in areas related to platform-based science.[6] These barriers, that emerge from the very different geostrategic context of the last decade, have created challenges for many in the scientific community. These barriers also raise uncomfortable debates in an era of more overt conflict over the probity or not of whether scientific institutions could, in some circumstances, such as nuclear research facilities, be legitimate targets of war.

Technological developments have fundamentally altered the global information environment. The combination of behavioural science and information technologies has reinforced the ability to deploy disinformation in cognitive warfare.[7] Information disorder[8] and cognitive warfare disrupt democracy, drive polarisation, and generate conditions that are generally destabilising.

The science-power relationship is stark across all of these examples. That is an unavoidable component of the context in which the next era of science diplomacy will be practised.

Looking Forward

As the multipolar world has become overtly more transactional, it is inevitable that science is caught up in how national strategies evolve. Science and technology are also increasingly core to how trade agreements operate. But there has been a cost: a relative loss of focus on and commitment to the issues confronting the global commons. Global commons span many of the examples of international interests listed above, including places, interests, challenges, and resources.

Growing polarisation and changed attitudes to both international cooperation and long-term thinking in some liberal democracies also impact scientists' and diplomats' ability to focus on the global commons. While there are growing concerns about the limits being placed on international scientific cooperation in an era of heightened economic and geostrategic competition, of which restraints on global scientific mobility are but one example, there remain pragmatic paths forward to address issues of the global commons.

Taking those paths will require a mature understanding of how to navigate the relationships among science-knowledge, knowledge-power, and power-state interests. The science community might accelerate this progress by recognising the pragmatic side of science diplomacy.[1,9] The challenge for those pursuing progress on the global commons will increasingly be finding points of alignment between domestic political and business interests and issues of the global commons.

Progress on the global commons relies on international scientific and diplomatic cooperation, the multilateral system, and the achievement of global or near-global agreements. There will continue to be many opportunities where scientific and diplomatic interests can align.

However, given the urgency associated with many issues of the global commons and the relative failure of interventions such as the Sustainable Development Goals, new forms of dialogue and cooperation may need to be considered. Those new forms must better consider the different incentive structures and interests associated with different types of global commons and integrate this nuanced understanding alongside robust scientific capability. The role of non-state actors, particularly platform companies, must be considered. International cooperation will be increasingly shaped by infrastructure, governance, and institutional design.[6]

The practices of science and diplomacy have both evolved during the last two centuries. So too has the interface between the two disciplines. The next era of that evolution must be characterised by a deeper understanding of the pragmatic constraints and emerging opportunities on both sides of the interface.

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When Science Meets Geopolitics: US Policy Shifts, Talent Reconfiguration, and the Rise of South–South Collaboration

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Introduction: A Structural Turning Point

The global movement of highly skilled individuals has entered a new and fundamentally more contested phase. For much of the twentieth century, the logic governing talent flows was relatively straightforward: researchers left the Global South for the North in search of better-funded laboratories, stronger institutions, and more stable career trajectories. The 'brain drain' paradigm — for all its limitations — offered a recognisable framework for understanding this directional, asymmetric movement.[1] That framework has not merely aged; it has been overtaken by a reality far more complex, more politically saturated, and more difficult to map onto the tidy geographies of sender and receiver that once defined the field.

The mobility of researchers, engineers, international students, and innovators is now shaped as much by geopolitical calculation, visa architecture, and research security policy as by scientific merit or institutional prestige. To capture the geographically and politically conditioned character of high-skilled mobility in an era of strategic competition for knowledge, innovation, and geopolitical influence, Buyuktanir Karacan and Tapia Takaki introduce the concept of *geotalent*. The full theoretical elaboration of this concept is ongoing, but its core insight is already apparent: where scientists can go, and what they can do when they get there, is increasingly determined by forces well beyond their individual control.

This article examines four dimensions of this reconfiguration: first, the structural disruption caused by recent United States (US) policy shifts and the erosion of its long-standing scientific attraction; second, the emergence of a genuinely multipolar science landscape, with particular attention to China's systematic reversal of brain drain and Europe's deliberate strategic repositioning; third, the accelerating growth of South–South scientific collaboration as a strategic response to a world in flux; and fourth, India's evolving science diplomacy as a case that crystallises both the tensions and the opportunities of this new global knowledge order.

The United States: From Magnet to Question Mark

The United States built its scientific pre-eminence on federal investment, institutional openness, and the deliberate recruitment of global talent. Foreign-born individuals accounted for 22 per cent of the US STEM workforce in 2023 and are disproportionately represented among doctorate-level researchers and innovators.[2,3] Their contribution is also reflected in scientific excellence at the highest level: immigrants account for approximately one-third of US-affiliated Nobel laureates and have received around 40 per cent of the Nobel Prizes awarded to Americans in physics, chemistry, and medicine since 2000.[4,5] These figures underscore the extent to which the United States' research capacity and global scientific competitiveness have been built on international talent attraction and retention.

That model is now under significant strain. The FY2027 federal budget request proposes cuts of 55 per cent to the National Science Foundation (NSF) and 13 per cent to the National Institutes of Health (NIH).[6] Since 2025, the US government has reportedly lost over 10,000 STEM PhD holders through layoffs and an increasingly uncertain research environment.[7] The Fogarty International Center faces repeated proposals for elimination, and multilateral commitments to large-scale science infrastructure such as ITER and Lunar Gateway are in question. NIH grantees have been directed to seek advance approval before co-authoring with researchers at foreign institutions[8] — a restriction that, whatever its security rationale, signals a fundamental retreat from the norms of open science.

Burrows and Hardegree (2026)[9] have characterised this as a potential 'Reverse Sputnik' — a self-inflicted erosion of scientific capacity by the very nation that once defined it. The US is shifting toward a more transactional science diplomacy — prioritising bilateral arrangements serving immediate strategic objectives over the longer-term relationship-building that historically underpinned its scientific soft power.[6] The global scientific community is now recalibrating rapidly.

A Multipolar Science Landscape: China's Rise and Europe's Response

Global science is reorganising itself across multiple competing and complementary poles (OECD, 2025).[10] As the US turns inward, others have moved quickly and deliberately to occupy the ground it is leaving behind. Montaño Ramirez and Petersen (2026)[11] demonstrate empirically that the global science system's core-periphery structure has been in meaningful transition since 1980, with the Global South's share of research co-production rising significantly across four decades.

China and the United States have reached a historic parity in global R&D spending, both operating at roughly $1 trillion annually, yet with fundamentally different structural priorities.[12] The more telling story, however, is human: between 2010 and 2021, over 12,000 Chinese-descent researchers returned from the US, drawn by housing subsidies, medical insurance, and competitive research grants.[13,14] These returnees — known as 'Sea Turtles' — are building research ecosystems, not simply going home. Institutions such as Westlake University and the Shenzhen Bay Laboratory have been established largely around diaspora returnee scientists and are already producing globally competitive research. Through targeted returnee programmes and purpose-built institutions, China is systematically reversing the historic direction of brain drain — not through coercion or ideology, but through the straightforward logic of competitive attraction operating at scale.[14]

Europe's response has been equally deliberate, if pursued through different means. The European Commission's 'Choose Europe for Science' initiative, launched in 2025, positions the EU as a destination for researchers from across the world — whether compelled to leave by political pressure, economic instability, or deteriorating research conditions, or simply drawn by the promise of a more open, stable, and well-resourced scientific environment. The initiative is not framed as a response to any single country's policy failures; rather, it is a deliberate and inclusive signal that Europe welcomes global scientific talent. The EU Visa Strategy streamlines pathways for internationally mobile scientists, while EURAXESS and the EU Talent Pool provide institutional infrastructure for retaining globally mobile researchers.[15] Horizon Europe — which now includes fourteen non-EU associated members, including South Korea, Egypt, New Zealand and Japan — functions increasingly as a geopolitical instrument as much as a research funding programme. Critically, Europe is not simply competing for talent from the US pipeline; it is building a more diversified ecosystem that includes significant partnerships with Africa, Latin America, and Asia through its Global Gateway strategy. Singapore has meanwhile surpassed Switzerland in at least one major global talent ranking, and the United Arab Emirates and Saudi Arabia are investing heavily in STEM and AI infrastructure.[16]

