Strengthening Science-Policy Interface: Charting India's S&T-led Transformation

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Scope

As the global economy shifts decisively towards knowledge-driven models, science and technology (S&T) have become indispensable engines of transformation. Beyond their traditional roles in innovation and advancement, in the present times, S&T form the backbone of policymaking for effective governance and national development. In this shifting landscape, science is more than a driver of sectoral progress; it has to stand as a cornerstone of governance that is resilient, responsive, and equipped for the future.

India's development journey reflects this paradigm shift. The integration of science-informed policy and advisory mechanisms has catalysed progress across multiple sectors and is poised to play an even more strategic role in steering the nation's future. Science advice is now central to designing agile policies, ensuring effective implementation, and enhancing institutional resilience.

This contribution examines the catalytic role of science advisory systems in shaping India's scientific and technological trajectory. It explains the manner in which institutions such as the Office of the Principal Scientific Adviser to the Government of India (OPSA) are facilitating this transformation by developing and guiding S&T missions for the nation's well-being by, fostering collaborations with and between stakeholders, strengthening scientific infrastructure and ensuring their access on an equal opportunity basis, and increasing India's engagement in global policy platforms.

Looking ahead, the article discusses the manner in which data-driven foresight, systems thinking, and anticipatory governance can equip India to navigate through technological disruptions and societal

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complexities. As the pace of change accelerates, strengthening the science-policy interface will be the key, not only in sustaining national progress but also in ensuring India's effective presence in the global discourse on science, technology, and innovation.

Introduction: Science advisory at the heart of public policy and governance

The evolution of India's science-policy interface, or the science advice mechanism, is a result of 78 years of scientific vision, institution-building, and the integration of science with society, economy, and polity. Today, India is among a handful of countries with a well-established science advice mechanism that blends scientific knowledge with decision-making, public engagement, and institutional transformation. Evidence-driven, public-facing, and outcome-oriented science advice is critical now more than ever due to the growing complexity of the technoscientific evolutions and their socio-economic repercussions [1]. To understand how a strong and future-facing science-policy interface can be built, we enumerate some of the key milestones in India's path to a societally meaningful scientific enterprise, assess contemporary needs and anticipate the future trends.

The adventurous yet critical need for a scientific temper was made fundamental to the country's ethos as we earned our independence and became a republic. This era (1947-1967) was a period of institution building, where the Council of Scientific and Industrial Research (CSIR) saw its expansion, the first set of Indian Institutes of Technology was established, and the Departments of Scientific Research, Space and Atomic Energy were established. The Science Policy Resolution of 1958 [2] laid the foundation of India's scientific enterprise, which was built on the tenets of scientific temper and which saw science and technology as a tool for socio-economic transformation [3]. Dr Shanti Swarup Bhatnagar, Dr Homi Bhabha, Dr Vikram Sarabhai, and Dr C.V. Raman were among the architects of this transformation [4]. Following the SPR 1958, the investment in the scientific enterprise grew manyfold, and numerous scientific organisations and laboratories were established. The Technology Policy Statement (TPS) 1983 [5] used this foundation and focused on two key elements of technological self-reliance and indigenous technology development. Science and Technology Policy (STP) 2003 [6] and Science, Technology and Innovation Policy (STIP) 2013 [7] aimed to integrate science with technology and later with innovation to enable the nation to be globally competitive.

The evolution of science advisory in India

The trajectories of India's scientific enterprise and the science advice mechanism have been intricately interwoven. The constitution of the Advisory Committee for Coordinating Scientific Research (ACCSR) was the very first post-independence step that recognised the need for science advice. Thereafter, the Scientific Advisory Committee to the Cabinet (SACC) was constituted in 1956 to provide scientific advice for decision-making to the government. SACC was followed by Committee on Science and Technology (CoST, 1968-1970), National Committee on Science and Technology (NCST, 1971-80), Scientific Advisory Committee to the Cabinet (SACC, 1981-1985), and Science Advisory Council to the Prime Minister (SAC-PM, 1986-1990). These variously helped the country to strengthen its science advice mechanisms.

