Strengthening Nation through Science: Role of Science Diplomacy in India's Development

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Introduction

Science diplomacy integrates science and diplomacy to foster international cooperation and advance socio-economic progress. It has solidified India's global scientific standing and is pivotal in nation-building efforts, promoting international cooperation, innovation, and sustainable development.[1,2] Science has a significant role in/for diplomacy, and diplomacy also contributes appreciably in strengthening the science base in emerging and critical areas, including the strategic domain.

By leveraging its scientific expertise and diplomatic outreach, India has become a proactive player in the global scientific community, contributing to a more interconnected and prosperous world. This integration of science and diplomacy is crucial for international collaborations, pushing research agendas, and bolstering India's socio-economic progress.[3]

India has used a sophisticated approach to science diplomacy to address global concerns, build alliances, and strengthen its standing in the international arena by utilising its scientific expertise. The Indian Space Research Organisation (ISRO) exemplifies this through space missions, such as the Mangalyaan and Chandrayaan, which have not only showcased the country's technological capabilities but also fostered international cooperation.[4,5] Collaborative ventures with countries like the United States, Russia, and European nations have enhanced India's space exploration endeavours and strengthened diplomatic ties.[6]

Government institutions like the Department of Science and Technology (DST) and the Department of Biotechnology (DBT) have facilitated collaborations in renewable energy, healthcare, and agriculture. Similarly, CSIR, ICAR, and ICMR have also established strong foreign research collaborations through their bilateral and multilateral S&T schemes.

The present leadership has adopted science as a tactical instrument for diplomacy, resulting in multiple bilateral and international partnerships paving the way for National development. These efforts have placed India on the global scientific pedestal, as reflected in Figure 1.

Key Examples of Indian Science Diplomacy

India actively engages in various science diplomacy programs to promote international collaboration and

address global challenges. Some illustrative cases of India's science diplomacy include:

- **International Solar Alliance (ISA)**: This alliance was co-founded by India and France in 2015 to promote global solar energy deployment, mobilising investments, facilitating technology transfer, and building capacity. It has over 119 member countries.[7] India developed a dedicated SAARC Satellite for civil application.
- **Biotechnology and Healthcare Initiatives**: Through partnerships with organisations like CEPI and GAVI, India has contributed to global health by participating in vaccine development, disease surveillance, and healthcare capacity-building.
- **Science and Technology Fellowship Programmes**: Launched by various S&T departments of the Government of India, these programmes aim to train Indian scientists, enhancing their capacity to participate in international forums and build collaborations.
- **Participation in Multilateral Forums**: Active involvement in BRICS, G20, and the UN, advocating for inclusive approaches to S&T and contributing to global discussions on sustainable development and climate change. In the G20 Summit held under India's Presidency in 2023, one crucial vertical was Science 20 (S20), focussing on the three major global initiatives, i.e. Clean Energy for a Greener Future, Universal Holistic Health, and Connecting Science to Society.[8]
- **Global Collaborations in S&T:** India's science diplomacy is exemplified through diverse initiatives such as the SAARC's Meteorological Research Centre, Coastal Zone Management Centre, and Agricultural Information Centre, all fostering regional scientific cooperation. The India-based Neutrino Observatory (INO) collaborates with international partners like Fermilab (USA), KEK (Japan) and CERN (Europe) to advance particle physics.[9] Joint efforts with France's Centre National de la Recherche Scientifique (CNRS) span nanotechnology, biotechnology and environmental science. The Integrated Long Term Programme (ILTP) with Russia enhances collaboration in space research, biotechnology and advanced materials.[10]



Figure 1. India's Global Position in S&T (Source: Ministry of Science & Technology, Government of India)

Additionally, the Department of Atomic Energy (DAE) works with the IAEA and GCNEP, and maintains bilateral agreements to advance India's nuclear energy capabilities.[11]

Strengthening National Security through Diplomatic Relations

The Defence Research and Development Organisation (DRDO), India, engages in international collaborations to enhance its R&D capabilities through joint projects, technology transfer agreements, and co-development of defence systems. Notable collaborations include:

- **Israel**: Working with Israel Aerospace Industries (IAI) on several projects, including the Barak 8 surface-to-air missile system, focusing on missile technology, radar systems, and unmanned aerial vehicles (UAVs).[12,13]
- **Russia**: Maintaining a long-standing defence relationship, highlighted by the BrahMos supersonic cruise missile, which is a joint venture between DRDO and Russia's NPO Mashinostroyenia.[14,15]
- **United States**: Collaborating with American defence agencies and companies, including Lockheed Martin, on the development of the Multi-Role Helicopter (MRH) and participation in joint research initiatives like the Defence Technology and Trade Initiative (DTTI) and Indo-US Joint Technology Group (JTG). [16]
- **France**: Partnering with French defence companies like Dassault Aviation and MBDA on various projects, including missile systems and avionics for fighter jets like the Rafale.[17]
- **United Kingdom**: Engaging in joint research in advanced materials and defence technologies, exemplified by the partnership with Rolls-Royce for developing aircraft engines and related technologies.
- **European Union**: Collaborating with several European defence stations and companies on R&D in electronic warfare, communication systems, and advanced sensors.