The South–South Turn: Regional Collaboration as Strategic Choice

The deepening of South–South scientific collaboration is unfolding against a backdrop of profound structural change in the international order. The relative decline of multilateralism, the fragmentation of global governance, and the rise of competing geopolitical blocs have fundamentally altered the conditions under which science diplomacy operates. The expansion of BRICS+ in 2024 — bringing in Egypt, Ethiopia, Iran, Saudi Arabia, the UAE, and others — signals a deliberate effort by the Global South to build alternative frameworks for cooperation, and science is increasingly central to that architecture: member states are expanding shared research infrastructures and aligning innovation priorities in ways that bypass traditional Northern intermediaries. The African Union has positioned science and technology as a pillar of its Agenda 2063 framework, while regional platforms such as SAARC and ASEAN's STI mechanisms are developing research agendas oriented toward shared challenges — climate resilience, food security, public health — rather than the priorities of external funders. The rapid growth of private technology companies, the blurring of civilian and military research through dual-use technologies and escalating regional conflicts have introduced new fault lines into international scientific partnerships. In this fragmented and multipolar landscape, South–South cooperation is no longer a secondary channel — it is becoming a strategic choice pursued by governments that can no longer assume the stability, neutrality, or continuity of Western-led scientific frameworks.

Scientific diasporas are central to this process. When highly skilled professionals maintain active connections with their countries of origin — through co-authorship, joint supervision, entrepreneurship, and policy advice — they become architects of alternative knowledge networks that do not depend on Northern intermediation.[17,18] Bonilla et al. (2023)[18] document how this has taken concrete institutional form across Latin America, Africa, and Asia, through diaspora engagement platforms that build scientific communities across borders without requiring permanent return. The challenge is to convert what has often been underfunded South–South cooperation into a deliberate, institutionalised strategic priority.

India: Navigating Between Ambition and Disruption

India occupies a particularly significant position in this reconfigured landscape. After the 1980s, India moved from the periphery to near the centre of global research co-production.[11] Its net outflow of highly skilled professionals remains the world's largest — more than five times that of the next country — making the Indian diaspora one of the most strategically significant knowledge networks on the planet.[19]

India's science diplomacy has evolved accordingly. The 'Atmanirbhar Bharat' (Self-Reliant India) agenda and the Science, Technology, and Innovation Policy (STIP) 2020 reflect an ambition to become a top-tier scientific power — not by importing excellence but by cultivating it domestically and activating it globally.[20] The Vaibhav Summit and the PRABHASS platform attempt to build a 'network of networks' connecting Indian scientists abroad with domestic institutions and national research priorities. The Indo-US Science and Technology Forum (IUSSTF) has historically connected over 14,000 scientists across Triple Helix partnerships linking universities, industry, and government.[21]

But the current US retrenchment forces a strategic question: as the American side of that relationship becomes more conditional and transactional, does India double down on its US partnerships or diversify? The more promising path is to use this disruption as an opportunity to lead South–South scientific integration. India's size, its diaspora's global reach, its growing domestic research capacity, and its democratic credentials make it a credible convener of a more equitable global science system. The EU's expanding Horizon Europe partnerships, the new science diplomacy framework adopted by the European Council[22], and Global Gateway commitments signal willing partners for precisely this kind of reorientation.[15] India's deepening research ties with Brazil, South Africa, the Gulf states, and ASEAN partners further suggest that a multi-directional science diplomacy — anchored in the Global South but globally connected — is already beginning to take shape.

Conclusion: An Opportunity Disguised as a Crisis

What is unfolding in global science policy and diplomacy today is not an anomaly — it is the latest chapter in a long history of knowledge systems disrupted by power and conflict. Researchers have fled political collapse before — Syrian scientists displaced by a decade of civil war, Ukrainians forced to relocate overnight following the 2022 invasion, and Afghan academics who lost everything when institutional frameworks collapsed around them. What is different today is the scale, the simultaneity, and the drivers. Thousands of researchers have lost positions not to bombs or authoritarian purges but to budget spreadsheets, executive orders, and the quiet erosion of institutional trust. Yet, geopolitical rupture is only one of the forces reshaping the geography of scientific talent. Climate change, water scarcity, and the compounding pressures of environmental degradation are already beginning to displace populations — and scientists are not exempt. The talent mobility we are witnessing today is driven primarily by shifting power configurations and policy choices. But the mobility of tomorrow will be shaped by forces harder to negotiate, harder to reverse, and far less amenable to diplomatic resolution.

Disruption also creates openings. China is engineering a systematic reversal of brain drain through institutional investment. Europe is positioning itself as a science haven with deliberate strategic intent. South–South networks are gaining real institutional weight. Countries like India, Brazil, South Africa, and Singapore are asserting themselves as scientific actors in their own right — not merely recipients of Northern knowledge transfer. The movement of highly skilled people is no longer simply a migration story. It is a story about power — about who defines the frontiers of knowledge and whose problems science chooses to prioritise. The countries and institutions that build equitable, resilient, and collaborative frameworks in response to the current disruption will shape the next era of global science. That is not a threat. It is an invitation.

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Science, Technology and Innovation for Inclusive Transformation: Advancing India–Africa Cooperation

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Abstract

The relationship between science, technology and innovation (STI) and Africa's structural transformation has become an operational imperative. For a continent confronting simultaneous pressures—demographic acceleration, climate disruption, industrial stagnation, and health and food insecurity—STI is the architecture through which sustainable, sovereign, and inclusive futures must be constructed. Yet the material foundations remain critically underdeveloped: sub-Saharan Africa's R&D expenditure stands at just 0.4% of GDP (continental target is 1% of GDP), less than one-fifth of the global average of 2.0%,[1] while the continent captured a mere 0.6% of global venture capital in 2024.[2] This paper argues that India–Africa STI cooperation must transcend beyond the ceremonial and episodic engagements, reorienting toward sustained, evidence-driven, and institutionally embedded collaboration grounded in science diplomacy, policy alignment, and shared developmental purpose. It identifies high-impact domains for partnership and foregrounds the indispensable role of data systems, inclusive ecosystem design, and innovation financing in converting scientific knowledge into transformative development outcomes.

Introduction

Africa's development predicament is a structural paradox: a continent of extraordinary endowments—natural resources, arable land, critical minerals, and a young, expanding population—that remains at the margins of global value creation and knowledge production. What distinguishes the present moment is the recognition that these challenges demand systematic, science-based, and innovation-driven responses coordinated across institutions, sectors, and borders, and cannot be resolved through aid transfers or commodity revenues alone.

India emerges as a strategically apposite partner: its domestic experience deploying STI for large-scale, low-cost development challenges—from digital public infrastructure to generic pharmaceuticals and agricultural innovation—constitutes a model directly relevant to African contexts. India's Department of Science and Technology pursues international STI engagement through the India–Africa S&T Initiative,[3] commanding cooperation agreements across 83 countries, a network that, properly oriented, could powerfully accelerate Africa's knowledge economy.

Africa's STI Priorities

Africa's STI priorities[7] are structural necessities, not aspirational abstractions. As Table 1 illustrates, R&D expenditure has stagnated at 0.4% of GDP since 2005,[1] while the haemorrhage of approximately 70,000 skilled professionals annually[4] depletes the very human capital innovation ecosystems require. The

Table 1: Key STI and Innovation Ecosystem Indicators — Africa vs Global Benchmarks

Indicator	Africa / Sub-Saharan Africa	Global Average / Benchmark
R&D expenditure (% of GDP)	0.4% (stagnant since 2005)[1]	2.0%[1]
Share of global venture capital (2024)	0.6%[2]	Africa = 18% of the world population[2]
Skilled professionals emigrating annually	~70,000[4]	Among the highest rates globally[4]
Intra-regional trade share	~16% of total continental trade[5]	Asia >60%; Europe >70%[5,6]
Intra-African trade value (2024)	US$220 billion[5]	+13.9% growth driven by AfCFTA[5]

institutional logic is clear: ecosystems succeed when actors align around concrete, nationally relevant problems, and when knowledge-to-market translation mechanisms are deliberately constructed rather than assumed. This demands systemic integration of STI with industrial strategy, education, procurement, and regulatory frameworks—with universities, research councils, the private sector, and development partners functioning as co-architects, not episodic collaborators.

