Office of the Principal Scientific Adviser to the Government of India

1999-2024 Years of Impact through Science Advice

special EDITION

vigyan dhara

JUNE 2025

25 Years of Office of PSA

Strategy and Synergy for Security

I-STEM Linking Researchers and Resources

National Knowledge Network

National One Health Mission

RuTAG

Celebrating 25 years of impact through Science Advice

A Legacy *Through* Time

Late Dr. R. Chidambaram at the 2008 annual meeting of the World Economic Forum in Davos, Switzerland.

Former PSA Late Dr. R. Chidambaram with Late Dr. Baldev Raj visiting the PFBR Simulator Development Platform.

Former PSAs Late Dr. A.P.J. Abdul Kalam and Late Dr. R. Chidambaram with Late Dr. K. Kasturirangan during a press conference.

Former PSA Late Dr. R. Chidambaram with Former Scientific Secretary Prof. S.V. Raghavan.

Late Dr. R. Chidambaram inaugurating the RuTAG Centre at NIT, Trichy.

Former PSA Late Dr. A.P.J. Abdul Kalam with Late S. Bahuguna at a conference, 2001.

Former PSA Prof. K VijayRaghavan with former Hon'ble President R. N. Kovind.

Former PSA Late Dr. A.P.J. Abdul Kalam and former RBI Governor Dr. Bimal Jalan.

PSA Prof. Ajay Sood and Scientific Secretary Dr. Parvinder Maini at the CSAR, Paris, 2024.

Former PSAs Late Dr. A.P.J. Kalam and Late Dr. R. Chidambaram during a press conference.

Former PSA Prof. K. VijayRaghavan during COVID-19 briefing.

Prof. K. VijayRaghavan with Member Science, Dr. V. K. Saraswat, Dr. Arabinda Mitra during the first PM-STIAC Meeting.

Hon'ble PM Narendra Modi with former PSA Prof. K. VijayRaghavan.

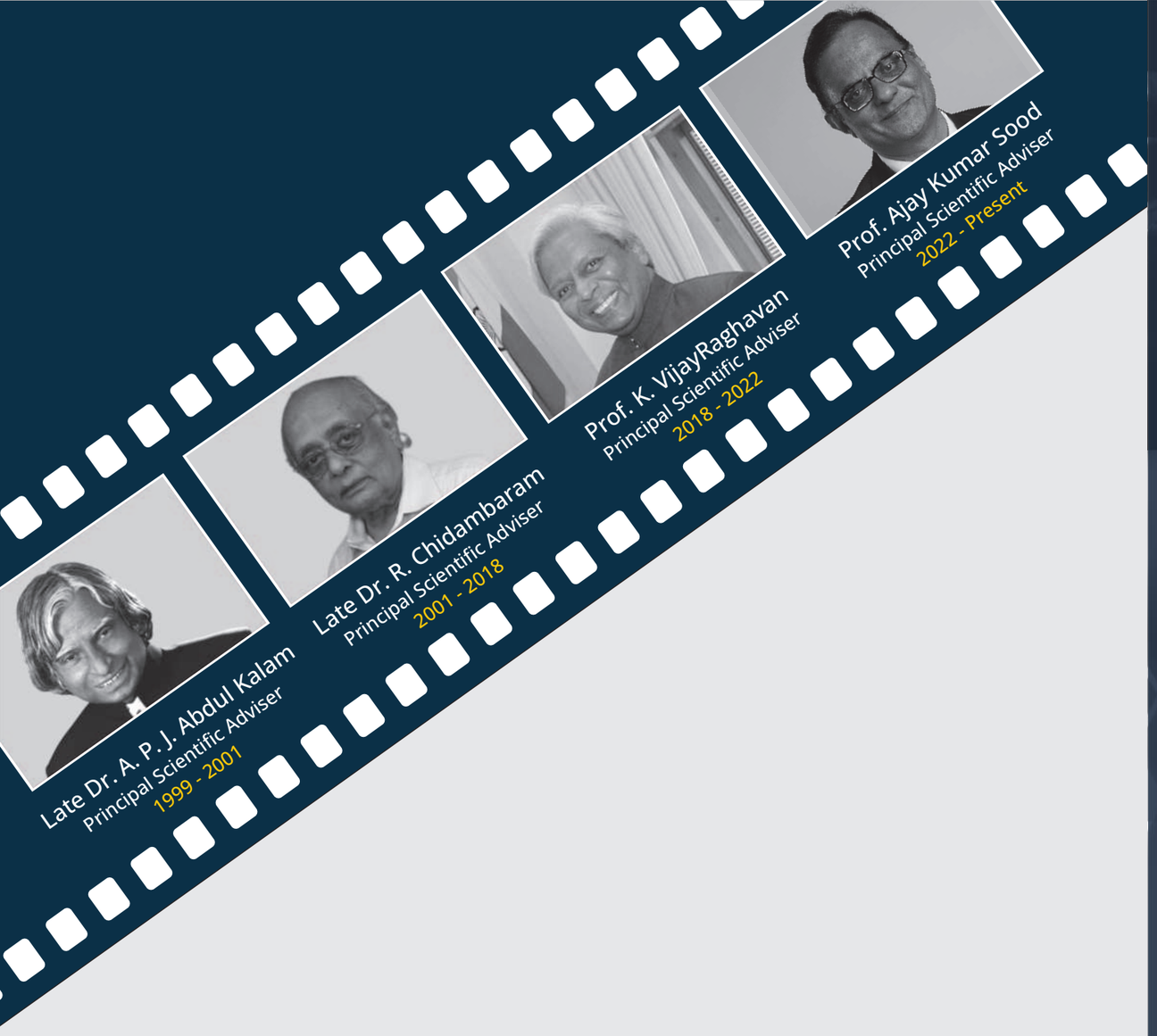
Hon'ble Minister Dr. Jitendra Singh, PSA Prof. Ajay Sood, Scientific Secretary Dr. Parvinder Maini unveil the Technology Panorma Report at Vigyan Bhawan, 2024.

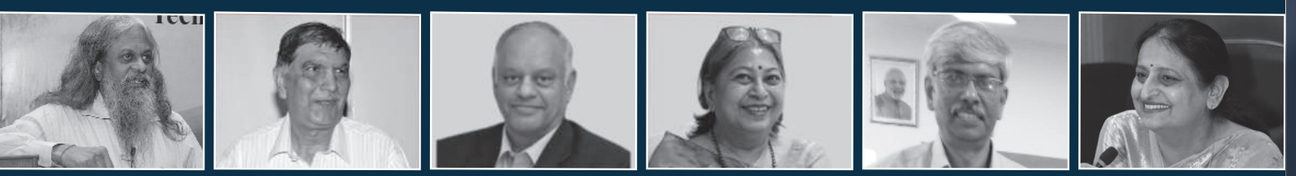
Hon'ble Minister Shri Ashwini Vaishnaw, Hon'ble Minister Dr. S. Jaishankar, and PSA Prof. Ajay Sood at the first India-EU TTC stocktaking meet.

Science Advisory Council to the Prime Minister (SAC-PM), during 2009-13.

Science Advisory Council to the Prime Minister (SAC-PM), during 2004–2009.

PSA Prof. Ajay Sood in discussion with UNESCO DG Audrey Azoulay.





25 1999-2024 Years of Impact through Science Advice

Office of the Principal Scientific Adviser to the Government of India

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Prof. Ajay Kumar Sood

Principal Scientific Adviser to the
Government of India

Foreword

Science policy and science advice are fundamentally scientific in nature. Much like the process in science research, even in policy, we begin with identifying a key issue, formulating a hypothesis or objective, and designing a framework to address it. Hence the approach is a very systems thinking approach. It is structured, methodical, and evidence-driven, rather than ad hoc.

Policy decisions in science are not made overnight. They require thoughtful deliberations, openness to diverse inputs, and a willingness to evolve strategies when needed. It is a continuous cycle of learning, consultation, and refinement. Scientists, by nature, are trained to ask questions, consult relevant literature, and collaborate. These same principles apply to effective policy-making and have worked well in the science advice landscape of the nation through the Office of the Principal Scientific Adviser (OPSA) to the Government of India.

Science advisory is grounded in analysing real-world challenges, building frameworks, and guiding decisions with clarity and context. It bridges "hardcore" scientific knowledge with the science of science policy, turning domain expertise into actionable, scalable strategies. The Principal Scientific Advisers (PSAs) of India have been scientists and technologists first. Their firsthand experience in the Science & Technology (S&T) ecosystem gives them a deep understanding of the issues, enabling them to view societal challenges through a scientific lens. This embeddedness in the country's scientific milieu is critical as it ensures that science advice is not disconnected from the realities of research, implementation, or public need. That same fabric made it an easy transition for me from science to policy, because as the PSA, I get to be at the intersection of both, taking them forward together for nation building.

India's scientific enterprise has been deeply intertwined with its nation-building journey. From the earliest days of Independence, our country's leadership recognised that science, technology, and innovation would be central pillars in rebuilding a self-reliant, resilient, and modern India. Post-Independence, India focused on building a robust education system to fuel national development. As the scientific landscape evolved, the need for a central advisory body became clear. In 1999, the OPSA was established to provide evidence-based scientific advice to the highest levels of decision-making in the Government of India. Since its inception, OPSA has served as a central node in India's S&T landscape, offering pragmatic, objective, and actionable advice to the Prime Minister and the Cabinet. Its core mission has been to ensure that science and technology are seamlessly integrated into the machinery of governance and policy-making, and that India's scientific potential translates into tangible outcomes for the nation and its citizens.

Through critical S&T infrastructure, OPSA continues to work as a key pillar to support the nation's advancement towards strategic autonomy. OPSA's role in nurturing S&T ecosystem has included strategic thinking, institutional innovation, and a systems-level approach to harnessing national capabilities. One of the most important milestones in this journey was the establishment of the Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) in the year 2018, through which OPSA has led the conceptualisation and rollout of a range of national missions including those on quantum technologies, artificial intelligence, deep ocean exploration, and one health for society. These missions are not isolated projects, but strategic investments in the future of India, designed to ensure that the country is at the frontier of emerging and critical technologies.