The Office of the Principal Scientific Adviser (OPSA)[1] was established in 1999 with Dr A.P.J. Abdul Kalam as the first Principal Scientific Adviser. OPSA works on a larger canvas of the Indian Science firmament, creating synergies between departments and establishments to provide a seamless mechanism for science advice. OPSA has a singular mandate of providing evidence-based and policy-focused science advice to the Prime Minister and the Cabinet on all matters related to Science, Technology, and Innovation (STI). Further, in 2018, the Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) was established to streamline the efforts under SACC and SAC-PM, to inform national policies and initiatives.

Since its inception in 1999, the mandates and functions of the OPSA have increasingly expanded. It now advises on critical and emerging technologies, actively participates in international fora, and engages with the public to instil trust in scientific enterprise. This trajectory has been captured in the June 2025 edition of OPSA's Vigyan Dhara Magazine, which also marks 25 years of the OPSA [8].

OPSA has been emphasising the infusion of rigorous scientific evidence into policymaking. Through this, it has developed numerous national initiatives such as the National One Health Mission, One Nation-One Subscription Initiative, National Quantum Mission, Artificial Intelligence Mission and several others.

A milestone institution for India's research governance, Anusandhan National Research Foundation (ANRF), was conceptualised by the PM-STIAC. The sector-agnostic nature of science advice and its mandate to synergise diverse stakeholders were leveraged through each one of these initiatives. Through such initiatives, OPSA informs decisions and lends

1 Office of the Principal Scientific Adviser to the Government of India. https://www.psa.gov.in/

credibility, transparency and scientific reason for specific public policy choices. OPSA safeguards that the advisory process is inclusive and public-facing and ensures this through open dialogues, community-wide consultations and effective outreach. India's science academies have served as guardians of scientific temper and public trust. By proactively shaping the narratives and communicating consensus scientific knowledge, OPSA and the academies have synergistically fostered an environment where science is seen as a credible, inclusive, socially conscious enterprise that merits the confidence and trust of society.

In the following specific examples of instruments of science advice that translate this vision into action are discussed.

Instruments of science advice

Within India's governance framework, OPSA translates scientific knowledge into science advice to navigate the ecosystem and public policy. The office serves as a synergising platform where diverse expertise converges to inform decisions. Through carefully constructed partnerships with stakeholders spanning central and state governments, research institutions, and the industry, OPSA ensures that policy choices are evidence-based and takes cognisance of the depth, nuance and confidence levels of varied scientific inputs.

The office's mandate encompasses both advisory needs in real time and for longer-term strategic concerns, India's interests to determine its trajectory in the STI space. OPSA recognises that effective science advice requires understanding not only of what the research reveals, but also how those insights can be meaningfully utilised within existing institutional frameworks and resource constraints. This perspective shapes the office's approach to continually develop novel innovation ecosystems and maintain a vigil on emerging technological domains that may require policy interventions in the near future.

Central to OPSA's activities is the recognition that contemporary challenges cannot be adequately addressed by inputs from traditional disciplinary boundaries. Thus, for example, Climate change intersects with agriculture, energy, urban planning besides human migration and attendant sociological ramifications, accentuated ecological and geological hazards. Similarly, the emerging digital technologies are reshaping education, healthcare, the future of jobs and governance itself and how the nation can be equipped to meet associated challenges in a well-orchestrated manner. The OPSA, therefore, emphasises a systems thinking, identifying connections and opportunities for coordination between disparate stakeholders that might otherwise be overlooked.

Various missions and initiatives of OPSA address socio-economic challenges by drawing on scientific knowledge and being mindful of implementation realities and diverse stakeholder perspectives.

Strategic advisory through PM-STIAC

The Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) [9] represents OPSA's primary vehicle for systematic engagement with India's S&T ecosystem. Rather than offering any ad-hoc advice, PM-STIAC undertakes careful assessment of challenges and opportunities, and develops roadmaps that inform decision-making at the governmental level. The council serves as an advisory mechanism that balances scientific rigour and its scope with pragmatic policy prescriptions.

The One Health Mission of PM-STIAC recognised that human, animal, and environmental health systems function as interconnected networks rather than separate domains. This understanding informed approaches to pandemic preparedness and broader planning of health and nutrition security. Similarly, the National Quantum Mission buttresses India's engagement with quantum technologies, an area where fundamental research advances will translate into practical applications in computing, communication, and sensing systems, in near real time.