India's Cooperation Strengths

India's value proposition is distinguished not by financial volume but by developmental relevance. Its tradition of frugal engineering, scalable digital public infrastructure, globally competitive generic pharmaceutical industry, and expertise in space technology and renewable energy constitute a portfolio of capabilities directly applicable to African challenges. With agreements across 83 countries,[3] India has demonstrated the capacity for sustained scientific partnerships across diverse geopolitical contexts. The India–South Africa bilateral relationship—deepened through G20 and BRICS platforms and spanning biotechnology, astronomy, nanotechnology, and energy technologies since 1995—demonstrates that sustained, agenda-driven engagement accumulates compound institutional returns.

Priority Areas for Collaboration

The highest-return collaboration opportunities are those where knowledge application directly reduces structural poverty, expands productive capacity, and builds resilience. Table 2 maps five priority sectors against their joint programme focus areas and development objectives.

Digital innovation warrants particular strategic attention. India's capacity to architect scalable digital public infrastructure—from identity systems and payment rails to health data platforms—aligns powerfully with Africa's demand for efficient, interoperable, and sovereign digital governance. Enterprise development is equally critical: Africa's industrialisation depends not only on large capital projects, but also on a competitive, globally integrated private sector, for which India's experience with Small and Medium-sized Enterprises (SMEs) provides support, and industrial clusters offer replicable models.

Science Diplomacy and Policy Alignment

In an era of sharpening geopolitical rivalries and supply chain fragmentation, science diplomacy has re-emerged as one of the few genuinely constructive instruments of international relations. Unlike transactional foreign policy, it builds epistemic trust and institutional familiarity that enable durable

Table 2: India–Africa STI Priority Collaboration Sectors

Sector	Joint Programme Focus Areas	Development Objective
Agriculture	Climate-smart farming, seed systems, post-harvest loss reduction, rural mechanisation	Food security + income generation
Health	Diagnostics, vaccine R&D, digital health, local pharmaceutical manufacturing	Health resilience + industrial development
Energy	Off-grid electrification, battery storage, green hydrogen, clean cooking	Renewable transition + energy access
Digital Innovation	Fintech, e-governance, AI governance, cyber resilience, digital skills	Sovereign digital infrastructure
Enterprise Development	SME support, technology parks, industrial clusters, commercialisation pathways	Private sector competitiveness

cooperation. India and Africa share a foundational solidarity—rooted in non-alignment, a shared colonial history, and South–South philosophy—that provides the ideational substrate for a deeper knowledge-based partnership. The task is to operationalise that solidarity through structured research partnerships, mobility programmes, joint innovation platforms, and iterative policy dialogue.

AUDA-NEPAD and the African Union Commission bear the institutional responsibility of ensuring that bilateral and multilateral STI engagements align with continental strategic frameworks rather than fragment into disconnected project portfolios. Agenda 2063 demands robust monitoring, evaluation, and accountability architectures—STI cooperation must be designed around measurable outcomes, transparent reporting, and iterative learning mechanisms.

The Role of Data and Evidence

STI governance is only as robust as its evidence base. Governments require granular, timely data on R&D flows, firm-level innovation, technology adoption, patent activity, and startup survival to design genuinely transformative interventions. Without such data, STI policy defaults to input optimism—measuring expenditure rather than impact. Shared investment in harmonised STI metrics, joint evaluation frameworks, and digital evidence platforms would strengthen the empirical legitimacy of India–Africa cooperation and generate the institutional learning necessary for continuous improvement. Evidence, in this framing, is not a reporting requirement: it is the feedback mechanism through which cooperation evolves from good intentions to genuine transformation.

Innovation Ecosystems and Inclusion

The capacity to generate, absorb, and commercialise knowledge is a systemic property, not an individual one. Africa's ecosystem constraints are severe and measurable—as Table 1 shows, the continent captured just 0.6% of global venture capital[2] despite representing 18% of world population, and intra-African trade remains disproportionately low at approximately 16% of total continental trade[5]—reflecting not a deficit of entrepreneurial ambition but a systemic failure of enabling conditions: patient capital, regulatory certainty, market connectivity, and institutional support.

The India–Africa partnership must therefore function as an ecosystem intervention: co-investing in joint research centres, startup exchange programmes, technology transfer frameworks, and incubation infrastructure. Cooperation must be architecturally inclusive—integrating women, youth, and marginalised communities not as a normative addendum but as an economic imperative—and epistemically respectful, treating African knowledge systems and locally generated solutions as assets for co-creation, not gaps to be filled by external expertise.

Strategic Directions

Five mutually reinforcing strategic directions emerge from this analysis, summarised in Table 3.

These directions are not sequentially achievable; they are mutually reinforcing and must be pursued in parallel. AUDA-NEPAD and India's Department of Science and Technology must provide the institutional convening and coordination that bilateral STI cooperation demands—sustained beyond electoral cycles, diplomatic summitry, and the short horizon of project funding.

Table 3: Five Strategic Directions for India–Africa STI Cooperation

S.No.	Direction	Operational Mechanism	Strategic Rationale
1	**Sectoral Depth**	Time-bound, jointly governed programmes in high-productivity sectors	Move beyond declarations to funded, measurable commitments
2	**Talent Pipeline**	Fellowships, researcher exchanges, joint doctoral programmes	Counter brain drain; build bilateral scientific networks
3	**Ecosystem Support**	Incubators, testing facilities, commercialisation pathways	Integrate innovation support as structural — not peripheral — priority
4	**Science Diplomacy**	Dedicated bilateral STI governance and policy dialogue mechanisms	Institutionalise cooperation beyond summitry and project cycles
5	**Data & Evidence**	Harmonised STI metrics, joint evaluation, digital evidence platforms	Embed accountability and learning from programme inception

Conclusion

India–Africa STI cooperation today needs to be strengthened. Structural conditions for a genuinely transformative partnership are more favourable than at any prior moment: shared developmental philosophies, complementary institutional capabilities, growing political engagement, and an African continental market increasingly integrated through the AfCFTA. Yet the gap between potential, readiness and performance remains wide. Africa's R&D expenditure must urgently converge toward the global average of 2.0% of GDP,[1] and intra-African trade—growing to US $ 220 billion in 2024[5]—must be deepened through regulatory harmonisation and digital trade infrastructure. The opportunity before both partners is not simply to cooperate more, but to do so with greater precision, ambition, and an unwavering commitment to ensuring that the knowledge generated translates into sovereign capability, shared prosperity and genuinely inclusive transformation.

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Viewpoint

The Abyssal Frontier: Vertical Sovereignty and the Ethics of Ocean Governance

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Abstract

As the global energy transition accelerates, the seabed has emerged as a primary frontier for mineral extraction, challenging the traditional Westphalian conception of sovereignty, a topic inherent to Science Diplomacy. This article analyses the bioethical and political tensions arising from deep-sea mining, arguing that contemporary oceanic governance remains trapped in a planar, bidimensional cartography. By introducing the concept of vertical sovereignty, this paper demonstrates how the lack of material access and technological capability in the Global South constitutes a direct threat to national security. Furthermore, it examines the ontological extractivism enabled by quantum computing and Digital Sequence Information (DSI). The study concludes that effective access to the deep ocean is not a technical luxury, but a condition for epistemic justice and the protection of biospheric integrity.

The Internationalisation of the Commons

The global energy transition has triggered a technoscientific race for critical minerals located primarily in abyssal plains. While the United Nations Convention on the Law of the Sea (UNCLOS) defines these spaces as the "Common Heritage of Mankind," this legal category is facing a legitimacy crisis. The gap between nominal sovereignty and material access generates a strategic vulnerability for states in the Global South. Traditionally, International Relations have operated on a bidimensional cartography where sovereignty is limited to surface lines. This epistemic limitation ignores the volume and vertical depth of the ocean—the subsoil and abyssal trenches—as spaces for power exercise. However, the current climate crisis has shifted the geopolitical centre of gravity toward the deep ocean. The seabed is now presented as a new frontier for global extractivism, representing multidimensional challenges that cannot be analysed in isolation.