Complementing this is OPSA's operation of the Empowered Technology Group (ETG). The ETG is tasked with evolving policies, strategies and missions for generation of innovations and support systems for multiple applications. Its mandate also includes generating science and technology tasks in strategic, economic and social sectors in partnership with Government departments, institutions and industries. ETG has actively engaged with ministries and departments to shape policies, adopt emerging technologies for governance and strengthen India's self-reliance in critical technologies. The work of the ETG is closely aligned with the national vision of Make in India, and it contributes directly to the country's ambition of Viksit Bharat @2047.

In this way, OPSA's mandate is not only strategic but also systemic. It offers foresight and coordination across ministries and departments, facilitates collaborative research and public-private partnerships, and builds capacities that enable India to remain globally competitive in science and technology. The Office has fostered partnerships between academic institutions, industries, and civil society to co-create solutions for societal challenges. An example of this is the application of the quadruple helix model in rural settings, where science and technology have been used to enhance livelihoods, improve access to services, and build local capacities.

OPSA also ensures that science reaches the broader society through initiatives such as RuTAG (Rural Technology Action Group) and RSVC (RuTAGe Smart Village Center). These programmes enable grassroots access to technology and innovation, often solving hyper-local challenges through collaborative design between academic institutions, authorities and local communities. Further recognising that inclusive development requires inclusive participation, OPSA launched Manthan platform on August 15, 2022, a platform that brings together a diverse set of stakeholders to co-create ideas, address policy challenges, and accelerate technology translation.

In terms of capacity building and access to resources, OPSA has driven major initiatives like I-STEM (Indian Science, Technology and Engineering Facilities Map), and One Nation One Subscription (ONOS), to democratise access to scientific knowledge by enabling equitable access not only in Tier-1 but in Tier-2 and Tier-3 institutions as well. Among the landmark outcomes shaped through OPSA's advisory role is the creation of the Anusandhan National Research Foundation (ANRF) that is poised to elevate research funding, promote interdisciplinary collaboration, and set new benchmarks for research excellence.

OPSA's journey over the past 25 years has also included active global engagement through bilateral partnerships, multilateral scientific collaborations, or science diplomacy, representing India's science and technology leadership on the international stage.

The role of OPSA has evolved significantly, guiding national missions in emerging areas such as biotechnology, information technology, energy security, and more.

Today, OPSA continues to serve as the nerve centre for science and technology policy at the highest level. It leads the integration of science into national development through a multi-dimensional approach. Science advice, by its very nature, must evolve to keep pace with the changing context of governance and global challenges. OPSA's journey reflects this dynamic character. It has responded to shifting national priorities and global emergencies with agility and foresight. For instance, during the COVID-19 pandemic, the Office worked closely with expert groups and ministries to strengthen evidence-based decision-making. This period also witnessed the emergence of new paradigms of science advice, such as the National One Health Mission, which OPSA helped frame as a collaborative response to the intersections of human, animal, and wildlife health. Through such efforts, the Office has demonstrated how science advice can be both anticipatory and responsive, grounded in systems thinking, and inclusive in its design.

Tracing down that journey of OPSA under the continuous leadership of visionary science leaders, it is with great pride and reflection that we present this commemorative edition of our magazine, celebrating the silver jubilee mark of OPSA. This milestone is a testament to the enduring vision of integrating science, technology, and innovation into the very fabric of national policy and governance. We also celebrate the contributions of the many individuals, scientific advisers, experts, administrators, scholars, and collaborators, who have collectively shaped the Office's journey and impact.

This edition of Vigyan Dhara magazine traces the rich and multi-dimensional journey of the Office through detailed mapping of the evolution and institutionalisation of science advice in the country and its instrumentation through OPSA. While elaborating on the initiatives, missions and milestones mentioned above, and more, the edition also draws parallels and contrasts with global science architecture models.

As we look ahead, the role of science advice in addressing emerging challenges - be it climate change, health security, energy transitions, Quantum or AI governance - will be more critical than ever. OPSA is well-positioned to lead this next chapter, building on its legacy. With its mandate continually expanding to include science diplomacy, public engagement, and ecosystem development, I am confident that the Office will continue to shape a future where scientific knowledge is central to equitable and sustainable development.

Reflection from

Scientific Secretary

Dr. Parvinder Maini

State of Science Advice and its Future Outlook in India

As the Office of the Principal Scientific Adviser to the Government of India (OPSA) marked its 25th anniversary, it is a fitting moment not only for institutional celebration but for introspection -about the evolving role of science in governance, the maturing ecosystem of scientific advice in India, and the road ahead.

From the early years of independence, India recognised the value of integrating science into the foundations of nation-building. The establishment of the Advisory Committee for Coordinating Scientific Research (ACCSR) in 1948, followed by successive mechanisms like the Scientific Advisory Committee to the Cabinet (SACC) and the more recent PM-STIAC (Prime Minister's Science, Technology and Innovation Advisory Council), have laid the groundwork for what has now become a more structured and dynamic advisory framework.

The formal establishment of the OPSA in 1999 was both a culmination of this legacy and a recognition of the growing need for a centralised, cross-cutting institution to provide high-level scientific counsel to the cabinet and Government of India.

OPSA has since worked at the critical intersection of science, policy, and society - facilitating evidence-based decision-making, advancing technology missions, and catalysing systems thinking across sectors.

OPSA's central role has been to institutionalise the integration of science into policy formulation. Over the past two and a half decades, the Office has consistently worked with key stakeholders -from the Prime Minister's Office and Cabinet Secretariat to sectoral ministries and scientific institutions -to elevate the role of scientific reasoning in governance. This has led to several nationally significant interventions, including the establishment of Science and Technology (S&T) missions, shaping of sectoral policy choices, and response strategies during critical times such as the COVID-19 pandemic.

One of OPSA's most significant contributions has been in fostering inter-ministerial and cross-sectoral collaboration. The challenges faced today -ranging from climate change to food and energy security -do not reside within the boundaries of a single ministry or discipline. OPSA's ability to mobilise collaborative frameworks has made it an effective platform for multi-stakeholder leadership, aligning scientific advancements with sector-specific priorities.

The Road Ahead: Future Priorities for Science Advice in India

Looking ahead, the next phase of OPSA's work must be defined by deeper sectoral integration, agility in response, and inclusivity in approach. As scientific complexity increases and societal challenges become more interconnected, India's science advisory mechanisms must evolve to match this new reality.

01 Embedding S&T into Sectoral Policy Processes

Going forward, scientific inputs must not be limited to ad-hoc consultations or post-facto validation. Science and technology must be embedded across the full policy lifecycle -right from agenda-setting and design to implementation and monitoring. OPSA is uniquely positioned to serve as a connector across ministries and align national scientific capabilities with sector-specific goals in health, agriculture, energy, mobility and education.

02 Evidence-informed Science Funding Priorities

Globally, a key function of science advice systems is also to inform how R&D funding is prioritised -ensuring alignment with national goals through rigorous, data-driven analysis. In India, this role is equally vital. Science advice must extend beyond thematic inputs to actively shape the allocation of resources across the S&T ecosystem. To enable this, a structured and purpose-led interface between the science advisory system and financial governance is essential. Specifically, this means supporting the Department of Expenditure with timely, evidence-based inputs to support its annual assessment and allocation of budgets across scientific ministries and agencies. This approach would help move India towards more strategic, impact-oriented science funding, grounded in both national needs and future foresight.

03 Foresight and Agility in Technology Governance

Anticipatory governance is critical in a fast-moving technological landscape. OPSA will enhance its foresight capabilities through horizon scanning, technology trend analysis, and scenario planning to better inform long-term policy decisions. These insights must be institutionalised into the policy process, allowing India to be proactive rather than reactive in regulating emerging technologies and fostering innovation ecosystems.

04 Translating Research into Policy and Social Impact

Bridging the "valley of death" between research and policy impact is a persistent challenge. OPSA could play a critical role in creating mechanisms for rapid knowledge translation -developing synthesis reports, policy briefs, and implementation toolkits that bring scientific evidence into formats and timelines conducive to policy uptake across the sectors.

05 Inclusive and Participatory Science Advice

The science advisory ecosystem must reflect the full spectrum of knowledge and experience -ranging from formal academic institutions to grassroots innovators, startups, civil society, and the private sector. The approaches need to increasingly emphasise inclusivity, particularly drawing from the social sciences, behavioural economics, and systems thinking, to ensure that scientific advice is attuned to real-world needs and culturally grounded insights.

06 Strengthening Science Diplomacy

In a globalised scientific landscape, science diplomacy is emerging as a crucial tool for both geopolitical influence and collaborative problem-solving. It is essential to deepen international engagements through bilateral technology roadmaps, multilateral platforms, and strategic science collaborations in frontier areas. The International Technology Engagement Strategy (ITES), piloted recently with quantum technologies, represents a model that can be scaled across other critical domains.

In Summary

India's journey from a scientifically aspirational nation to a S&T-enabled one brings together actors, ideas, and institutions for collective progress. The effectiveness of science advice ultimately depends on the strength of its institutional infrastructure. As the OPSA continues to strengthen this institutional architecture, there is a pressing need to encourage more scientists to engage with policy, and more policymakers to become fluent in scientific reasoning.

As we reflect on 25 years of this journey, we also look ahead with clarity and commitment. The future of science advice in India aspires to be more nimble, responsive, strategic, and inclusive -anchored in the spirit of public good and national development. The challenges we face are immense, but so is the potential of our scientific community and the resilience of our institutions.

Former Hon'ble PM Lal Bahadur Shastri with Dr. Homi Bhabha

Evolution and Institutionalisation of Science Advice Mechanisms in India

Dr. B. Chagun Basha
Chief Policy Adviser

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Office of the Principal Scientific Adviser to the Government of India

India stands among the select group of nations with a well-established and institutionalised system for science advice to the government. This strong foundation is the result of sustained emphasis on the science-policy interface since the early years of independence. The evolution of this system reflects a strategic recognition that scientific knowledge and evidence must inform national development, technology adoption, and long-term planning. The roots of India's science advisory architecture can be traced back to the post-independence era, a period marked by nation-building and the pursuit of self-reliance.

India's first generation of scientific leaders - including Dr. Homi Bhabha, Dr. P. C. Mahalanobis, Dr. S. S. Bhatnagar, Dr. Vikram Sarabhai, and others-played transformative roles not only in advancing their respective scientific disciplines, but also as institutional architects and trusted advisers to the government.