The PM-STIAC-led artificial intelligence initiative (India AI Mission) focuses on the advancement of national competitiveness in AI through the development of frameworks for the deployment of responsible and ethical AI across sectors. These efforts acknowledge the potential benefits of AI technologies and, at the same time, recognise the challenges in its implementation and associated ethical issues and societal impacts.

The Electric Vehicles (EV) Mission represents another area where scientific and technical knowledge informs policy development, supporting India's transition toward more sustainable transportation systems while recognising infrastructure, economic, and social factors that influence adoption patterns.

Synergy through ETG

The Empowered Technology Group (ETG) [10] extends OPSA's reach across the institutional landscape. It engages with ministries, industry representatives, research laboratories, public sector enterprises and functions as a coordination mechanism to align technological planning and investment decisions across agencies and sectors. Policy guidance through the ETG involves multidisciplinary analysis of technological opportunities and challenges. Rather than offering simple recommendations, the

group develops nuanced roadmaps that take cognisance of trade-offs, constraints of resources, aspects of indigenisation and complexities in their implementation. This effort comprises a review of current efforts by varied agencies and stakeholders to identify coordination needs to ensure that different initiatives complement rather than replicate.

Technology procurement and induction represent another key area of ETG activity. When significant investments in the technology space are under consideration, ETG evaluates and guides to ensure alignment between financial commitments and the strategic objectives. ETG also evaluates and creates synergies between agencies and identifies actions for self-reliance through innovative indigenisation.

STIAC activities show that, besides technical inputs, its advice now includes facilitation of sectoral mission planning, setting of collective priorities, and creating synergistic coordination among partnering agencies/institutions. By convening experts, policymakers, and practitioners for advice on shared goals, these mechanisms embed scientific expertise, both in the design and execution of policies and programmes. That said, it recognises that sustenance of their impact will require adaptive and agile governance structures, clearly defined accountability channels, and continued collaboration between government, academia, industry, and civil society. With these instruments in place, India now has an established and structured system and pathways to embed scientific evidence into policy, with provisions for continued assessment of their efficacy. This is expected to inform both the national priorities and international engagements.

Catalytic role of institutional science advice

Institutional science advice in India operates within a policy ecosystem where research priorities, funding mechanisms, and innovation pathways intersect at multiple junctures. In such a landscape, the OPSA functions as a catalytic node to integrate evidence-based insights with policies for societal development. Drawing on specific initiatives and their implementation, this discussion below explores how institutional science advice translates scientific evidence into policy outcomes and initiatives.

Role of Science Advice in Expanding Research Horizons:

By synthesising global trends and domestic capabilities, science advice identifies knowledge gaps and prioritises areas where an investment can yield optimum outcomes. It then guides the development of shared research infrastructures that enable diverse institutions to collaborate in synergy and ensure that research agendas are responsive to both the

science and translational opportunities at the cutting edge, and cater to the needs of varied stakeholders.

Expanding Access to Knowledge through One Nation One Subscription (ONOS) Initiative:

Researchers across India have long faced challenges in accessing scholarly publications and scientific literature, particularly in institutions with limited resources. The One Nation One Subscription (ONOS) initiative (proposed initially by an inter-academy group, [11, 12] is a response to remove these barriers. Through engagements with publishers and funding agencies, efforts were made to develop frameworks that broaden access to research resources and maintain sustainable models for knowledge distribution (Fig. 1). The approach recognises that scientific progress depends on equal opportunity access to the research community. It is, however, too early to assess the impact of these efforts, with their reach still being enlarged.

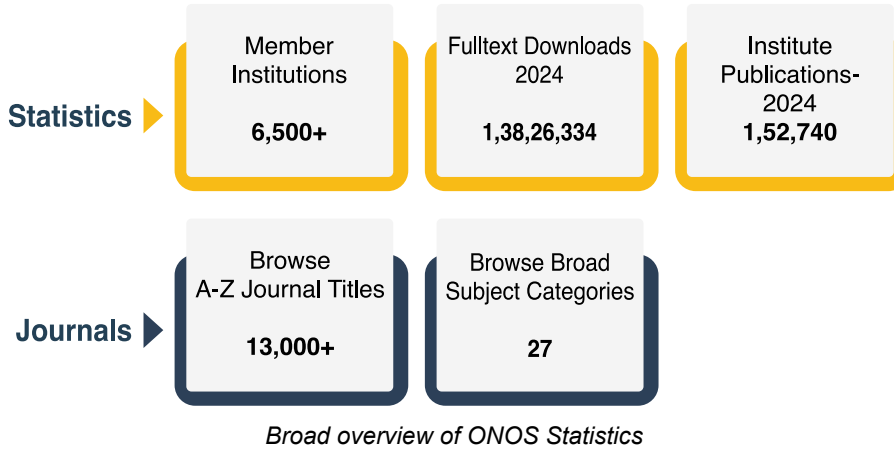


Figure 1: Broad Overview of Statistics during the first phase of ONOS (2025-27)