Vertical Sovereignty and the Security Gap

State sovereignty cannot remain a purely planar attribute. It becomes an inoperative abstraction if the state lacks the ontological correlate provided by technical capability for immersion and monitoring. As noted by Tilot et al. (2021)[1], the management of deep-sea resources—such as polymetallic nodules and cobalt-rich crusts—cannot be understood through bidimensional logic, given that deep-sea mining (DSM) activities operate in a tridimensional, hyper-complex manner. Furthermore, standard economic assessments often fail to capture the long-term ecological risks and structural losses associated with these operations.[2] For oceanic states like Costa Rica, the incapacity to monitor abyssal plains is not merely an industrial lag; it is a fracture in national security. Keeping this infrastructure void is equivalent to possessing terrestrial borders without institutional presence. Thus, vertical sovereignty is introduced:

sovereignty as a material capacity for exercise. If a state cannot access its own seabed, it cannot guarantee the protection of its biospheric integrity.

The Access Dilemma: Capital and Technology

The architectural framework governing contemporary oceanic spaces inherits a Westphalian matrix—a structural paradigm dating back to 1648 that privileges nation-state borders and treats territory as flat, static zones of exclusive control—that instrumentalises the law in favour of hegemonic actors. When Global North imposes the rhetoric of the commons and open access to data without transferring the technological power to process it, the framework operates as a rationalisation of asymmetric dispossession.

The current technological race has shifted the focus toward an increasingly instrumentalised science diplomacy. In this fragmented order, technical knowledge is no longer a collaborative good but a territory of strategic dispute. For countries like Costa Rica, Blue Soft Power (the strategic deployment of technical and political capabilities) acts as the bridge that translates oceanographic and biological data into legal and diplomatic mandates.

However, quantum extractivism and the dematerialisation of marine resources represent a significant threat. Through simulations of molecular interactions within chemosynthetic microbiota, hegemonic actors can patent synthetic biomimetic compounds in distant laboratories, circumventing the benefit-sharing obligations of the BBNJ Treaty (the international agreement on the conservation and sustainable use of marine Biological Diversity of Areas Beyond National Jurisdiction). This constitutes a fundamental threat to the distributive justice that the international community claims to uphold.

Science Diplomacy as a Tool for Epistemic Sovereignty

In the current geopolitical landscape, a state's capacity to influence the governance of global commons depends on its epistemic authority. For Costa Rica, the transition toward a Blue Soft Power state requires science to operate as a fundamental vector of foreign policy. Science diplomacy is often defined as the use of scientific collaboration to address common problems and build constructive international relations.[3] However, in the context of the deep-sea, it is a vital tool for sovereignty, allowing a state to engage in multilateral negotiations as a generator of situated technical evidence. As Gual Soler (2021)[4] suggests, in the 21st century, science diplomacy must be understood as the strategic direction of international relations to impel national interests in an arena of competition. This implies three essential dimensions:

1. Ensuring that the generation of oceanographic data remains a public, autonomous effort.
2. Utilising scientific evidence to challenge the Westphalian planar view of the ocean.
3. Promoting a governance model where the validation of knowledge reflects the diverse ontologies of coastal and insular nations.

By bridging the gap between university research and the Ministry of Foreign Affairs, Costa Rica transforms the technical complexity of the abyssal plains into an asset for negotiation, grounded in rigorous science and an ethical commitment to the common good.[5]

Toward Bioethical Governance

A truly reparative international policy must declare the quantum processing power applied to global commons as a transnational public good. The participation of states like Costa Rica in for a, such as the International Seabed Authority, demonstrates that legitimacy in the 21st century emanates from epistemic coherence. By advocating for a precautionary moratorium on deep-sea mining, Costa Rica exercises a transgenerational responsibility, recognising that the systemic resilience of the planet depends on our capacity to treat the ocean as a living, unitary system.

Conclusion

Consolidating vertical sovereignty and a robust Blue Soft Power is an ongoing project of political and technological recomposition. To move these principles from theoretical mandates into actionable global policy, the international community must establish clear operationalisation pathways. Ensuring the long-term integrity of the biosphere requires the implementation of specific institutional arrangements structured around three fundamental axes:

a) **Operationalising data justice via processing quotas:** Moving beyond passive data-sharing methodologies requires a binding framework within the International Seabed Authority and the BBNJ framework. This can be institutionalised through a transnational public good computing pool that legally mandates high-income nations and corporate actors to allocate a fixed percentage of their cloud-computing and quantum-processing infrastructure to scientific institutions in the Global South. In practice, oceanic states like Costa Rica would not merely receive raw digital files, but the structural capacity to run autonomous modelling and bioinformatic analyses on their own terms.

b) **Institutionalising epistemic diplomacy: States must transition from traditional, surface-bound diplomatic representation to specialised** technoscientific missions. This involves the formal integration of *Scientific and Technological Attachés* directly into maritime and diplomatic delegations. These attachés will serve as permanent institutional mediators, tasked with auditing deep-sea mining proposals, translating oceanographic data into real-time legal mandates, and defending national biospheric interests within multilateral fora.

c) **Creating regional implementation hubs:** The enforcement of the BBNJ Treaty cannot rely solely on fragmented national responses or centralised Western oversight. Instead, it must be executed through *Regional Ocean Governance Platforms*—collaborative frameworks shared by geographically contiguous coastal and insular nations. For the Central American and Pacific contexts, such platforms would standardise regulatory frameworks, coordinate shared patrol and deep-sea monitoring technologies, and establish a unified diplomatic bloc to enforce binding benefit-sharing mechanisms against algorithmic and digital biopiracy.

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India's RDI Fund and the New Imperative of Science Diplomacy

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Abstract

India's Research, Development and Innovation (RDI) Fund represents an important development in the country's innovation financing architecture. Designed to mobilise patient capital for strategic and emerging technologies, the Fund seeks to address structural gaps in private sector research and development investment. While primarily a domestic instrument, this article argues that the RDI Fund has significant implications for India's science diplomacy. It reflects an evolving emphasis in India's science and technology policy discourse, where strengthening domestic innovation capabilities is increasingly viewed alongside sustained international scientific collaboration. In this context, domestic technological capacity becomes an important enabler of global scientific engagement and influence. By situating the RDI Fund within comparative international innovation financing models, the article highlights its hybrid design and its potential role in shaping India's position in global science and technology governance.

Introduction

Science diplomacy has become an increasingly important dimension of international relations in an era where technological capabilities are closely linked with geopolitical influence. In contemporary global governance, science and technology are no longer confined to cooperation and knowledge exchange alone; they are also embedded in questions of economic competitiveness, strategic autonomy and international positioning.

Conventionally, the concept of science diplomacy has been analysed through collaborative models: science in diplomacy, diplomacy for science, and science for diplomacy. Though this model has allowed states to join global science networks and engage in extensive scientific cooperation, it has also highlighted technological disparities, in which the agenda-setting capacity lies with nations with stronger innovation systems. Under this changing scenario, domestic innovation systems have become crucial factors in shaping a state's international scientific interactions.

India's Research, Development and Innovation (RDI) Fund has been developed to reflect this evolving context. The purpose of the Fund is to spur participation from the private sector in high-risk/high-reward areas, with an indicative budget of ₹1 lakh crore. While its immediate focus is domestic, its broader significance lies in reshaping India's capacity to engage in global science diplomacy from a position of strengthened technological capability.

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[*] Views in the article are of the author and do not belong to the organisation they represent.

RDI Fund: Architecture and Comparative Positioning

The RDI Fund introduces a structural shift in India's innovation financing architecture.

First, it seeks to mobilise private capital into frontier technology domains such as artificial intelligence, quantum technologies, advanced manufacturing, biotechnology and clean energy. These sectors are characterised by long gestation periods, high uncertainty, and significant market failures, in which private investment is typically constrained. India's gross expenditure on R&D (GERD) remains around 0.6–0.7% of GDP, with the private sector contributing only about 36–40% of total GERD, compared to substantially higher private-sector shares in leading innovation economies such as South Korea with GERD ~ 5.0% of GDP (approximately 78%), China with GERD ~ 2.6% (around 77%), and the OECD (GERD ~ 2.7% of GDP) average of nearly 74%.[1,2] Addressing this structural gap is central to the Fund's design.