For instance, Dr. Bhabha's counsel led to the creation of the Department of Atomic Energy (DAE), while Dr. Sarabhai was instrumental in shaping the Indian Space Research Organisation (ISRO). Their legacy helped embed scientific thinking into policymaking processes and laid the groundwork for India's formal science advice mechanisms.

This article traces the trajectory of science advice in India, highlighting the evolution, mandates, and key outcomes of various apex advisory bodies from 1948 to the present. In doing so, it also reflects on the gradual but steady institutionalisation of science advice into structured, cross-sectoral mechanisms that continue to guide India's science, technology, and innovation landscape and the overall governance ecosystem.

Advisory Committee for Coordinating Scientific Research (ACCSR, 1948-1956)

Young Dr. A.P.J. Abdul Kalam with Dr. Vikram Sarabhai

Established in the early years of independent India, the Advisory Committee for Coordinating Scientific Research (ACCSR) was among the first institutional mechanisms aimed at integrating science into the national development agenda. Its formation underscored the priority accorded to scientific advancement in shaping the country's future.

Chaired by Hon'ble PM Pandit Jawaharlal Nehru, the ACCSR brought together leading scientists and policymakers to guide the government in building scientific capacity. Its primary objectives included the development of scientific infrastructure, promotion of research institutions, and the coordination of efforts across sectors to prevent duplication and ensure optimal use of resources.

The work of the ACCSR laid the groundwork for India's evolving science policy framework. It played a critical role in shaping the early direction of scientific planning in the country and led to the creation of the Scientific Advisory Committee to the Cabinet (SACC) in 1956 - the nation's first formalised science advisory body.

Scientific Advisory Committee to the Cabinet (SACC, 1956-1968)

In May 1956, the Government of India established the Scientific Advisory Committee to the Cabinet (SACC), a pioneering step toward integrating scientific expertise into national policymaking. Chaired by Dr. Homi Bhabha, one of India's foremost scientists, the committee comprised 15 distinguished members drawn from various scientific disciplines.

The SACC was entrusted with advising the Cabinet on a broad range of matters related to science and its application for societal benefit. Its formal terms of reference included formulating scientific policy, setting research priorities, and ensuring that science served as a driver of national development.

A major milestone in the committee's work was its role in drafting the Scientific Policy Resolution of 1958. This seminal document laid the foundation for India's post-independence scientific enterprise and articulated a national vision for promoting scientific temper, research capacity, and innovation. It also catalysed the establishment of numerous national laboratories and scientific institutions, helping embed science within India's development agenda.

SACC functioned as a vital link between scientific advice and government action. Its recommendations, along with the Cabinet's decisions, were regularly communicated to relevant ministries and departments, ensuring that science and technology priorities were closely aligned with national planning and governance.

Though the committee was dissolved in 1968, its influence endured in its newer versions as the country progressed. SACC marked a significant evolution in the institutionalisation of science advice in India and set a precedent for future advisory bodies at the highest levels of government.

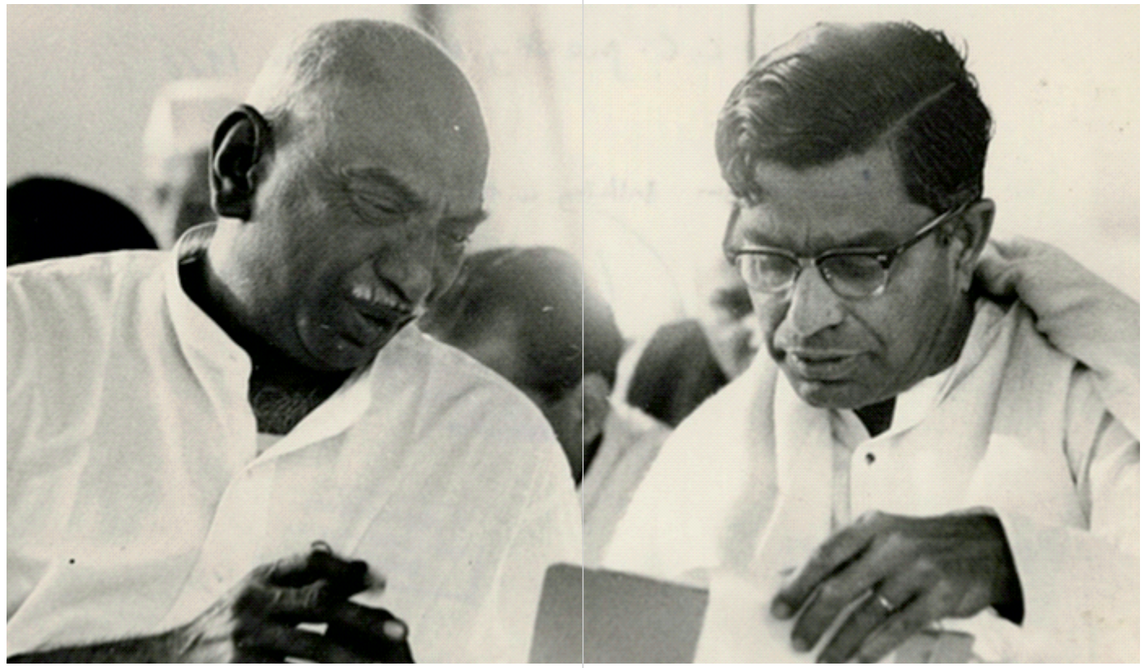
Committee on Science and Technology
(CoST, 1968-1970)

In 1968, The Committee on Science and Technology (CoST), chaired by a pioneering nuclear physicist Dr. B.D. Nagchaudhri, was established by the Government of India to provide strategic guidance on the formulation and implementation of national policies in Science and Technology(S&T). Operating until 1970, CoST played a crucial role in identifying S&T priorities aligned with India's developmental needs. One of its key objectives was to advise the government on the effective development and utilisation of the country's scientific resources, while also ensuring a balanced approach between the use of indigenous technologies and the selective adoption of foreign technologies in keeping with national interests.

A major outcome of CoST's work was the preparation of an implementation strategy for the Scientific Policy Resolution of 1958. The committee also undertook several in-depth studies, including analyses of R&D expenditures in selected sectors, the role of R&D in both public and private industry, and its integration with national research institutions. Additionally, it reviewed personnel-related issues such as the migration of scientists, working conditions in research environments, and the efficient allocation of research funds.

CoST also provided targeted advice on key technological areas of national importance during that period. These included metals and minerals, water resources, dry and irrigated farming, agro-chemicals, computers, silicones, high polymers, ceramics, fine chemicals, and the sustainable management of natural resources. Though short-lived, the committee's work marked a significant step in formalising science advice in India's overall governance framework.

National Committee on Science and Technology
(NCST, 1971-1980)



Former Tamil Nadu CM Mr. Kamaraj with Dr. C. Subramaniam

NCST was constituted in 1971 as a high-level advisory body with significantly stronger administrative positioning than its predecessor, the CoST, to advance the role of S&T in addressing India's development priorities. At a time when the country was increasingly looking to integrate scientific capacity with economic planning and national security, the NCST served as a key institutional mechanism to guide this effort.

Shri Chidambaram Subramaniam, a principal architect of India's Green Revolution and then Union Minister for Science and Technology, was appointed as the first Chair of the NCST. Under his leadership, the committee placed strong emphasis on fostering Centre–State collaboration, resulting in the establishment of State Science and Technology Councils to decentralise and regionalise scientific planning. Over the subsequent years, leadership of the NCST transitioned to other senior policymakers, including Shri Tonse Ananth Pai (1974), and later, Shri P.N. Haksar and Shri V.G. Rajyadhyaksha, both serving in their capacities as Deputy Chairmen of the Planning Commission between 1975 and 1977. Following its reconstitution in June 1977, the NCST was chaired by Dr. Atma Ram, former Director-General of CSIR, who also held the role of Principal Scientific Adviser to the Prime Minister during this period.

Between 1971 and 1979, NCST was tasked with a comprehensive mandate-to revamp the nation's scientific, technological, and industrial frameworks, encompassing both civilian and defense sectors. It was responsible for advising the government on the preparation of a National S&T Plan, thereby extending and deepening the functions previously undertaken by CoST. In 1973, the committee formulated a strategic approach to the national S&T plan, which subsequently informed three consecutive Five-Year Plan cycles. This planning process adopted a hybrid methodology, combining sector-specific strategies with a broad, integrated overview of the country's S&T needs across nearly 24 key sectors.

One of NCST's most significant contributions was laying the conceptual foundation for India's first Technology Policy Statement (TPS), eventually released in 1983. Developed during a period marked by technology denial regimes and restricted global access, the TPS reflected NCST's sustained efforts to articulate a self-reliant technology doctrine for India. Though the formal release of the policy came later, NCST's role in shaping its direction was pivotal. The committee's work during this period was instrumental in redefining the interface between science, technology, and national sovereignty, marking a critical phase in the evolution of India's technology policy landscape.

Hon'ble (Former) President Dr. Rajendra Prasad conferring Padma Shri to Dr. Atma Ram

Scientific Advisory Committee to the Cabinet (SACC, 1981-1985)

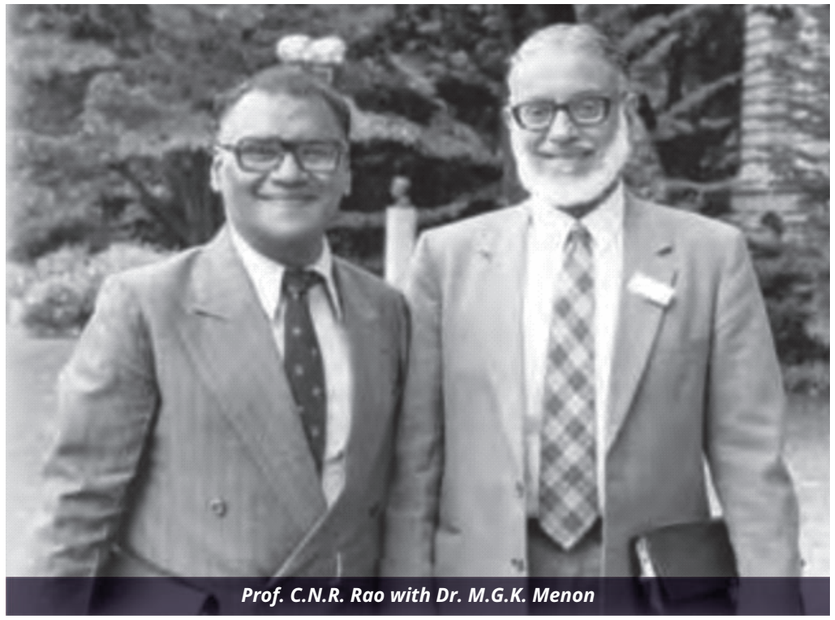
Dr. M. S. Swaminathan with Nobel laureate Norman Borlaug

The Scientific Advisory Committee to the Cabinet (SACC) was reconstituted in March 1981 as the successor to the NCST, reaffirming the Government of India's commitment to embedding scientific expertise into high-level policy deliberation. The committee was initially chaired by Prof. M.S. Swaminathan, a renowned geneticist and key architect of India's Green Revolution, who was then serving as Member (Science) in the Planning Commission. The SACC brought together 23 to 25 members, including heads of major S&T agencies, academic institutions, and research organisations, ensuring a broad representation of India's scientific leadership.