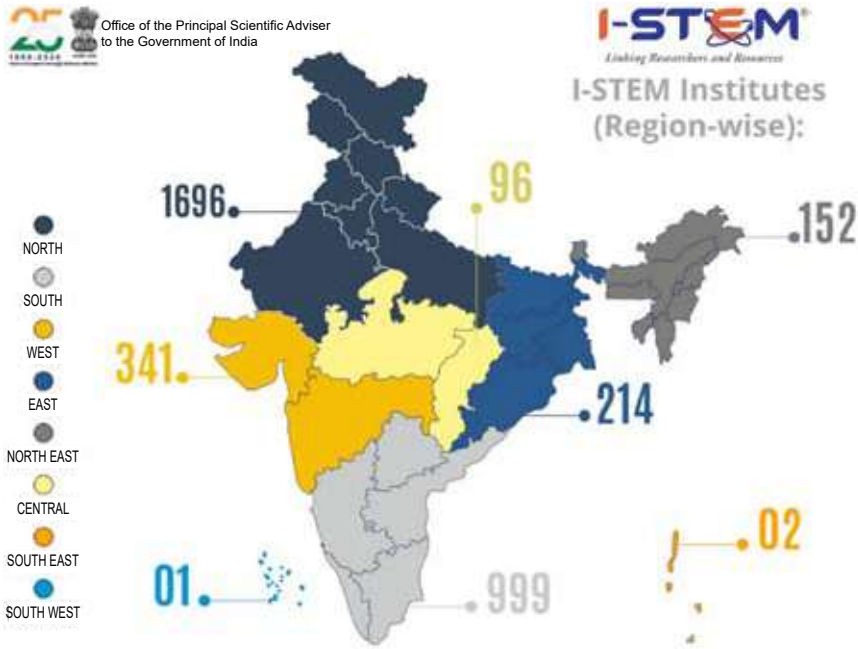
Research Governance through Anusandhan National Research Foundation (ANRF):

A recent review of research governance saw the creation of the Anusandhan National Research Foundation under the 2023 ANRF Act, with a five-year allocation of Rs 50,000 crore. ANRF is guided by an executive council [13]. This new framework aims to bring coherence to fragmented funding and priorities across sectors while maintaining scientific rigour. By bringing diverse funding streams under a single umbrella, this framework seeks to reduce duplication, foster strategic

alignment, and uphold scientific integrity across the national research landscape. With the vision of promoting translational research, the ANRF aims to build partnerships between Industry and academia, and therefore, to ensure effective participation and share of the industry and other non-government sources in investment in research, the ANRF envisages that over 60% of the total 50,000 crore will be provided by non-governmental sources [14].

Access to Scientific Infrastructure and Resources through I-STEM:

For long, research in India has been constrained by limited, invisible and uneven distribution of laboratory facilities. Recognising this, the Indian Science, Technology and Engineering Facilities Map (I-STEM) [15] portal was launched in 2020 as a gateway for researchers



I-STEM institutes are those facilities that have listed their scientific infrastructure on the portal, enabling wider access for the research community.

Figure 2: Illustration of I-STEM institutions across the country, mapped region-wise

and innovators to discover and access instruments across institutions. By uniting disparate laboratories behind a single portal and offering tailored support, such as priority booking for early-career and women scientists, I-STEM seeks to turn unseen and underutilised laboratory capacities into shared opportunities. Special initiatives within I-STEM promote

participation of women in science and engineering, provide platforms for collaboration, capacity development and technical support.

Science Advice in Ecosystem Facilitation:

Science advice fosters cohesive research and innovation ecosystems by mapping stakeholder strengths and recommending collaborative frameworks that bridge academia, industry, and government. Through guidance on partnership models and resource sharing, advisory inputs help establish incubators, clusters, and consortia that streamline technology transfer and amplify collective impact across sectors.