Second, the Fund focuses on patient capital tools, like equity, debt, and blended finance. This shows a move away from traditional grant-based methods toward market-aligned financial instruments that put a premium on long-term value creation and scalability.

The Fund's design also incorporates incentives to attract sustained private-sector participation in high-risk technology domains. The RDI Fund proposes long-tenure financing through both debt and equity instruments, with support available for up to 50 per cent of the total project cost. By providing unsecured patient capital, the Fund reduces financing constraints for firms operating in frontier sectors characterised by high uncertainty, long development cycles and limited access to conventional commercial finance. This risk-sharing approach is expected to improve private sector confidence while encouraging greater participation in strategically important deep-technology areas.

Third, the Fund operates through a two-tier financial mechanism, in which professional Second-Level Fund Managers (SLFMs) are responsible for capital allocation. This design aims to improve efficiency, reduce administrative bottlenecks and enhance investment discipline.

The RDI Fund is a natural extension of India's ongoing efforts to strengthen its research and innovation ecosystem. Consecutive efforts over the past decades have contributed to a measurable strengthening of India's innovation ecosystem. These include mission-mode programs geared toward developing startups, strengthening institutional capacities, and supporting innovation-led entrepreneurship. India has improved significantly in the Global Innovation Index, rising from 81 in 2015 to 38 in 2025, reflecting steady progress in innovation inputs and outputs. India is among the top five countries in terms of scientific publication outcomes, indicating a strong and expanding research base. In addition, India has developed one of the world's largest startup ecosystems, with more than 110 unicorns as of recent estimates. The RDI Fund marks another milestone in this trajectory.

Innovation financing models differ greatly when viewed globally. The Small Business Innovation Research (SBIR) Program in the United States connects funding for early-stage innovations with government purchases.[3] This makes sure that technological development meets government needs. Israel's Yozma Program is an example of a catalytic venture capital model in which the government helped private investment ecosystems grow by sharing risks and making investments together. This enabled these ecosystems to join global innovation networks.[4]

Co-investment is also central to Korea's venture investment strategies and to Singapore's early-stage public–private financing frameworks. Similarly, the United Kingdom's innovation investment models integrate market discipline with public support.[5] The SIDBI Fund of Funds for Startups (FFS) is an important example of a tool used by India to indirectly mobilise venture capital through fund-of-funds mechanisms.

In light of these innovations, the RDI Fund has been developed to integrate catalytic capital and indirect financing models, thereby emphasising strategic technology domains and the development of long-term capabilities.

Science Diplomacy: From Collaboration to Capability

Science diplomacy is increasingly shifting from an emphasis on collaboration to one of capability. While India's historical engagement has emphasised the collaborative/cooperative aspects of science diplomacy[6], it has also created opportunities for participation in multisectoral scientific initiatives and large-scale research frameworks worldwide. The collaborative nature of these science diplomacy activities has facilitated the integration of countries into the global science system and exposed asymmetries in technological capabilities, with countries with more developed innovation ecosystems often exercising greater influence over the setting of research priorities, governance structures, and global standards.

The launch of the RDI Fund represents a gradual shift toward a capability-based framework for science diplomacy, where domestic technological strength is used as the basis for international interaction rather than merely an outcome of it. This transition redefines how scientific influence is created and exercised in the global system.

Technological Capability as Diplomatic Capital

Technology is a key form of diplomatic capital in today's global governance landscape. Consequently, sectors such as semiconductors, space, AI, and clean energy all exhibit strong correlations among their innovation capabilities, production capacities, and standard-setting abilities. Countries with robust and supportive innovation ecosystems will have greater opportunities to participate in the creation of global rules and norms, to shape regulation, and to negotiate technology partnerships on more equitable terms.[7] Conversely, countries without robust technology bases will create dependencies and fewer equal opportunities for partnerships.

The RDI Fund will provide India with the tools necessary to improve its overall positioning as the global landscape shifts. By strengthening domestic innovation capability, the RDI Fund will enable India to establish itself as an equitable and effective participant in global technology governance, as well as in strategic partnerships in emerging technology sectors.

From Domestic Innovation to Global Integration

While the RDI Fund has a predominantly domestic focus, all innovation outputs are inherently global. Technologies developed in these emerging sectors will be incorporated into global supply chains and licensing agreements.

India Stack, particularly the Unified Payments Interface (UPI), illustrates how domestically developed digital public infrastructure can achieve global relevance at scale. India Stack demonstrates that foundational digital technologies, when designed for interoperability, openness, and scalability, can extend beyond national boundaries and influence global digital ecosystems and emerging financial technology standards. Building on this model, the RDI Fund can enable similar pathways in deep technology domains such as artificial intelligence, quantum technologies, and advanced manufacturing. This creates an opportunity for India to increasingly participate in global innovation systems not only as a consumer of technology but also as a contributor to global standards, interoperable platforms, and technology governance frameworks.

Implications for Science Diplomacy

The RDI Fund has three primary implications for India's science diplomacy strategy: (1) Moving to influence through capabilities instead of participation and using India's domestic capability as a source of strength in external relationships; (2) Increasing India's ability to define its own research priorities and negotiate international partnerships and technology agreements from a position of technological capability and strategic autonomy; (3) Creating pathways for greater cooperation with the Global South through technology sharing, co-development and context-appropriate innovation diffusion.

The ability to lead in critical technologies is based upon both technologically capable designs and the scale of production. By investing in frontier technologies, the RDI Fund would enable India to take a greater role in many existing international forums, such as the G20, BRICS (Brazil, Russia, India, China, and South Africa), and the Quadrilateral Security Dialogue (QUAD). Additionally, through these activities, the RDI Fund can build new avenues of South-South collaboration.[7]

The effectiveness of the RDI Fund will also depend on its coordination with India’s existing bilateral and multilateral science and technology partnerships. India already maintains extensive S&T cooperation frameworks with countries such as the United States, France, Japan, Germany, and Australia, alongside participation in multilateral forums and partnerships, including the G20, BRICS, SCO and Quad. Alignment between the Fund’s priority technology sectors and these international cooperation mechanisms could facilitate joint research, co-development initiatives, researcher mobility and technology partnerships. Such coordination would strengthen the integration of domestic innovation financing with India’s broader science diplomacy objectives and international technology engagement.

Many developing countries seek affordable and contextual technological solutions. Therefore, India's innovation ecosystem makes it an important partner for those countries. In this context, science diplomacy can serve as a mechanism for equitable knowledge exchange, capacity building, and collaboration on development-oriented issues. It will act not only as a tool for cooperation but also as an instrument for projecting domestic innovation capacity into global governance structures.

Limitations and Risks

Although the RDI Fund has enormous potential for impact, it faces challenges in several areas. A strong domestic focus, while strategically justified, could risk insularity if not complemented by deliberate international engagement. There is also the question of whether supported innovations will achieve global competitiveness or remain confined to domestic markets.

The success of the RDI Fund will depend on factors such as the extent to which it is integrated with industrial and trade policy, the coordination of funding with existing science and technology initiatives, and its ability to continue attracting long-term private-sector investment. Without these attributes, there is a high risk that the RDI Fund will fail to achieve the desired outcomes.

The RDI Fund could benefit from an enhanced scientific diplomacy strategy that fully captures its potential, leveraging various elements. These elements should include co-investment structures with trusted international partners; stronger linkages with bilateral and multilateral S&T agreements, and support for global deployment of Indian technologies; and integrating the RDI Fund with development diplomacy initiatives, particularly in the Global South, where technology sharing/building will provide the basis for developing long-term and mutually beneficial strategic partnerships. By using these approaches, India can maintain its domestic focus on self-reliance while simultaneously strengthening its global technology footprint.

Conclusion

The success of the RDI Fund may be assessed through both domestic innovation outcomes and international technological positioning. Domestic indicators could include increased private-sector participation in R&D, the commercialisation of deep-technology innovations, growth in patents and technology-intensive startups, and the scaling of frontier-technology enterprises. In the international context, an important indicator would be the extent to which technologies supported through the Fund achieve global competitiveness, participate in international value chains and contribute to emerging global standards and interoperable technology systems. Additional measures may include international co-development partnerships, technology exports and the adoption of Indian-origin technological platforms in partner countries.