In May 1982, the chairmanship of SACC was assumed by Prof. M.G.K. Menon, former Chairman of ISRO and Director-General of Defence Research & Development Organisation (DRDO), further strengthening the committee's strategic orientation. Under their leadership, the committee made several influential policy recommendations, reflecting the growing complexity and importance of science and technology in national planning.

Among its most significant contributions during this period was the establishment of the National Biotechnology Board, which laid the foundation for the eventual creation of the Department of Biotechnology (DBT) - a landmark institutional development in India's biosciences sector. The SACC also recommended the formation of the National S&T Entrepreneurship Board, aimed at fostering innovation-driven enterprises and enhancing the interface between science, technology, and industry.

Science Advisory Council to the Prime Minister (SAC-PM, 1986-1990)



Prof. C.N.R. Rao with Dr. M.G.K. Menon

The Science Advisory Council to the Prime Minister (SAC-PM) was established in February 1986, as a high-level advisory body to guide national priorities in science and technology through direct engagement with the Prime Minister's Office. Chaired by Prof. C.N.R. Rao, one of India's most distinguished scientists and educators, the Council comprised eight other experts drawn from a diverse spectrum of fields including academia, industry, agriculture, medicine, and engineering. This heterogenous composition reflected a deliberate effort to bring multidisciplinary perspectives into national science policy deliberations.

During its tenure, SAC-PM offered strategic advice on a wide range of emerging and critical technology areas such as parallel computing, advanced materials, instrumentation, electronics, chemical industries, robotics, lasers, genetic engineering, photonics, and building materials. In addition, the Council addressed pressing challenges related to fertiliser use, renewable resources, food systems, healthcare, and inland water transport, demonstrating its comprehensive approach to science-led development.

A notable focus during this period was the advancement of technology foresight activities, aimed at anticipating future scientific and industrial trends and aligning them with India's developmental goals. The Council also played a pivotal role in promoting the effective implementation of the TPS of 1983, ensuring that policy directives translated into actionable research and innovation strategies on the ground. Through its work, SAC-PM significantly shaped India's technological vision during the late 1980s, reinforcing the strategic link between scientific expertise and policy leadership.

Review of Apex Science Councils:
Reflections and Realignments
(1990-1999)

The 1990s marked a period of critical review and institutional recalibration for India's apex science advisory mechanisms. Building on the foundations laid by earlier bodies such as the NCST, SACC, and SAC-PM, this decade witnessed a strategic reassessment of the role, structure, and efficacy of science and technology advisory systems in a rapidly evolving national and global context. While formal high-level councils were less active in this phase, the Government of India initiated several efforts to evaluate the effectiveness of past science advisory frameworks and explore models better suited to emerging technological, economic, and geopolitical realities.

Amid liberalisation and increasing global integration, there was growing recognition of the need for more agile, interdisciplinary, and outcome-driven advisory structures that could respond to complex challenges such as industrial modernisation, sustainable development, and the rising prominence of information and communication technologies. In this context, the groundwork was laid for a new generation of science advisory bodies, which would go on to emerge in late 90s or the early 2000s with renewed mandates and closer alignment with national priorities.

This transitional phase also saw the strengthening of institutional mechanisms within ministries and departments, and greater involvement of expert groups and task forces on specific themes such as biotechnology, nanotechnology, energy, environment, and public health.

The emphasis increasingly shifted toward domain-specific policy inputs, enhanced inter-ministerial coordination, and the integration of science advice into sectoral planning processes. In many ways, the 1990s served as a bridge between the legacy of post-independence science advisory efforts and the emergence of more contemporary, mission-oriented advisory institutions in the new millennium.

Establishment of Office of the Principal Scientific Adviser to the Government of India
(1999)

The formal establishment of the Office of the Principal Scientific Adviser (OPSA) to the Government of India in November 1999 marked a significant institutional milestone in the evolution of science advice mechanisms in the country. Conceived as a central, high-level advisory role, the OPSA was created to provide coordinated, evidence-based guidance on matters of science and technology directly to the highest levels of government, including the Prime Minister's Office and the Cabinet. This development reflected a maturing of India's science policy architecture -building on decades of experience with various committees and councils, and responding to the growing complexity of S&T's role in national development and strategic decision-making.

The Office is tasked with catalysing mission-driven approaches, fostering cross-sectoral coordination, and ensuring the integration of cutting-edge science into national planning and governance. It also serves as the nodal point for interfacing with international scientific developments, facilitating global collaborations, advising on emerging councils, and responding to the growing complexity of S&T's role in national development and strategic decision-making technologies with long-term national implications. Over time, the mandate of the OPSA expanded to include oversight of large-scale initiatives such as technology missions, innovation policy frameworks, and public-private research and innovation (R&I) partnerships.

Functioning within the Cabinet Secretariat, the OPSA has been playing a key role in institutionalising foresight-driven, systems-level thinking, and continues to serve as an anchor for national science and technology strategy, working closely with ministries, academia, industry, and the broader scientific community. Its establishment marked the beginning of a more structured, and strategically empowered science advisory ecosystem in India.

The OPSA has been led by distinguished scientists who have each shaped and strengthened the role of science and technology in national policy and strategic governance.

Dr. A.P.J. Abdul Kalam

A renowned aerospace scientist and visionary, served as the first PSA from November 1999 to November 2001. In this capacity, he played a pivotal role in shaping national policies, strategies, and missions aimed at leveraging science and technology for development. He also served as ex-officio Chairman of the reconstituted SACC. During his tenure, Dr. Kalam spearheaded the Technology Vision 2020 and India Millennium Mission 2020, laying out a roadmap for a technologically empowered India. His tenure as PSA was a prelude to his subsequent election as the President of India in July 2002, where he continued to champion the cause of science and innovation.

Dr. R. Chidambaram

A distinguished nuclear physicist, succeeded Dr. Kalam in November 2001 and served as PSA until early 2018. His tenure was marked by several transformative initiatives, including the National Knowledge Network (NKN) and the Nanoelectronics Mission, which significantly expanded India's scientific and digital infrastructure. As PSA and Chair of SACC, Dr. Chidambaram also served as the Chair of the Core Technical Group (CTG) under the Strategic Forces Command (SFC), which forms a critical component of India's Nuclear Command Authority (NCA). This role enabled the integration of scientific expertise into national security and defence technologies, particularly in the modernisation of nuclear systems.

Prof. K. VijayRaghavan

An eminent developmental biologist, took over as the third PSA in April 2018, serving until April 2022. His tenure coincided with the global COVID-19 pandemic, during which he provided strategic scientific advice to the Government of India on mitigation, preparedness, and public health measures. A significant institutional development under his leadership was the establishment of the Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) and the Empowered Technology Group (ETG). These mechanisms provided a renewed thrust to coordinated national S&T initiatives, including the conceptualisation and implementation of S&T clusters and mission-mode programmes across key sectors.

Prof. Ajay Kumar Sood

An eminent physicist, assumed office as the fourth PSA in April 2022, and continues to serve in this role. As Chair of PM-STIAC and ETG, he has focused on shaping national missions on disruptive technologies, including Quantum Technologies and Artificial Intelligence. His tenure is also distinguished by an active international engagement agenda, with India playing a leading role in initiatives such as India–US TRUST, India–EU Trade and Technology Council (TTC), QUAD AI and Quad Investors Network (QUIN) Working Group, and broadly India's International Technology Engagement Strategy (ITES). One of the key achievements during this period is the conceptualisation and institutionalisation of the Chief Science Advisers Roundtable (CSAR) -a multilateral platform that has elevated India's presence in global science diplomacy and international S&T governance.

Science Advisory Council to the Prime Minister (SAC-PM, 2004- 2013)

Hon'ble (Former) President Pranab Mukherjee, Hon'ble (Former) PM Dr. Manmohan Singh and Prof. C.N.R. Rao with fellow Bharat Ratna Awardee Sachin Tendulkar

In 2004, the SAC-PM was reconstituted with a renewed mandate under the leadership of Professor C.N.R. Rao, one of India's most respected scientists. While its core terms of reference remained largely consistent with those of its earlier iteration (1986–1990), this second phase of SAC-PM operated in a more institutionally matured environment, with a clearer focus on bridging science and policy. Functioning in parallel with the SACC - with occasionally overlapping mandates -SAC-PM played a key role in steering some of the transformative developments.

SAC-PM's second tenure, spanning nearly a full decade, allowed it the continuity and stability needed to ensure that several of its recommendations were translated into tangible policy outcomes and institutional frameworks.

Among its most impactful contributions was the establishment of the Indian Institutes of Science Education and Research (IISERs), which significantly strengthened the country's science education and research ecosystem. Another milestone was the creation of the Department of Health Research (DHR) in 2007, aimed at bolstering institutional support and strategic direction for biomedical and public health research.

Prime Minister's Science Technology and Innovation Advisory Council (PM-STIAC, 2018)

In August 2018, building upon the institutional legacy and impact of earlier apex science advisory bodies such as the SACC and the SAC-PM, the Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) was established. Conceived as a high-level advisory instrument, the Council is chaired by the PSA and comprises 21 eminent members drawn from diverse sectors, including academia, industry, civil society, and government. PM-STIAC was designed to provide strategic, multi-stakeholder advice to the Prime Minister and the Cabinet on a broad range of issues related to Science, Technology, and Innovation (STI), as well as sectors that would have impact from STI.