Advancing Nuclear Science and Technology through Diplomacy

The DAE in India engages in extensive international collaborations to advance nuclear science and technology across various domains, including nuclear power, safety, medicine, and fundamental research in physics.[18] Key collaborations include working with the International Atomic Energy Agency (IAEA**)** on nuclear safety, security, and safeguards, with India being a significant contributor to IAEA's research and training programs. The India-U.S. Civil Nuclear Agreement, also known as the 123 Agreement, signed in 2008, facilitates cooperation in nuclear energy development and nuclear safety.[19] With Russia, DAE collaborates on the Kudankulam Nuclear Power Plant.[20] The DAE works with Russia's Rosatom on reactor technology, nuclear fuel supply, and safety systems. Partnership with French nuclear energy company EDF and nuclear reactor manufacturer AREVA focuses on technology transfer, safety training, and the planned construction of nuclear reactors at Jaitapur.[21] The European Atomic Energy Community (Euratom) partners with DAE on nuclear fusion research and other advanced nuclear technologies. India is an associate member of the ITER project, an international nuclear fusion research and engineering megaproject in France. Similarly, DAE collaborates with the UK, Japan and other countries. These international collaborations enhance DAE's nuclear technology capabilities, ensure the safety and security of its nuclear facilities, and contribute to global nuclear research initiatives.

Addressing Global Challenges through Science Diplomacy

India's commitment to addressing global challenges through S&T is exemplified by its robust international partnerships, focusing on innovative solutions and sustainable development. Notable initiatives include the Indo-US Science and Technology Forum (IUSSTF) for clean energy, water, health, and advanced materials, and the India-UK Science and Innovation Council for Newton-Bhabha Fund, UKIERI, and joint research projects in sustainable cities, health, and energy. The Indo-German Science & Technology Centre (IGSTC) targets advanced manufacturing, biotechnology, and renewable energy, while the India-Israel Industrial R&D and Technological Innovation Fund (I4F) focuses on water management, agriculture, energy, and healthcare.

Other key collaborations include Indo-Japan Science and Technology Cooperation in AI, robotics, renewable energy, and disaster management technologies; Indo-French Centre for the Promotion of Advanced Research (IFCPAR/CEFIPRA) for life sciences, IT, environmental science, and industry-academia collaborations; BRICS Science, Technology and Innovation (STI) Framework Program targeting Joint research projects, innovation programs, and capacity-building among BRICS countries, and India-Australia Strategic Research Fund (AISRF) in agriculture, energy, health, and environmental sciences, including marine and climate science.

Academic Diplomacy: Harnessing Higher Education for Nation Building

India's higher education landscape features diverse institutions, from prestigious universities to specialised research centres. Through the lens of science diplomacy, higher education institutions (HEIs) have emerged as pivotal actors in shaping global relations, driving socio-economic development, and advancing national interests. An initiative like a yearly in-person course on science diplomacy focusing on South-South cooperation is being organised under the auspices of the Indian Technical and Economic Cooperation Programme of the Ministry of External Affairs of India since 2017.[22] By nurturing a cadre of science diplomats, India is better equipped to engage in dialogue, negotiate agreements and promote scientific collaboration on the global stage.

Programs like the Indo-US Fulbright Fellowship and Erasmus Mundus promote student mobility and academic cooperation, enriching the educational experience and promoting intercultural dialogue. India's participation in forums such as the BRICS Network University, the Asia-Pacific Economic Cooperation (APEC) Education Network, and the Association of Indian Universities (AIU) facilitates academic cooperation, exchange of best practices, and capacity building across borders.

The Pan-African e-Network Project (PAENP) initiative launched by the Government of India exemplifies its commitment to bridging the digital divide between Africa and the rest of the world by providing high-quality education and medical services.[23] The project connects African nations with Indian institutions, facilitating distance education, telemedicine, and e-governance services. Indian Universities such as Amity University, IIT and IGNOU contribute immensely to this project.

Conclusions

The collaborative efforts with countries like the USA, Russia, Israel, France, Japan, Germany, the UK, and Australia have significantly bolstered India's scientific and technological landscape. These partnerships have facilitated the exchange of expertise, technology transfer, joint research, and capacity building, contributing to India's growth as a global leader in S&T. By leveraging international support, India continues to advance its scientific endeavours, addressing national and global challenges. Through initiatives spanning space exploration, healthcare, renewable energy, and beyond, India continues to demonstrate its commitment to harnessing the power of science for the greater good while simultaneously strengthening its bonds with nations across the globe.

However, challenges persist in India's science diplomacy efforts, including resource constraints, bureaucratic hurdles, and geopolitical complexities. Addressing these challenges requires a concerted effort from policymakers, scientists, and diplomats to streamline processes, enhance coordination, and prioritise scientific cooperation in India's foreign policy agenda.

In conclusion, India's strategic embrace of international scientific collaboration underscores its dedication to leveraging global expertise for mutual advancement and addressing shared challenges. By fostering robust partnerships and navigating the intricacies of science diplomacy, India not only elevates its scientific and technological capabilities but also contributes significantly to the development of global scientific community. Overcoming the existing hurdles will require sustained commitment and innovation in policy and practice, ensuring that science remains a cornerstone of India's international relations and a catalyst for sustainable development and global progress.

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