The RDI Fund is a significant advancement in India's innovation finance system and its diplomacy regarding scientific matters. While primarily designed as a domestic instrument, it has broader implications for India's participation in international governance of science and technology. In this regard, the RDI Fund marks a shift from a focus on collaborative science diplomacy to one that is based on developing indigenous capacities for innovation and development. In an increasingly technology-driven world, these capacities will become increasingly important as sources of diplomatic power and leverage.

As India develops new capabilities by providing access to funding for innovation development and expanding existing networks of science, the RDI Fund will help India become an influential member of many of the world's major science networks. Thus, the RDI Fund not only provides a vehicle for financial support but also points to an emerging model of science diplomacy, one in which national capability underpins global engagement and in which India is positioned not only as a participant in global science but also as a shaper of its future direction.

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Commentary //////////////////////////////

Addressing Biosecurity Risks in Private Laboratories and Biological Supply Chains

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In November 2025, a doctor from Hyderabad with access to laboratory materials was investigated for his alleged attempt to manufacture ricin out of his personal residence.[1] Ricin, a biological toxin derived from castor beans, is defined as a category B bioterrorism agent by the US Centers for Disease Control and Prevention (CDC).[2] The investigations found castor materials and laboratory equipment from the premises. The incident highlighted the broader problem of how access to laboratory materials and knowledge can be weaponised when controls are not in place. This case clearly revealed issues of existing biosafety, where biological agents and toxins may impact populations through unintended externalities, such as leaks or mishandling, and biosecurity, where such agents are actively deployed to harm targets by malicious actors.

Such cases are not limited to India, nor are they rare. In 2018, German authorities found Sief Allah H in Cologne, Germany, who had reportedly acquired castor beans and researched methods for producing ricin within a residential setting.[3] In 2020, Pascale Ferrier, a Canadian national, produced ricin in her home and mailed ricin-laced letters to the then United States President Donald Trump and law enforcement officials in Texas.[4] Both these cases demonstrated how relatively accessible biological toxins and publicly available technical information can be weaponised by individuals operating outside formal scientific institutions.

These examples should not be interpreted as evidence that private laboratories, instruments, and biological agents are inherently dangerous, or that scientific openness itself is a threat. The issue is governance, or rather, a lack of governance in critical areas.

Governance of Labs and Materials in India

India's biotechnology and diagnostics sectors have expanded rapidly over the past 5 years.[5] Private pathology laboratories now perform functions that were once concentrated within government institutions and large research centres. These labs handle infectious samples and biological materials, conduct molecular diagnostics, and increasingly operate with sophisticated testing capabilities.[6] This expansion has improved healthcare access and research capacity, but has also created a regulatory gap being discussed. Unlike the countries mentioned above, oversight mechanisms for private laboratories in India remain fragmented and heavily dependent on voluntary compliance.[7]

Currently, laboratory biosafety in India is dispersed across multiple ministries, agencies, and guidelines, including the Department of Biotechnology (DBT)[8], which acts as the de facto agency overseeing biosafety, biosecurity and biotechnology innovation; the Indian Council of Agricultural Research and Biosafety[9], which goes beyond human biosafety and biotechnology and adds risks that may include animal exposure; and environmental regulations under the Environment Protection Act.[10] Private-sector labs must be authorised by the National Accreditation Board for Testing and Calibration Laboratories (NABL), which is limited to accreditation. This dispersed governance results in uneven safety enforcement.

This problem becomes more significant when viewed in the context of global biosecurity concerns. The Biological Weapons Convention (BWC) imposes obligations on states to prevent the misuse of biological materials. Compliance with these conventions, especially considering private pathology labs and private access to biological materials and knowledge, is not limited to military controls and border monitoring. It also requires domestic governance of laboratories, research institutions, supply chains, and scientific exchange networks. With India lacking a single oversight authority and excluding private-sector labs from the process that government labs and biosafety labs are required to undergo, enforcement of the BWC becomes superficial.

Governance Gaps and Recommendations

India has relevant regulatory guidelines on certain issues, but their implementation is patchy, especially in the private sector. Systems of laboratory accreditation, including NABL certification, emphasise technical proficiency and diagnostic expertise. A broader strategy for biosafety regulation is necessary to tackle the biosecurity cases as identified above. Laboratory facilities working with infectious or hazardous biological substances must be integrated into systems characterised by standardised inventories, chain-of-custody documentation, compulsory biosafety training, and periodic audits.

One gap in Indian governance is the lack of a standardised incident-reporting system for laboratory incidents. Such a framework was originally introduced in 2013 through the establishment of the Biotechnology Regulation Authority of India Bill (BRAI Bill)[11]; however, the bill lapsed and was not reintroduced. India has since lacked a central authority to oversee biosafety and biosecurity. Zavaleta-Monestel *et al.* noted that lab-associated infections and containment breaches are also often underreported.[12] A lack of mandatory and standardised reporting protocols makes it difficult for regulators to pinpoint vulnerabilities and institutional weaknesses.[13]

Another aspect involves the increased availability of biotech and scientific tools. In most cases, it is good to share scientific knowledge.[14] But this discussion is further complicated by the emergence of AI-driven chatbots, which make this type of knowledge easily accessible to untrained professionals or malicious actors.[15] Discussions about international biosecurity have shifted their focus towards dual-use research, which means conducting scientifically justified experiments that may have harmful applications. Globally, the focus on governance has begun to evolve, given the risks posed by dual-use research involving pathogens, toxin enhancement, and transmissibility.[16] In India, risk assessment mechanisms remain underdeveloped, particularly among private entities.

There should also be a greater focus on supply chain control. Biological agents and laboratory equipment can be legally purchased for various uses. Controlling these purchases does not mean placing limits on legitimate scientific trade, but implementing better controls when such purchases are made. While the Directorate General of Foreign Trade (DGFT)'s Export of Special Chemicals, Organisms, Materials, Equipment and Technologies (SCOMET) list under the Ministry of Commerce and Industry already covers the trade and transfer of such materials, there is a gap in overseeing domestic purchases, which can be out of the norm or outside of a regulated amount. The Hyderabad, Canada and Cologne ricin cases demonstrated how materials with legitimate industrial or agricultural uses can become part of improvised toxin production efforts.

While the BRAI did lapse, and these gaps exist because of the fragmented nature of the biosecurity and biosafety governance, there are a few ways that can address the oversight gap that can be implemented under existing government agencies, such as the DBT, as discussed:

1. Implement the National Biosecurity Procurement Monitoring Program

India must develop a centralised system to monitor biosecurity-related procurements of biological agents, chemical precursors, and specialised lab equipment. Instead of placing unnecessary bans on commercial transactions involving scientific products, the system must target atypical purchases, bulk buying, and dangerous combinations of materials. Supplier firms, dealers, and laboratory companies can be asked to retain purchase documentation and report suspicious procurement activities to competent regulatory agencies. Integration of information technology monitoring programs with established regulatory bodies, such as the DBT, and state-level health departments, will ensure preventive surveillance without stifling legitimate science and industry.

2. Develop Risk-Based Laboratory Licensing

The NABL must expand its licensing program to accommodate different levels of security and monitoring based on the types of hazardous biological materials, toxins, or dual-use capabilities possessed by each laboratory. Compliance procedures and requirements must differ. For example, labs handling hazardous biological materials or toxins must meet stringent safety standards, including regular biosafety audits, personnel reliability screening, and a mandatory incident reporting system.

3. Ensure Mandatory Inspections and Compliance Reviews of Private Pathology Labs

The regulatory agency that monitors private pathology labs must conduct periodic inspections that focus specifically on biosafety and biosecurity compliance. Inspections must review practices for the storage and transport of infectious materials, stock records of dangerous biologicals, waste disposal, staff biosafety training, and electronic records management to prevent leaks that could be exploited by malicious actors. In addition, any lab that works with high-risk pathogens or other biological agents must undergo periodic surprise inspections and third-party biosafety reviews. This would eliminate regulatory discrepancies across the country's burgeoning private diagnostics industry.