Functioning as a national apex forum, PM-STIAC plays a pivotal role in priority setting, aligning scientific expertise with pressing developmental and strategic needs. It facilitates the design and implementation of mission-oriented programmes, shares policy recommendations, and supports the creation of multi-sectoral roadmaps. The Council also serves as a critical interface to ensure that scientific and technological advances are seamlessly integrated into governance and decision-making at the highest level.

Since its inception, PM-STIAC has been instrumental in shaping several national S&T missions, such as those on One Health, Quantum Technologies, Artificial Intelligence, Deep Ocean Exploration, Electric Mobility, Green Hydrogen, Critical Minerals, Bioeconomy, Carbon Capture, Utilisation and Storage (CCUS), and Technical Textiles, among others. It has also provided inputs into the formulation of key national policy frameworks, including those for drones, space sector modernisation, and deep-tech startups etc. Notable initiatives facilitated by the Council include the One Nation One Subscription (ONOS) and the Anusandhan National Research Foundation (ANRF).

PM-STIAC continues to serve as an essential juncture for evidence-based policymaking, where scientific insights are brought to bear on complex sectoral and cross-sectoral challenges.

Empowered Technology Group (ETG, 2020)

PSA Prof. Sood addressing the Technology Advisory Group (TAG) of Empowered Technology Group (ETG)

With the overarching mandate of enhancing India's technological competitiveness and self-reliance, the Empowered Technology Group (ETG) was constituted by the Union Cabinet in February 2020 as a high-level institutional mechanism under the OPSA. Envisioned as a strategic advisory body, the ETG is tasked with streamlining national efforts in technology development, procurement, and research and development across multiple sectors. The Group is chaired by the Principal Scientific Adviser and comprises senior representatives from key scientific and administrative bodies including the Atomic Energy Commission, Space Commission, DRDO, and the Ministries of Electronics & Information Technology, Telecommunications, and Science & Technology. It is also supported by a Technology Advisory Group (TAG), which brings additional expertise from leaders across academia, industry, and civil society.

At its core, ETG is driven by the objective of promoting technology indigenisation. Its work is organised across three key pillars: policy guidance, procurement facilitation, and R&D evaluation. In the policy domain, ETG formulates long-term technology roadmaps, fosters cross-ministerial coordination, and recommends frameworks to strengthen indigenous capabilities while reducing external dependencies. It has introduced the appointment of Technology Officers within ministries to advance proactive technology adoption and strategic foresight. In procurement, ETG enables joint inter-ministerial approaches to avoid duplication, encourages domestic sourcing, and supports the creation of a digital marketplace for publicly funded technologies. In the R&D space, it assesses high-value proposals from various government agencies to ensure alignment with national priorities, while fostering capacity-building among policymakers and institutional leadership.

Since its inception, ETG has reviewed and enabled over 120 proposals related to national missions, technology procurement strategies, large-scale infrastructure planning, and inter-agency agreements. It complements and strengthens the functioning of the PM-STIAC, bringing an implementation-oriented lens to technology governance. Today, ETG stands as a central platform for embedding scientific and technological foresight into national planning, and for steering India's strategic sectors toward greater autonomy, resilience, and future-readiness.

Looking Ahead

As India's science advisory ecosystem continues to mature, the future of science advice lies not just in responding to immediate policy needs but in anticipating change and proactively shaping long-term strategies. Innovations in methods and frameworks for science advice are opening new frontiers -especially through the integration of emerging technologies such as artificial intelligence, big data analytics, and advanced computational tools. These technologies offer unprecedented capabilities to synthesise vast and diverse datasets, enabling advisers to extract actionable insights across multiple sectors with greater speed and precision.

A critical area of advancement involves the development and use of robust data systems, indicators, and composite indices to track ecosystem-level signals. This analytical depth allows for more accurate gap assessments and evidence-based recommendations at finer granularities, making science advice more targeted and impactful. Strengthening national capacity in data interpretation and systems analytics will be key to optimally directing scientific resources and interventions.

Equally important is the embedding of foresight capabilities and anticipatory governance frameworks within science advice mechanisms. The ability to foresee emerging challenges -be it in health, energy, environment, security -and to prepare systemic responses in advance, enhances national resilience. Building institutional expertise in strategic foresight will ensure that India's science advice remains future-oriented and agile in the face of known as well as unknown uncertainties.

The path ahead involves a continuous evolution of the science advice infrastructure itself. By embracing innovations in data science, leveraging cross-sectoral knowledge, and cultivating in-house capabilities in predictive analytics and policy foresight, India's science advisory system can move towards deeper strategic influence. Such an approach will further institutionalise scientific evidence in governance and elevate the role of science advice in shaping a resilient, inclusive, and innovation-driven future.

Acknowledgement

This compilation draws upon the collective wisdom of several distinguished figures who have shaped India's science advisory landscape over the decades. The article reflects insights gathered from a wide array of sources, including writings, speeches, biographies, annual reports, and interviews of eminent scientists, policymakers, and institutional leaders. Sincere gratitude is extended to former Principal Scientific Adviser Prof. K. VijayRaghavan, former Director General, CSIR Dr. R.A. Mashelkar and former Secretary, DST, Dr. T. Ramasami for their generous time and thoughtful reflections that greatly enriched this article. Special thanks are also due to former Scientific Secretaries Dr. Y.S. Rajan, Prof. S.V. Raghavan, Dr. Swati Basu, and Dr. Arabinda Mitra for sharing valuable institutional experiences. Acknowledgement is also due to former officials who have contributed to the development and functioning of various science advisory mechanisms, particularly Dr. V. Rao Aiyyagiri, Dr. R.S. Mani, and Dr. Pawan Sikka. Contributions of former PSA Fellows Lt. Gen. Amit Sharma and Dr. Vasudeva is also gratefully acknowledged.

04

Chief Science Advisers Roundtable (CSAR) jointly organised by the Office of the PSA and UNESCO in Paris, France

How Countries Engage in Science Advice?

A COMPARATIVE OVERVIEW OF SCIENCE-POLICY INTERFACES

In an age of complex challenges, from climate change to pandemics to artificial intelligence, cyber and more, the role of scientific advice in shaping public policies is growing more and more critical. Around the world, governments are increasingly turning to scientific evidence and building science advisory ecosystems to ensure informed decisions on everything from public health and climate resilience to emerging technologies and national security. However, the nature in which this science advice is structured, delivered, and acted upon differs widely across countries.

Globally, the ecosystems of individuals and institutions engaged in providing science advice for policymaking are diverse and evolving.

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Source: Times of India

The structure of science advisory and its role and influence on decision-making vary from country to country. Science advice became critical globally due to its sector-agnostic nature. Science advisers and advisory bodies possess a distinct position in the policy landscape due to their expertise, experience, and, most critically, their degree of independence from policymaking institutions. With this understanding, this article examines global best practices in institutional science advice while also highlighting the role of the Office of the Principal Scientific Adviser to the Government of India (OPSA) in imparting science advice on different policy matters. The article is based on the comparative study conducted for Australia, Japan, South Africa, the United Arab Emirates (UAE), the United Kingdom (UK), the United States of America (USA), and India. Different structures and models of science advice exist in different countries. For instance, countries like India and Australia have individual chief science advisers whereas the US uses an agency model through the Office of Science and Technology Policy (OSTP). Japan and South Africa have advisory councils with experts from various fields. Furthermore, the National Science Academies also provide science advice in some contexts.

A comparative look at six countries alongside India reveals the varied architectures through which science advice is structured and delivered across the globe. The lines between science policy, science advice, and policy advice seem to blur, as the Chief Science Advisers/equivalents tend to perform duties of all three activities. The degree of their engagement and influence also differs, shaped by how these roles are positioned within the administrative machinery of each nation.

The varied administrative positioning of the science adviser or an advisory body from country to country determines the level of impact that science advice can have on policy matters across sectors. These impacts range from shaping Science and Technology (S&T) policy choices, impacting national and international policy positions in key technology domains, to aiding future preparedness and rapid response, and notably on budgetary planning and reappropriation. The time between evidence creation to decision-making also varies from country to country, shaped by governance structures and institutional mechanisms.

The following insights evaluate India's position in relation to the science advisory capabilities observed in the above-mentioned six nations.

01 Institutional Positioning and Its Impact:

Independent positioning enhances objectivity and inclusion in science advice. Japan's Council for Science, Technology, and Innovation (CSTI), chaired by the Prime Minister, focuses on budgetary and policy strategies, while the Science Council of Japan (SCJ) has a multidimensional focus that includes areas such as industry, academia, and government partnerships, enabling public-facing science, science for sustainability, foresight, etc. UAE, UK, and USA align with government priorities, while Australia and South Africa, despite being within ministries, pursue broader goals. The OPSA of India, reporting to the Prime Minister's Office and being administratively located within the Cabinet Secretariat of India, also exhibits a mix of strategies comprising several novel elements while also reflecting some of the key national priorities in its functions.

02 Budgetary planning and reappropriation for R&D:

Only a handful of science advisory bodies provide strategic advice in the national R&D budget in terms of its appropriation and reappropriation. OSTP of the USA, along with the Office of Management and Budget, develops multi-agency research and development priorities every year. This engagement has brought different critical areas, such as trustworthy AI, climate action, equity and inclusivity in STEM, national security, and pandemic readiness, into the focus of R&D budgetary impetus. CSTI of Japan develops comprehensive budgetary and research allocation guidelines. The departmental science advisers in the UK have a decisive say in R&D budgetary allocations of their respective departments. Though the Indian science advisory does not have a decisive say in budgetary planning and reappropriation for R&D, the recently created Anusandhan National Research Foundation (ANRF) is a pivotal step, providing the Indian science advisory an avenue to play a part in identifying priorities for the R&D budget.

03 Science Advisories shaping Science, Technology, and Innovation (STI) Policies:

Almost all of the countries analysed above play a key role in shaping the STI policy landscape of their country. Even though most countries engage in the continuous creation of evidence and dissemination of information, the nature of this engagement often remains top-down which means that the government or administrative host seeks input from the advisory. In Australia, the UK, and South Africa, the government itself seeks knowledge input from advisers in the form of advisory documents at regular intervals. The Indian Science Advisory plays a critical role in priority setting and shaping diverse science, technology, and innovation policies as well as sectoral policies through instruments such as the Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) and the Empowered Technology Group (ETG).