Shaping a Unified One Health Framework:

PM-STIAC conceptualised a comprehensive health security approach, recognising that emerging health challenges would require coordinated responses across stakeholders. The National One Health Mission [16] was approved by the government on 1st January 2024 and is coordinating efforts across twelve ministries and departments. OPSA held consultations between government agencies, private sector entities, multilateral organisations, and academic institutions (Fig. 3) to develop a framework for inter-ministerial coordination. The complexity of coordination across multiple agencies presents an ongoing challenge. The collaborative approach also extends to international forums, such as the G20 platforms, where such an integrated health security model contributes to global policies.

Innovation Networks and Partnerships through Manthan:

The Manthan platform [17] was developed to address gaps between knowledge generation and its translation into usable products. Operating through four pillars comprising opportunity creation, proposal submission, innovation exhibition, and collaborative meeting spaces, the platform has facilitated partnerships between government research organisations and industries, including collaborations in technology and other sectors. The aviation industry is one such success story.

OPSA's Strategic Alliance Division (SAD) extended this collaborative approach through targeted engagement with industry, foundations, academia, startups, and Micro, Small and Medium Enterprises for joint research and development through the establishment of Centres of Excellence by industry, but within academic institutions, and the development of innovative solutions for social challenges. An illustrious example of the success of this effort is empowering Science and Technology Clusters to facilitate the alignment of research endeavours with industrial partners, thereby enhancing collaboration and promoting the practical

application of innovative findings. And, such partnerships demonstrate the efficacy of scientific advisory mechanisms in creating value for stakeholders and in assisting national priorities.

Figure 3: Stakeholder agencies synergised for collective priority setting for the National One Health Mission

Demand-Driven Technological Innovation through RuTAG and RSVCs:

The Rural Technology Action Group (RuTAG) [18] and its associated Smart Village Centre initiative (RSVC) represent the demand-driven innovation approach. Established in 2004, RuTAG operates through seven IITs and focuses on identifying and addressing technology needs in rural areas. The recently launched RuTAG Smart Village Centres (now close to 50) provide platforms for testing and deploying technologies that address specific rural challenges, such as. The RSVC initiative was conceptualised to address the challenge of technology adoption in rural areas and aims to establish physical infrastructures that promote technology dissemination/education among rural communities, provides space for market linkage, carries out technology demonstrations and

helps entrepreneurship development (Fig. 4). The 12 technology tracks of RSVC address diverse rural challenges related to agriculture and waste management, renewable energy, fintech, livelihood and entrepreneurship, affordable housing, FinTech, capacity building, Government scheme apps, WASH, custom solutions and assistive technologies [19].