India's biosecurity strategy thus needs to move beyond being reactive. An arrest after the crime has been committed is not an alternative to effective systems of governance that focus on prevention. This requires institutional robustness, which entails a clear licensing structure for facilities handling potentially dangerous biological material, personnel screening when required, biosafety audits, and secure databases.

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Science, Policy and Purpose

My Journey Through India's Climate Action

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The year 2007 remains etched in my memory as a defining moment - not only in the global understanding of climate change, but also in shaping the trajectory of my own professional journey. The release of the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) fundamentally altered the way the world viewed climate science and its implications for humanity.

For the first time, the scientific evidence was presented with such clarity and confidence that there was little room left for doubt. Climate change was no longer a distant environmental concern or a subject confined to academic debate. It had emerged as an urgent developmental, economic, and societal challenge.

For India, the findings were especially alarming. The report pointed towards increasing water stress, vulnerability of Himalayan ecosystems, declining agricultural productivity, risks to coastal populations from sea-level rise, and a growing frequency of extreme weather events.

For policymakers, scientists, and administrators alike, it was a moment of reckoning.

A National Response Begins to Emerge

Recognising the seriousness of the issue, the Government of India initiated the process of preparing a coordinated national response. The Ministry of Environment and Forests was tasked with developing a broad climate framework, while a high-level drafting mechanism under the Office of the Principal Scientific Adviser (PSA) to the Government of India was established to guide the process. This ensured that the framework would be grounded in scientific evidence and practicality.

At the international level, too, India's climate engagement was evolving rapidly. During the Thirteenth Conference of the Parties (CoP-13) to the United Nations Framework Convention on Climate Change held in Bali in December 2007, the then Union Minister of Science & Technology and Earth Sciences was appointed to lead the Indian delegation. Though subtle, the decision reflected an important shift in thinking: climate change was not merely an environmental issue - it was fundamentally linked with science, technology, energy security, economic growth, and national development.

Soon thereafter, an inter-ministerial coordination mechanism was set up to steer the preparation of India's National Action Plan on Climate Change (NAPCC). The Union Minister of Science & Technology chaired the National Coordination Committee on Climate Change (N4C), and I had the privilege of serving as its Member Secretary. It was both an honour and a daunting challenge. Climate change was a highly complex and cross-sectoral issue. Any national strategy would need to reconcile multiple priorities - developmental aspirations, scientific realities, energy demands, international negotiations, and institutional capacities.

Building Consensus Across Systems: A Coordinated Teamwork

The process of preparing the NAPCC involved extensive consultations across ministries, scientific institutions, research organisations, academia and subject experts. These discussions were often intense and intellectually demanding. Each stakeholder brought a unique perspective, shaped by their institutional mandates and experiences. Reconciling these varied viewpoints required patience, sustained dialogue, evidence-based discussions, and a willingness to seek common ground. Yet, it was precisely this diversity of thought that enriched the final framework.

The drafting process was highly iterative, with repeated rounds of review, discussion, revision, and refinement. Every mission, recommendation, and implementation mechanism was examined carefully to ensure both ambition and practicality. Inputs from scientific institutions, different ministries, and national coordination bodies helped shape a comprehensive framework that balanced developmental priorities with environmental sustainability.

On 30 June 2008, the then Prime Minister, late Dr Manmohan Singh, formally launched the NAPCC. For me, it was a deeply satisfying moment - to witness the culmination of months of collective effort and to contribute, in some measure, to a framework that would shape India's climate response for years to come.

From Vision to Implementation

Following the approval of the NAPCC, attention shifted from policy formulation to implementation. The NAPCC identified eight National Missions addressing critical dimensions of climate change and sustainable development. Of these eight missions, four focused on mitigation, three on adaptation, and one on the science (knowledge) aspects of climate change.

S.No.	NAPCC Mission	Focus Area	Implementing Ministry/Dept
1	National Solar Mission	Mitigation	Ministry of New and Renewable Energy
2	National Mission on Sustainable Habitat	Mitigation	Ministry of Urban Development
3	National Mission for Enhanced Energy Efficiency	Mitigation	Ministry of Power
4	National Mission for a Green India	Mitigation	Ministry of Environment, Forest and Climate Change of India
5	National Water Mission	Adaptation	Ministry of Water Resources
6	National Mission for Sustainable Agriculture	Adaptation	Ministry of Agriculture
7	National Mission for Sustaining the Himalayan Eco-system	Adaptation	Department of Science & Technology (DST)
8	National Mission on Strategic Knowledge for Climate Change	Science/ Adaptation	DST

DST was entrusted with the responsibility of implementing the last two missions, namely:

- *National Mission for Sustaining the Himalayan Ecosystem (NMSHE)*
- *National Mission on Strategic Knowledge for Climate Change (NMSKCC)*

In May 2009, after completing my tenure with the Ministry of Science & Technology, I returned to DST to lead the implementation of these missions. A dedicated Climate Change Programme Cell was established to coordinate this effort.

It is relatively rare in government service to be involved both in the conceptualisation of a policy and later in its implementation. While this continuity offered intellectual satisfaction, it also brought a strong sense of accountability. The real challenge lay not in drafting mission documents, but in translating broad policy objectives into functioning institutional systems and impactful programmes.

Very soon, the magnitude of the task became apparent.

Rebuilding Institutional Foundations

By this time, a major structural shift had already taken place with the formation of the Ministry of Earth Sciences (MoES) in July 2006. Several premier institutions dealing with weather and climate sciences, including the India Meteorological Department (IMD), Delhi; the National Centre for Medium Range Weather Forecasting (NCMRWF), Noida; and the Indian Institute of Tropical Meteorology (IITM), Pune, had moved from DST to the new ministry. Consequently, DST no longer possessed a direct institutional base in climate and atmospheric sciences.

In many ways, we were tasked to take up these two missions almost from scratch. The initial years involved painstaking groundwork. Although the mission documents were conceptually robust, they required further detailing in terms of deliverables and timelines before implementation. This led to another extensive round of consultations across institutions and stakeholders nationwide. Nearly two dozen consultations were organised to refine implementation strategies and institutional mechanisms. Both NMSHE and NMSKCC documents were revised nearly a dozen times to reach final drafts, which were submitted to the Prime Minister’s Council on Climate Change in August 2009 and received approval in October 2009.

Shimla Declaration on Sustainable Himalayan Development

The Himalayan Chief Ministers’ Conclave was held in Shimla on October 29-30, 2009, to address glacial melting and the impacts of climate change on the Himalayan ecosystem. I was invited to make a keynote address on the implementation strategies for NMSHE. Discussions also centred on mitigating climate-induced changes in the micro- and macro-environment, adapting agriculture to erratic weather and protecting mountain livelihoods. The Conclave resulted in the Shimla Declaration on Sustainable Himalayan Development.

Creating a National Climate Ecosystem

After approval of mission documents, our next task was to build a scientific and institutional ecosystem capable of sustaining long-term climate research and action. We adopted an evidence-based approach. Using SCOPUS and other databases, we mapped leading Indian institutions, researchers, and thematic strengths in climate science, adaptation, mitigation, and related domains. This exercise provided a clearer understanding of the national research landscape and helped identify areas requiring capacity enhancement.

Based on this mapping, several important initiatives were launched:

- Centres of Excellence
- Major R&D Programmes
- Thematic Research Networks
- Human Capacity Building Programmes
- Thematic Task Forces

Among all the missions, the Himalayan Mission posed perhaps the greatest complexity. It was the only mission under NAPCC with a distinctly location-specific focus. The Himalayas represented not only an ecologically fragile region but also a critical source of water and biodiversity for millions of people.

Addressing Himalayan sustainability required integrating multiple disciplines - glaciology, hydrology, biodiversity, agriculture, traditional knowledge systems, and socio-economic studies. Six thematic Task Forces led by premier institutions were created to address these interconnected dimensions.