Some of the key features of science advisory shaping STI policies:

A. Sector agnostic science advice:

One of the defining attributes of effective science advice is its ability to transcend the boundaries of traditional science policy and inform decision-making across diverse sectors of the economy and society, making it sector-agnostic. Sector agnostic science advice implies imparting science advice beyond science policy to include policy matters of other sectors, cutting across the economy and society. (e.g. health, national security, environment, agriculture, etc.). As this is one of the key features of science advice, most of the advisory bodies engage in imparting sector-agnostic science advice.

First meeting of G20 Chief Science Advisers Roundtable 2023 in Ramnagar, Uttarakhand.

B. Collective Priority Setting through cross-agency and cross-stakeholder synergies:

An important, though often implicit, function of science advisories is to coordinate priority setting across ministries and agencies. This involves fostering horizontal, vertical, cross-sectoral, and interdisciplinary collaboration. Several countries, including India, are advancing such synergies. The Science Council of Japan and the Emirates Scientists Council emphasise building national and global networks to link academia, industry, and government. Australia focuses on enhancing international collaboration in critical and emerging technologies. India's science advisory mechanism similarly plays a pivotal role in shaping multi-stakeholder engagements through its strategic initiatives and cross-sectoral collaborations.

C. Public Engagement with STEM:

Science advisers can bridge the gab between the government and the public on Science Technology & Innovation (STI) matters. For instance, Japan and the UAE engage the public through knowledge platforms, albeit one-way. India strives to enhance public-facing communication, explaining how evidence informs policy and encouraging public input.

D. Conducting assessments and evaluations of the S&T interventions and R&D activities:

The Emirates Scientists Council (ESC) develops an evidence-based assessment report of the performance of UAE's scientific research; the UK Government Office of Science, through GCSA (Government Chief Scientific Adviser), conducts reviews and assessments for different interventions; National Advisory Council on Innovation (NACI) in South Africa conducts the review of the National Research and Development Strategy and Ten-Year Innovation Plan that also informs their STI foresight exercise. Developing databases and repositories also provides key insights into the S&T ecosystems of the countries. Though the Indian Science Advisory provides policy guidance to several initiatives, its role in the assessment and evaluation of S&T interventions and R&D activities remains limited.

04 Science Advisories shaping national and international policy positions for key domains:

Advisories in Australia, the UK, the USA, and India provide policy advice in critical and emerging areas of technology, such as quantum technology, semiconductors, artificial intelligence, etc. and globally relevant policy areas such as open access to scholarly scientific knowledge. However, the extent and nature of their engagements in these areas vary from country to country. In India, the PM-STIAC has been instrumental in spotlighting technologies of national and strategic importance. The Council's early deliberations on artificial intelligence and quantum technologies catalysed a mission-oriented approach, eventually leading to the formal launch of national missions in these domains.

Science Advice mechanisms in many of the countries discussed above act as the interface between the international science advisory and the national S&T ecosystem. This is facilitated through platforms such as G20, Quadrilateral Security Dialogue (QUAD), the Global Research Council, Organisation for Economic Co-operation and Development (OECD), etc., as well as several bilateral partnerships.

The OPSA, India has made a significant attempt at this by spearheading the Chief Science Advisers' Roundtable (CSAR) in 2023 under the G20 framework and in 2024 with a widened scope in partnership with United Nations Educational, Scientific and Cultural Organisation (UNESCO).

The attempt has successfully connected the Indian science advice mechanism with the global science advice ecosystem. OPSA also played a critical role in ensuring the sustained continuation of the initiative under the G20 framework, with South Africa presiding over this year's roundtable.

05 Rapid response, future preparedness, and addressing uncertainties:

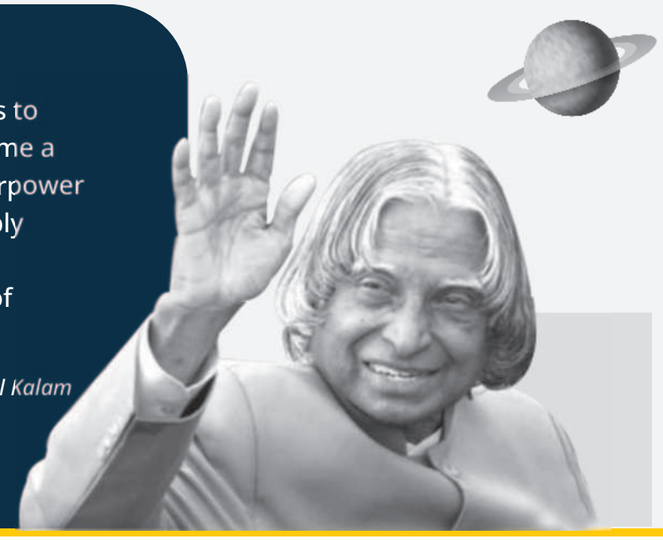
Chief science advisers and equivalent bodies play a vital role in providing rapid-response advice through both structured and ad hoc mechanisms. Australia's Rapid Response Information (RRI) Reports and the UK's Scientific Advisory Group for Emergencies (SAGE) exemplify institutionalised approaches to timely scientific input. Globally and in India, such mechanisms have proven critical in crises, including the COVID-19 pandemic. While ad hoc responses remain essential, the need for more permanent structures is increasingly recognised. Effective rapid response must be complemented by long-term foresight, preparedness, and mitigation strategies to address emerging technologies, uncertainties, and complex societal challenges.

Minimising the gap between the delivery of science advice and its translation into decision-making is crucial, particularly in fast-moving domains including that of disruptive technologies and during urgent response situations. It also depends on how long it takes for evidence to convince a decision. As evident in the country examples above, the optimal reduction of this time is possible only when the advisory and decision-making bodies work in tandem. The article shows how decisions are optimised and expedited due to an active engagement of science advisory at the conceptualisation, consultations, decision-making, and dissemination stages. Holistic engagement of science advisory mechanisms in the process of decision-making can meaningfully shape the policy discourse of any country.

25 Years Timeline

A renaissance is imperative for us to once again become a knowledge superpower rather than simply providing cheap labour in areas of high technology.

- Late Dr. A.P. J. Abdul Kalam



Technology is power and will continue to be so in the foreseeable future.

- Late Dr. R. Chidambaram

NOVEMBER 1999

Late Dr. A.P.J. Abdul Kalam
appointed as PSA

- Implementation of roadmap for Technology Vision 2020
- Conceptualisation of Society for Electronic Transactions and Security (SETS)
- Early Stage foundations for Provision of Urban Amenities to Rural Areas (PURA) - initiatives
- Shaping various strategic policy initiatives through Scientific Advisory Committee to the Cabinet (SAC-C)

JULY 2002

Late Dr. A.P.J. Abdul Kalam
elected as
President of India

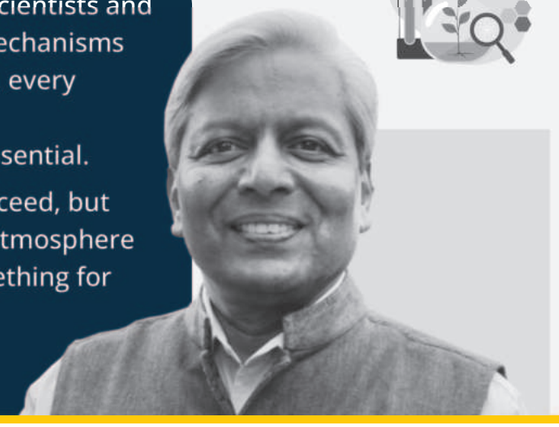
NOVEMBER 2001

Late Dr. Rajagopala Chidambaram
appointed as PSA

- Institutionalisation of SETS
- National Nanoelectronics Initiative
- Established Rural Technology Action Group (RuTAG)
- Establishment of National Knowledge Commision (NKC)
- Shaped strategic policies and initiatives in digital infrastructure, e-governance, and energy security
- Launch of National Knowledge Network (NKN)
- Provided strategic direction to emerging technology domains like Mega Science Vision 2035, AUSC (Advanced Ultra Supercritical) technology and the LIGO-India project.

TILL 2018

25 Years Timeline



The interaction of scientists and science Advisory mechanisms with every ministry, every minister, and the Prime Minister is essential.

Sometimes you succeed, but always there is an atmosphere of trying to do something for the public good.

- Prof. K. VijayRaghavan

Improving our science and technology output is linked to our economic growth...

essential for our goal to become a developed nation by 2047.

- Prof. Ajay Kumar Sood

APRIL
2018

Prof. K. VijayRaghavan
appointed as PSA

- Formation of Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC)
- Formation of Empowered Technology Group (ETG)
- Shaping of various national missions and initiatives through PM-STIAC and ETG
- COVID 19 Pandemic mitigation efforts
- Conceptualisation of Regional Science and Technology Clusters
- Conceptualised National Research Foundation
- Extended support to specialised synergy projects (Brain Research, AquaMAP, Mysore Planeterium)

APRIL
2022

Prof. Ajay Kumar Sood
appointed as PSA

- Launch of Manthan Platform, RUTAG (Phase 2) and RSVCs
- Launch of National One Health Mission (NOHM)
- Launch of One Nation One Subscription (ONOS)
- Operationalisation of Anusandhan National Research Foundation (ANRF)
- Operationalisation of National Quantum Mission (NQM)
- Conceptualisation and institutionalisation of the Chief Science Advisers' Roundtable (CSAR).
- Release of draft National Deep Tech Startup Policy (NDTSP) Framework.
- Shaping various national policy priorities and international engagement strategies for technology domains

Curated by :
Mr. Suryanjay Singh
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Milestone Overview

Society for Electronic Transactions and Security (SETS)

Society for Electronic Transactions and Security (SETS), an initiative of OPSA, is an idea to form a specialised organisation in the area of information security which was conceived by Dr. A.P.J. Abdul Kalam and implemented by Dr. R. Chidambaram.

SETS was registered as a non-profit society under the Societies Act of 1860 in May 2002 and established in the Public-Private Partnership mode. It was set up for the purpose of nucleating, sensitising and developing provable security designs that can protect the information wealth of the country and that can be used in applications of Information Security products and services.