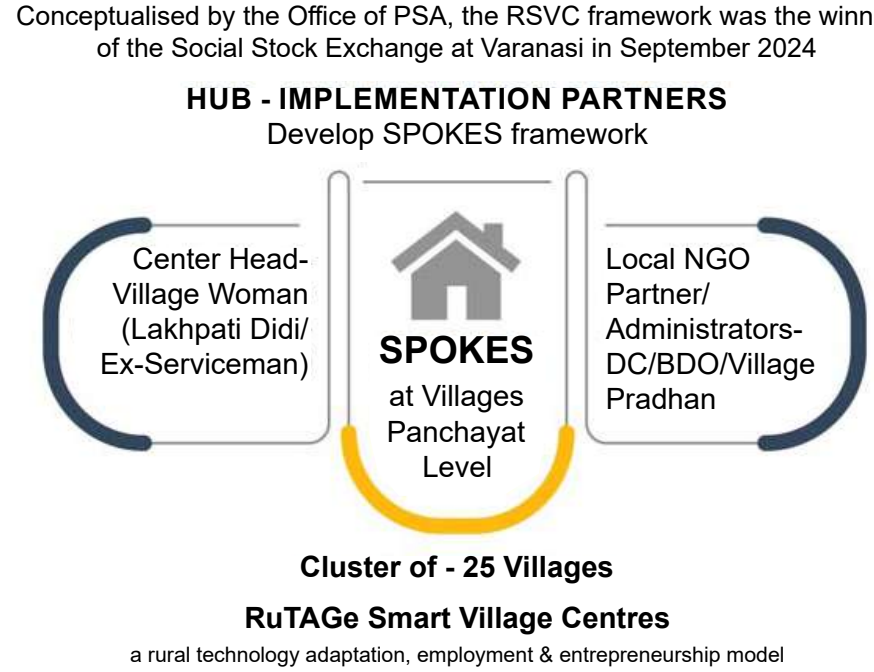


Figure 4: Hub and Spokes model by the RuTAG-RSVC initiative

RuTAG 2.0, launched in April 2023, focuses on commercialisation and broader dissemination of developed technologies. The initiative covers diverse sectors such as agriculture, textiles, energy, water conservation, healthcare, and livelihood enhancement. Through this approach, the aim is to ensure that practical solutions can be adopted at scale in rural communities.

S&T Clusters for Regional Development and Multi-Stakeholder Collaboration:

To encourage locally rooted solutions, OPSA has supported eight Science and Technology Clusters (S&T clusters) [20], where universities, startups, industry bodies, state governments, and international partners converge to address common challenges (Fig. 5). This shift toward place-based experimentation is guided by insights from PM-STIAC and expert groups, ensuring that regional pilots test solutions, like agri-tech in rural

areas and digital health in cities, to inform national policies without losing local relevance. Some of the notable outcomes of S&T clusters include the AR/VR-enabled artisan marketplace "Kalaanubhav.in," and the "One Delhi" digital transit app with over 3 lakh users.

Figure 5: The current eight Science and Technology (S&T) Clusters

Science Advice to Multi-ministerial and Multistakeholder Collectives and Prioritisation for National Missions:

In national missions, science-based advice plays a dual role through its contribution both to initial conceptualisation and mentorship during implementation. Thus, the role of PM-STIAC extends beyond traditional science advice to providing evidence-based input across ministries and stakeholders to ensuring strategic initiatives, while addressing practical implementation challenges. maintain scientific rigour (Fig. 6).

The National Quantum Mission (NQM) to bridge Scientific Ambition with Strategic Implementation:

Conceptualisation of the National Quantum Mission (NQM) [21] was one of the key missions discussed by PM-STIAC and involved a critical assessment of national competence in quantum technology and global developments. OPSA supported the establishment of four thematic hubs and coordinated between the Department of Science and Technology, academic institutions, and industry partners. The OPSA would ensure

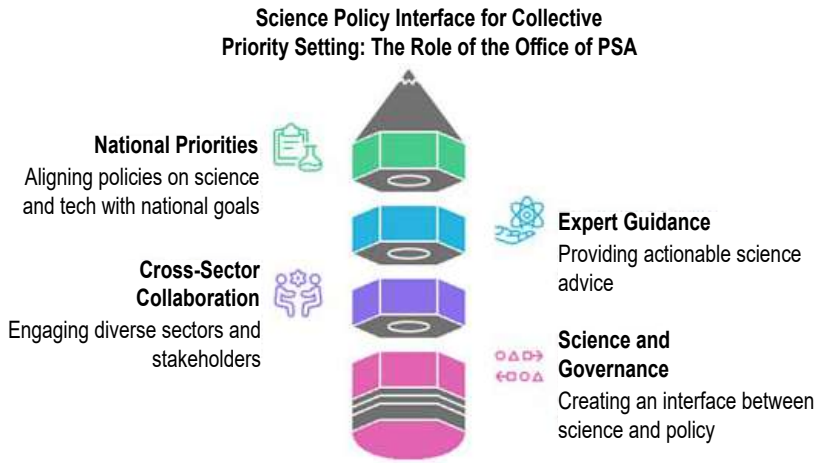


Figure 6: Illustration of how the science-policy interface plays a role in collective priority setting

that the mission's timeline is maintained, both in the advancement of scientific and technological development at a competent level and in meeting strategic objectives. It would also aim to identify translational possibilities.

The India AI Mission:

Identified as a national mission, the development of the India AI Mission involved a synthesis of inputs from and aspirations of multiple ministries, academic institutions, and industry partners towards the formulation of a national AI strategy. OPSAs' Science advice also helped develop the mission's seven pillars comprising computational capacity, foundational models, datasets, applications, and ethical frameworks to harmonise technical feasibility with societal needs.