DST collaborated closely with the Ministry of Environment and Forests to establish State Climate Change Centres across States and Union Territories. These centres played a crucial role in supporting State Action Plans on Climate Change and in creating regional institutional capacities. Several forward-looking initiatives were also undertaken, including Global Technology Watch Groups (GTWGs), Indo-Swiss collaborations on glaciology, the Fulbright-Kalam Climate Fellowship Program under Indo-US bilateral cooperation, and inter-university consortia focusing on Himalayan cryosphere studies.

A System Begins to Mature

As the programmes expanded, their impact gradually became visible. Research initiatives gained momentum. Institutional networks deepened. Young researchers began entering climate-related fields in larger numbers. Collaborative platforms strengthened interactions between scientists, policymakers, and practitioners.

More importantly, climate research in India began evolving from isolated institutional efforts into a more connected national ecosystem. The missions were no longer merely policy documents. They had evolved into living systems of action. The establishment of Centres of Excellence, thematic networks, research programmes, and State Climate Change Centres created institutional foundations that continue to contribute to India's climate preparedness and scientific capacity.

Reflections on the Journey

Looking back today, what stands out most is not merely the scale of programmes or institutional achievements, but the spirit in which the journey unfolded.

There were uncertainties. There were resource limitations. There were moments of doubt and institutional inertia. Yet there was also extraordinary commitment, collaboration, and belief that the effort mattered.

Climate change remains one of the most complex challenges humanity has ever faced. Addressing it requires much more than policy announcements or international negotiations. It demands scientific capability, resilient institutions, interdisciplinary thinking, and above all, sustained collective effort.

For me personally, the climate journey at DST was far more than an administrative assignment. It became an enriching experience in institution building, public policy, and national service. It taught me patience. It reinforced the importance of collaboration. And it offered the quiet satisfaction of contributing - however modestly - to a larger national mission whose significance will only grow in the years ahead.

In many ways, the story of India's climate action is still unfolding. The challenges ahead remain enormous, but so do the opportunities for science, innovation, and policy to work together in shaping a more resilient and sustainable future.

Acknowledgement

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News //

KAIST Launches Centre for Science Diplomacy to Advance Global Technology Cooperation

The Korea Advanced Institute of Science and Technology (KAIST) officially launched the KAIST Center for Science Diplomacy (KCSD) on 13 May 2026, to strengthen the interface between science, technology, and diplomacy amid growing global competition in strategic technologies. The Centre aims to promote technological sovereignty, enhance international cooperation, and contribute to addressing global challenges such as climate change, ageing populations, energy security, and digital transformation. To mark its launch, KAIST organised a global forum focused on the strategic direction of science diplomacy in an era increasingly shaped by artificial intelligence (AI) and quantum technologies. Discussions examined how countries can balance technological competitiveness and security with the need for international collaboration, while also developing norms and cooperative frameworks for emerging technologies. The Centre is expected to serve as a platform for advancing global science and technology partnerships, fostering trust among nations, and supporting collaborative solutions to shared global challenges.

EU Council Adopts First Framework for Science Diplomacy

The Council of the European Union has adopted a recommendation establishing the first European Union Framework for Science Diplomacy on 29 May 2026, marking a significant step towards integrating science, technology, and innovation more closely with the EU's foreign policy objectives. The framework aims to strengthen the EU's position as a global science and technology leader while leveraging scientific cooperation to advance diplomatic, economic, and strategic interests. Recognising science as a global public good, the framework emphasises open and secure international research collaboration as a means of building trust and fostering dialogue with partner countries. It seeks to promote European values, including democracy, human rights, academic freedom, and the rule of law, while balancing scientific cooperation with research security and broader foreign and security policy considerations. Particular attention is given to emerging technologies such as artificial intelligence and quantum technologies. The framework also calls for stronger partnerships with countries of the Global South, including the establishment of a Mediterranean Science Diplomacy Centre, and encourages closer coordination between diplomatic services, research organisations, and universities. It further highlights the importance of integrating science diplomacy into education and training programmes and strengthening monitoring of global scientific and technological developments.

MoUs Signed

India–Norway MoU on Highway Infrastructure

The National Highways Authority of India (NHAI) and the Norwegian Geotechnical Institute (NGI), Norway, have signed a Memorandum of Understanding (MoU) to strengthen technical expertise in the development and maintenance of national highway infrastructure. The collaboration will focus on areas such as tunnel engineering, slope stability assessment, natural hazard mitigation, infrastructure monitoring, and institutional capacity building. Under the agreement, NGI will provide technical support for site characterization, feasibility studies, detailed project reports, tunnel safety assessments, and advanced geotechnical analyses. The partnership will also facilitate the use of innovative tools, including InSAR-based slope monitoring and early warning systems to enhance infrastructure safety. In addition, both organisations will undertake joint research, training programmes, workshops, and knowledge-sharing initiatives. The five-year collaboration reflects growing India–Norway cooperation in infrastructure development, technology exchange, and sustainable engineering practices.

India–Nepal MoU on AI-Driven Language Technologies

The Digital India BHASHINI Division, under the Ministry of Electronics and Information Technology (MeitY), Government of India, signed a Memorandum of Understanding (MoU) with Kathmandu University's Centre for Digital Public Infrastructure and Artificial Intelligence (DPI-AI), Nepal, to strengthen collaboration in Language AI, multilingual digital public infrastructure, and inclusive digital transformation. The partnership aims to develop Nepali-language datasets, speech corpora, and AI-enabled tools, including speech recognition, machine translation, and multilingual conversational systems. It also seeks to support the preservation and digitisation of linguistic heritage, particularly for low-resource and underrepresented languages. Through BHASHINI's open and interoperable language technology ecosystem, the collaboration will enhance multilingual access to digital public services, education, skilling, and innovation. The MoU further promotes joint research, capacity building, and academic cooperation, reflecting the shared commitment of India and Nepal to harness technology for inclusive growth and regional development.

Announcements

Rowland Fellowship
Submission deadline: 1 August 2026

Further information at:
https://academicpositions.harvard.edu/postings/16238

Singapore-Southeast Asia Fellowship (S-SEAF)
Submission deadline: 1 August 2026

Further information at:
https://www.a-star.edu.sg/research/sseaf

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Call for Proposals

BRICS Call for Proposals

Last Date: July 03, 2026

Further information at: https://onlinedst.gov.in/Projectproposalformat.aspx?Id=2230

Building US - India partnership to drive innovation in Critical Minerals and Quantum Technology

Last Date: July 31, 2026

Further information at: https://endowment.iusstf.org/login

Collaborative Scientific Research Programme

Last Date: July 31, 2026

Further information at: https://www.cefipra.org/Docs/CSRP_Guidlelines_deadline_31072026.pdf

India-Finland Joint Innovation

Last Date: August 28, 2026

Further information at: https://tdb.gov.in/launch-india-finland-joint-innovation-call-2026

India-Japan Cooperative Science Programme

Last Date: September 3, 2026

Further information at: https://onlinedst.gov.in/Projectproposalformat.aspx?Id=1067

India-EU TTC Call for RECYCLING OF EV BATTERIES

Last Date: September 15, 2026

Further information at: https://heavyindustries.gov.in/en/india-eu-ttc

Call For Proposals on Organization for Prohibition of Chemical Weapons (OPCW)

Last Date: September 15, 2026

Further information at: https://nacwc.gov.in/writereaddata/NACWC_Training_Opportunities/english/1_Upload_1865.pdf

Forthcoming Events

Science Diplomacy in the 21st Century: Foundations, Players, and Dynamics for Future Practice
Date: October 4-10, 2026

Further information at:
https://www.sciencediplomacy.it/

Africa Science Diplomacy Conference
Date: November 30-December 1, 2026

Further information at:
https://www.sfsa.co.za/about/

International Conference on Research Infrastructures
Date: December 2-4, 2026

Further information at:
https://icri2026.it/

Science Forum South Africa 2026
Date: December 2-4, 2026

Further information at:
https://www.esastap.org.za/science-forum-south-africa-2026/


Science Diplomacy
India's Global Digest of Multidisciplinary Science
Science Diplomacy 2035
Protocol Diplomacy
Trade & Talent Diplomacy
Innovation Diplomacy
Quantum Diplomacy
Knowledge Diplomacy
SCIENCE & DIPLOMACY INITIATIVE
5 March 2026
RAISINA DIALOGUE 2026