SETS
Society for Electronic Transactions and Security

Launch of National Knowledge Network (NKN)

The idea of setting up the NKN was deliberated & finalised by the OPSA and the National Knowledge Commission (NKC) after a collaborative engagement with the key stakeholders. NKN project is aimed at establishing a strong and robust internal Indian network which will be capable of providing secure and reliable connectivity. NKN aims to transcend space and time limitations for all vibrant institutions in accessing information and knowledge and derive the associated benefits for themselves and for the society, potential users, telecom service providers, educational and research institutions.

The PM-STIAC was established as the apex science advisory body to the Government of India, subsuming the collective mandate of earlier science advisory instruments including that of Scientific Advisory Council to the Cabinet (SAC-C) and the Scientific Advisory Council to the Prime Minister (SAC-PM), to advise the Prime Minister and the Cabinet on all matters related to science, technology, and innovation

Formation of Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC)

Formation of Empowered Technology Group (ETG)

The Empowered Technology Group (ETG) was constituted as an institutionalised structure to proactively lay down, coordinate, and oversee national-level policies relating to procurement and induction, and research and development in technologies that require large outlays in resources both financial and human, and to render sound and timely advice for determining direction and trajectory of Government's R&D and Technology Development Programmes.

ETG aims to proactively lay down, coordinate, and oversee national-level policies relating to

01 Procurement and Induction of technologies

02 Research and Development (R&D) in technologies that require large outlays in resources, both financial and human

03 Render sound and timely advice for determining direction and trajectory of Government's R&D and Technology Development Programmes

Shaping various national policy priorities and international engagement strategies for technology domains

OPSA has been playing a critical role in shaping various national policy priorities (AI, Quantum, Green Hydrogen, Electric Mobility, etc) and India's technology diplomacy efforts (International Technology Engagement Strategy (ITES), India-EU Technology and Trade Council (TTC), India-US TRUST initiative, and QUAD technology engagements)

National Missions & Inititatives

OPSA through PM-STIAC and ETG has steered multiple missions and initiatives of national importance like: National Language Translational Mission; National One Health Mission; National Quantum Mission; Artificial Intelligence Mission, Electric Vehicle Mission; Deep Ocean Mission; BioE3 Policy; National Livelihood Mission etc. Few of the upcoming missions discussed in PM-STIAC are Carbon Capture Utilisation and Storage Mission, Cell and Gene Therapy Mission, Regulatory Mechanism for approval of Medical Devices.

Launch of Indian Science Technology and Engineering facilities Map (I-STEM)

Initiated the creation of a national portal to catalog and expand access to scientific instruments and research infrastructure.

As of 31.03.2025 total registered Institutes are 3,345 while the total equipments stand at 25,245.

Establishment of RuTAG

Rural Technology Action Group (RuTAG) is an initiative of OPSA since 2004. RuTAG, supported by the OPSA, was conceptualised as a mechanism to provide a higher level of S&T intervention and support for rural areas. Under this initiative, the interventions are designed to be primarily demand-driven, focusing on bridging technology gaps at the grassroots level, upgrading technology, and providing training and demonstrations through innovative projects.

Setting Up of Regional Science and Technology Clusters

OPSA has initiated setting up of regional S&T Clusters across India as result of 7th PM-STIAC meeting. As of date, eight S&T clusters have been established in Bengaluru (BeST), Bhubaneswar (BCKIC), Chandigarh (PI-RAHI), Delhi (DRIIV), Hyderabad (RICH), Jodhpur (JCKIC), Pune (PKC), and Visakhapatnam (AMTZ).

Scientific Secretaries of OPSA

2001-2002

Innovation is very much linked with economics and science; without resulting in some operational business, it is not innovation. You have to be continuously in an innovative business anywhere and India has to focus on scaling up with its innovations.

Shri Y. S. Rajan

2002-2008

It is important to build indigenous capabilities, not just for security, but for the advancement of science itself.

Late Dr. S.K. Sikka

2009-2015

The beauty about science is that when you think everything is done and understood, you start all over again.

Prof. S. V. Raghavan

2016-2017

When we talk about science, it doesn't pertain only to the scientific community. It's true significance lies in being translated into products, ultimately aimed towards the welfare of the society.

Dr. Swati Basu

2018-2021

For India to best reap the fruits of science, technology and innovation, we need to rethink how scientific infra-structure is accessed, how scientific knowledge is created, shared, and utilised to meet both national needs and international obligations.

Dr. Arabinda Mitra

2022-present

India has a young population and the talent to pursue science, giving it an edge over other nations. By advancing innovations in critical areas, India will continue progressing toward self-reliance. In the near future, we envision India emerging as a leading product-driven nation.

Dr. Parvinder Maini

05

Powering India's Progress through Science Advice

The Office of the Principal Scientific Adviser (OPSA) to the Government of India plays a catalytic role in shaping and driving initiatives of national importance, where scientific insights become foundational to mission design and execution. Over the past 25 years, OPSA has significantly influenced the trajectory of India's scientific and technological development as well as shaped the sectoral policies and programs. Through institutional science advice, OPSA has continued to provide a platform for policymakers, scientists, and sectoral experts to come together, enabling the conceptualisation and evolution of various initiatives of national importance. These initiatives have aimed at addressing societal, security, and developmental needs, and anticipating future challenges.

Science advice through OPSA has shaped India's position and efforts with respect to cyber security, holistic health, electric mobility, and frontier technologies like AI, Quantum, etc. This article traces the conceptualisation of some such key initiatives like National Knowledge Network, SETS, Mega Science Projects, EV Mission, National Quantum Mission, National AI Mission and the Deep Ocean Mission that hold national level impact and showcase how OPSA played a role in transforming scientific aspirations into policies and programs, with the support of relevant stakeholders. Each of these initiatives address varied and diversified issues like need for connectivity, concerns around cyber security, advancements for frontier technologies, science research and sustainability, etc. However, they all add to national advancement and share the common foundation of guidance through science advisory processes and the convening & collaborating capacity of OPSA to align diverse stakeholders.

COMPILED AND CURATED BY

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Source: Annual Report KEI Wires & Cables

Building India's Digital Knowledge Highway:

The National Knowledge Network

Today, we live in a world of seamless connectivity but this wasn't always the case. Even at the turn of the millennium, data was a scarce commodity and network speeds were limited. Information and Communication Technology was becoming increasingly important in the 2000s, especially in the field of collaborative research and development. The need for e-connectivity and sharing of knowledge resources was recognised particularly in data intensive and computationally demanding research problems which required use of high speed numerical techniques for assessment/analysis. Globally, the demand for computing and communication power was also increasing substantially as research and innovation moved towards a more collaborative and multi-disciplinary model.

The need for a dedicated high-speed research and education network (REN) in the nation was recognised by OPSA to enable better collaborative research. This vision laid the foundation for the National Knowledge Network (NKN), which addressed the requirement of a robust, high-bandwidth and low latency network to facilitate sharing of knowledge resources.

A Government of India initiative, NKN aimed at establishing a strong, high-speed digital communication infrastructure to connect educational and research institutions across the country.

CONTRIBUTORS

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Distinguished Scientist
CSIR & Project Head, NKN

Dr. Neeraj Sinha
Adviser/Scientist 'G', OPSA

Approved by the Union Cabinet in March 2010, NKN was launched with an outlay of INR 5990 Crore for a period of 10 years (March 2010-March 2020), which was further enhanced to INR 6956.88 Crore with an extension till March 2026.

The implementing agency for NKN is the National Informatics Centre (NIC) and the funding is by the Ministry of Electronics and Information Technology (MeitY). A high-level committee chaired by the PSA continues to meet and deliberate on the next phase of NKN.

NKN envisioned facilitating seamless access to information and collaboration among institutions. Its mission encompassed providing high availability, quality of service, security, and reliability to support the country in building quality institutions with relevant research facilities and creating a pool of highly trained professionals.

Key Features and Functionalities

NKN was established keeping the following features in mind:

1. Establishing a high-speed connectivity among similar institutes for knowledge sharing
2. Enabling collaborative research, development and innovation among institutes in India and the world over
3. Supporting advanced distance education in specialised disciplines in engineering, science, medicine, etc.
4. Facilitating ultra-high-speed infrastructure for e-Governance initiatives
5. Integrating sectoral networks spanning research, education, health, commerce, and governance
6. Connecting with global research networks, to collaborate with research communities across the globe

NKN Design & Objectives

Designed with scalability and adaptability in mind, NKN harnessed the exponential growth in computational and communication capacities. Its architectural framework was structured across three hierarchical layers: Core (Level 1), Distribution (Level 2), and Edge (User level).

The network was designed to support Overlay Networks, Dedicated Networks, and Virtual Networks. The main design objective for NKN was to create a setup that can be augmented and adapted to future requirements. Following a dialogue between NKN scientists, the network's design philosophy was agreed to be, "Encourage, Enable, Enrich and Empower" its user community to test and implement ideas without any limitations of the network technology. The benefit in terms of network speed that an institute can derive from NKN directly depended on the reliability and robustness of the internal Local Area Network (LAN) combined with other technologies used within the campus.

The objective of the NKN was to connect all stakeholders in science, technology, research and development, higher education, and governance using network speeds of 10 Gbps or higher, along with extremely low latency.

Almost all institutions engaged in research and scientific development in the country were connected with NKN. With the network in place, the sharing of high-performance computing facilities, virtual classrooms and very large data bases became a reality with the enablement of specialised applications.

By connecting premier institutions involved in basic and applied research, NKN acted as the nation's digital infrastructure for knowledge exchange. The entire network integrates with the global scientific community at multiple gigabits per second speed. NKN facilitated collaborative design in advanced engineering, allowing expert groups to access databases, conduct multi-party video conferences, and use high-end visualisation tools, all requiring substantial network bandwidth.