The Government of India additionally constituted an advisory group for the development of an India-specific regulatory framework to deal with AI-specific issues. This is chaired by the PSA. A subcommittee on 'AI Governance and Guidelines Development' was formed to provide actionable recommendations for AI governance in India [22-24].

National Green Hydrogen Mission:

The mission aims to make India a global hub for green hydrogen production, use, and export, and its governance structure comprises an advisory and empowered group of technical experts on scientific and technological matters. The Mission Secretariat is nested in the Ministry of New and Renewable Energy, mandated with the implementation of

this program [25]. This arrangement ensures that scientific expertise remains integrated throughout the mission's execution while maintaining clear implementation accountability.

S & T for Sustainable Livelihoods and Socio-Economic Challenges:

The Mission for Science & Technology in Sustainable Livelihood Systems deals with the use of science-based advice for rural development through systematic consultation involving multiple agencies, such as the Department of Science & Technology, the Ministry of Rural Development, and the Ministry of Social Justice and Empowerment. Advisory input relates to the identification of convergence opportunities in agricultural research, rural technology development, and social empowerment domains [26].

Strengthening Global Partnerships:

This effort focuses on international collaboration by identifying national strengths in areas such as quantum technologies, AI, digital public infrastructure, clean energy, etc. and suggesting priority areas for joint initiatives on a global scale. OPSA's inputs guided the creation of bilateral and multilateral working groups, funding consortia, and an agreement on shared infrastructure for strategic and sustainable partnerships.

Towards a Global Science Advice Mechanism:

India's engagement with international science advisory networks has evolved into a platform for collaborative action. The G20 Chief Science Advisers' Roundtable [27], initiated under India's 2023 Presidency, has been carried forward with UNESCO. South Africa convened representatives from over 25 countries to compare advisory models, discuss open-access strategies, coordinate One Health responses, and anticipate emerging scientific and technological challenges. Beyond dialogue, follow-up working groups were established to develop joint roadmaps and conduct collaborative research in areas such as One Health and Inclusivity in STEMM (Science, Technology, Engineering, Mathematics, and Medicine). Some of these efforts have led to national-level framework building, taking inspiration from these multilateral consultations.

International partnerships:

The QUAD Centre for Quantum Information Sciences [28] is co-led by the Quad countries (United States, Australia, Japan and India). In

this, India is represented by the PSA. A report titled Quantum Science & Technology in the QUAD Nations: Landscape and Opportunities, discusses the key challenges identified by QUAD countries in Quantum Sciences, identifies areas with potential for collaboration, and outlines specific actions [29].

India's role in engagements such as the India-EU Trade and Technology Council's Green & Clean Energy working group and leadership of the Indo-US Quantum Coordination Mechanism under India-US TRUST (erstwhile iCET, the Initiative on Critical and Emerging Technology) translates discussions into targeted initiatives with measurable objectives, shared funding commitments with regular reviews of the progress.

Policy Frameworks and the Vision:

OPSA informs the design of policy frameworks through integration of foresight analyses, inclusivity principles, and sectoral priorities. By grounding policy design in evidence-based foresight and stakeholder diversity, science advice helps craft frameworks that are resilient, adaptive, and aligned with India's innovation goals. Some examples of such frameworks are given below.

India's Mega Science Vision:

The Mega Science Vision 2035 provides a strategic roadmap for the country's engagement with large-scale scientific endeavours over the next decade. These are centred on six critical domains viz., High Energy Physics, Nuclear Physics, Astronomy and Astrophysics, Accelerator Science and Technology, Climate Research and Ecology and Environmental Science, and this initiative seeks to strengthen India's scientific capacity through a SWOT assessment of national strengths, weaknesses, opportunities, and challenges [30]. Four Mega Science Vision 2035 reports have been released so far, outlining their scope as detailed below.

1. **Mega Science Vision-2035 High Energy Physics Report**: The report presents a priority-based plan to pursue Mega Science Projects in High Energy Physics to achieve international competitiveness along three frontiers, namely, energy, intensity, and the cosmic (astrophysical or cosmological observations).
2. **Mega Science Vision-2035 Nuclear Physics Report**: The report surveys the emerging scientific horizons of nuclear physics, measures the capabilities of the Indian nuclear physics community, and puts forward a plan for undertaking Mega Science Projects in Nuclear Physics in the time frame of 2020-35

3. **Mega Science Vision-2035 Astronomy & Astrophysics Report**: The report develops a roadmap for the Mega Science Projects in Astronomy & Astrophysics in India and makes a case for Indian participation in international projects for developing important projects.
4. **Mega Science Vision-2035 Accelerator S&T and Applications:** The report surveys the relevance of accelerators in terms of their application and puts forward a prioritised list of projects to be pursued during 2020 and 2035.

Deep Technology Innovation Ecosystem:

Deep technological innovation relates to innovations based on substantial scientific or engineering breakthroughs with the potential to disrupt conventional growth trajectories. Sectors such as defence, aerospace, energy, climate and agriculture, etc. would increasingly benefit from adoption of deep tech innovations in technology areas such as AI, Quantum, Drones, IoT and bioengineering. With the rapidly increasing number of deep-tech startups that pioneer solutions once dominated by international players, the support in the form of long-term and patient capital and a skilled talent pool can help make the deep-tech ecosystem future-ready. A policy exercise by OPSA through extensive stakeholder participation suggested the need for dedicated financial support which resulted in the announcement of Rs 10,000 crore Deep Tech Fund of Funds [31], along with efforts to create thematic regulatory sandboxes (a controlled micro environment that enable entrepreneurs to test innovative products, services, or business models under regulatory supervision), to foster innovations in emerging technologies. This exercise underscored the importance of a streamlined process for intellectual property and for a policy framework to ease technology transfer from the laboratories to the market.

Inclusivity in STEMM:

Recognition that diverse perspectives contribute to scientific progress has led to systematic approaches to inclusivity within India's science and technology ecosystem. OPSA's approach to inclusivity in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) extends beyond demographic considerations and encompasses knowledge systems, linguistic diversity, and disciplinary perspectives. Through extensive public and expert consultations, a Self-Assessment and Reporting Framework on Inclusivity in STEMM has been developed to address challenges due to inadequate data across inclusivity indicators [32].

At a leadership-level meeting, the operationalisation of this framework in partnership with the Department of Higher Education (DHE), Capacity Building Commission (CBC), and All India Council for Technical Education (AICTE) was developed [33]. The effectiveness of this framework will depend on its adoption by institutions in letter and spirit to ensure a meaningful implementation. The efficacy of these initiatives will critically hinge on the ability to create a governance system to navigate through implementation challenges and the needs of diverse stakeholders.

Science Advice for Governance Capabilities

As India navigates through an increasingly complex technological landscape, OPSA has been developing capabilities that extend beyond traditional advisory functions to a system that identifies and prepares for emerging challenges and opportunities. This approach recognises that contemporary science governance requires frameworks that are nimble enough to identify interconnected issues, create systems to deal with them and prepare for associated technological change. The focus is on examining patterns across multiple domains to identify technological developments and policy inventions that may be needed. Towards this, the OPSA is building institutional capacity for systematic analysis of technological trajectories and their governance implications through steps like the International Technology Engagement Strategy for Quantum (ITES-Q) [34], released on the World Quantum Day of 2025.

The key focus of OPSA has been to make the Indian science firmament, future-ready in all respects, through a systems approach to identify critical and emerging technologies and social needs, recognising the relevant domains, including scientific, technological and social that would need integration, create systems for coordination in research, development, implementation, and help develop suitable governance structures.

The past experiences underscore the fact that a resilient science-policy interface must continually adapt to the evolving technoscientific landscape and, at the same time, uphold core principles of evidence-based policy and inclusivity. Past national as well as global experiences show that anchoring decision-making in sound science, encouraging dialogue, and safeguarding the integrity of information are key to navigating through technological and social disruptions and associated dilemmas in making educated, evidence-based decisions. The OPSA promises deeper convergence of science with policy goals, from driving innovations in emerging areas of quantum technology, green energy, and artificial intelligence to informing strategies on societal challenges like public health and climate change. There is an immense canvas, and the need is

to expand science advisory ecosystems at multiple levels of government and academia, such that even the state and local decision-makers also benefit from evidence-based scientific advice. It also aims to strengthen international collaborations through openness and willingness to share its resources for the global good. India is poised to evolve its science-policy interface in ways that science would catalyse its socio-economic transformation.

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