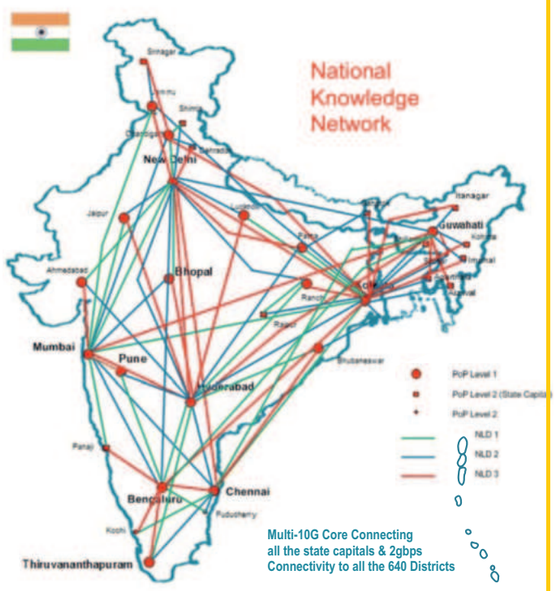
Some of the national collaborations and model projects where NKN was used include:

1. NKN supported the National Programme on Technology Enhanced Learning (NPTEL), enabling universities and colleges to download high-quality engineering and science e-content via high-speed links.
2. The National Digital Library project used NKN to create integrated digital libraries, preserving and providing electronic access for integrated digital learning across India as well as the world.
3. Virtual Classrooms operated on NKN's infrastructure, connecting 15 Indian Institute of Technology (IITs) with high-definition video conferencing to deliver quality technical education nationwide, overcoming geographic barriers.
4. The Department of Atomic Energy (DAE) used a dedicated segment of NKN as a secure private network, connecting 40 research and production units for effective collaboration.

Further, India also initiated efforts to extend NKN connectivity to SAARC nations. Once connected to the respective RENs, researchers in the region benefit from high-speed access to relevant digital infrastructure, fostering regional collaboration and integration.

NKN also provides ready access to worldwide mega science projects such as the Large Hadron Collider (LHC) at CERN, the European Organisation for Nuclear Research, and the European Synchrotron Radiation Facility (ESRF) at Grenoble, France through its high speed connectivity.

Since its inception, NKN has enabled collaborative innovation, virtual classrooms, high-performance computing, and the sharing of massive datasets across the country. It also functions as a testbed for advanced research in network security, service delivery models, and next-generation applications.



Map depicting core Point of Presence(PoPs) connectivity.

NKN Phase 2

Fifteen years since its inception, NKN has evolved as the National Research Education Network, connecting several premier institutions across India. The Phase 2 of NKN, which is expected to begin before the end of 2025, will continue to with the connections provided at present by NKN Phase 1, and additionally innovate to cater to the ever increasing demands of science and education. NKN Phase 2 will be upgrading its speed range from multiple 10 Gbps to multiple 100 Gbps connections, integrating dark fiber for emerging technologies like quantum cryptography, and enhancing international research collaboration with high-speed links to Asia-Pacific and Europe.

NKN Phase 2 will also support India's participation in global scientific missions like the Square Kilometre Array (SKA) radio telescope in Africa and Australia, which generates massive volumes of real-time data requiring ultra-fast connectivity. The network will continue to anchor India's National Supercomputing Mission (NSM), while introducing advanced cybersecurity protocols with greater traffic segregation to reduce vulnerabilities.

A key feature of Phase 2 will be the introduction of "dirty networks". These are securely isolated zones that allow researchers to test malware, cybersecurity tools, and ethical hacking scenarios without risking the broader network. These will be available to authorised labs within IITs and other institutions, enabling vital cybersecurity R&D while maintaining safeguards and accountability.

Additionally, NKN Phase 2 will improve inclusivity by aggregating smaller research stations like ICAR's (Indian Council of Agricultural Research) agricultural units through local hubs, connecting them efficiently to their parent organisations over a unified yet policy-controlled network infrastructure.

By August 2024, over 1,800 institutions had connected to NKN. The network empowered researchers to engage with global scientific platforms, facilitated collaborations across national and international institutions, and provided remote access to expensive research facilities and data repositories. It emerged as a critical digital infrastructure supporting advanced R&D, governance, and higher education.

Beyond academia, NKN contributed to administrative efficiency and transparency through support for e-governance platforms. It also fostered digital inclusion by allowing institutions from remote and rural regions to access the same quality of information and tools as their metropolitan counterparts. This harmonisation of digital access laid the foundation for more equitable knowledge dissemination. NKN carries not just research and education traffic, but also supports internet and e-Governance services.

NKN's footprint already extends beyond national borders to connect with regional networks in neighboring countries, encouraging knowledge diplomacy and regional innovation partnerships. With Phase 2, the platform aims to further facilitate the development of India's communications infrastructure and stimulate research.

Journey of SETS

As the digital world has expanded, cybersecurity vulnerabilities and attack vectors have also increased simultaneously. The expansion of Cyber-Physical Systems has led to a parallel rise in security challenges, including new threats and vulnerabilities. The increasing reliance on interconnected devices and services in domains like e-commerce, e-learning, e-governance, and e-health has added to the risks. This era of rapid digitisation and advancement in Cyber-Physical Systems brings both significant opportunities and associated security concerns.

Acknowledging the potential vulnerabilities, OPSA established the Society for Electronic Transactions and Security (SETS) with a core focus on cybersecurity, particularly in cryptography and hardware security. SETS is registered as a non-profit society under the Societies Act of 1860. It was formally registered in May 2002. The idea to form a specialised organisation in information security was conceived by Dr. A.P.J. Abdul Kalam, implemented by Dr. R. Chidambaram through OPSA, further guided by Prof. K. VijayRaghavan and is now being scaled up by Prof. Ajay Kumar Sood.

SETS was envisioned as an important R&D organisation in Information Security. Its mission was to focus on advancing research in cryptology and secure protocols; develop security prototypes; enable collaboration between academia and government for product-oriented innovation; and offer cybersecurity consultancy and training for critical sectors.

The objective of SETS is to act as a bridge between fundamental research and practical solutions, translating laboratory innovations into real-world applications in data security and analysis. Beyond R&D, SETS also serves as a link between academia, industry and government, enabling product development through joint initiatives.

CONTRIBUTOR

Dr. N. Subramanian
Executive Director,
SETS

Cybersecurity R&D at SETS

SETS's focus areas of R&D are currently centered around Cryptology & Computing, Hardware Security, Quantum Security, and Network Security. To support its extensive R&D programs, the organisation has built a suite of state-of-the-art facilities.

Cutting-Edge Labs & Facilities

- An Advanced Facility for Information Security and Cryptology (AFISC) – A Centre of Excellence in the field of Information Security and Cryptology.
- Side Channel and Fault Analysis Lab for carrying out the evaluation of implementation robustness of cryptographic algorithm and AI architectures in hardware.
- Hardware Testing Facility lab for carrying out security testing.
- Metro Area Quantum Access Network (MAQAN) testbed for secure quantum communication .
- Cyber Defense Lab for Threat-hunting and Incident response activities.
- Supercomputing facility called PARAM Spoorthi under the National Supercomputing Mission (NSM) for Cryptographic research.

PARAM Spoorthi Supercomputing Facility under NSM in SETS Facility

Highlights of Ongoing-R&D

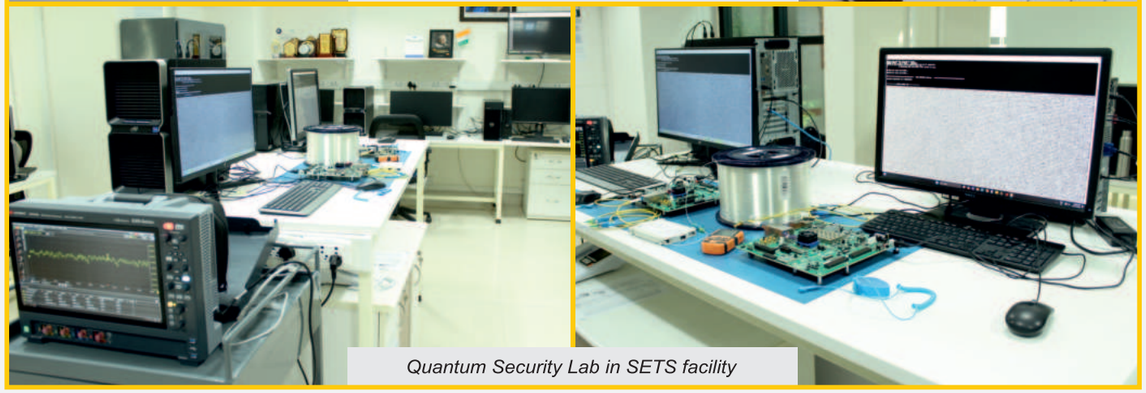
Cryptology & Computing: Development of Post Quantum Cryptography Solutions for secure boot in RISC-V Processor, enterprise PKI, secure IoTs for smart cities and for permissioned Blockchain framework. Leveraging Artificial Intelligence for early detection of ransomware, Side channel analysis, and malware analysis.

Hardware Security: Established Hardware testing & evaluation facility and evolving mechanisms for testing and validation of crypto systems.

Quantum Security: Established Metro Area Quantum Access Network (MAQAN) and developed novel post processing techniques for Quantum Key Distribution (QKD) & Key Distillation Engine for secure communication. Developed Quantum Random Number Generator and offered QRNG as service as a proof-of-concept.

Network Security: Development and deployment of Light-weight Virtual Private Network (VPN) for strategic agencies and development of Threat-Hunting & Incident Response and IoT Security & Sandbox solutions.

Hardware Security Lab in SETS facility



Quantum Security Lab in SETS facility

Contributions to National Missions

SETS in collaboration with academia and R&D labs is also contributing to key national missions towards development of indigenous technologies:

National Quantum Mission (NQM)

- NQM Communications Thematic Hub: Lead by IIT Madras, SETS along with other collaborating agencies are contributing towards development and deployment of Quantum Internet with Local Access (QuILA).

- NQM Computing Thematic Hub: Lead by IISc Bangalore, SETS along with other collaborating agencies are contributing towards Programmable Photonic Quantum Computing using polarisation and path encoded Qubits.

National Supercomputing Mission (NSM)

SETS along with other collaborators is contributing to the AI for Cybersecurity initiative under the NSM.

Knowledge Dissemination

SETS is engaged in Knowledge dissemination activities to share its R&D outcome with industry, academia, and government agencies through workshops, conferences and hands-on training programmes.

SETS along with the Institute of Mathematical Sciences, Chennai Mathematical Institute and Anna University organised the 25th edition of the INDOCRYPT during December, 2024. This brought leading cryptographers from across the globe, industry, government agencies, and researchers & students for brainstorming on recent developments in the field and presentation of ongoing works.

INDOCRYPT 2024 International Conference

National Level Roadmap

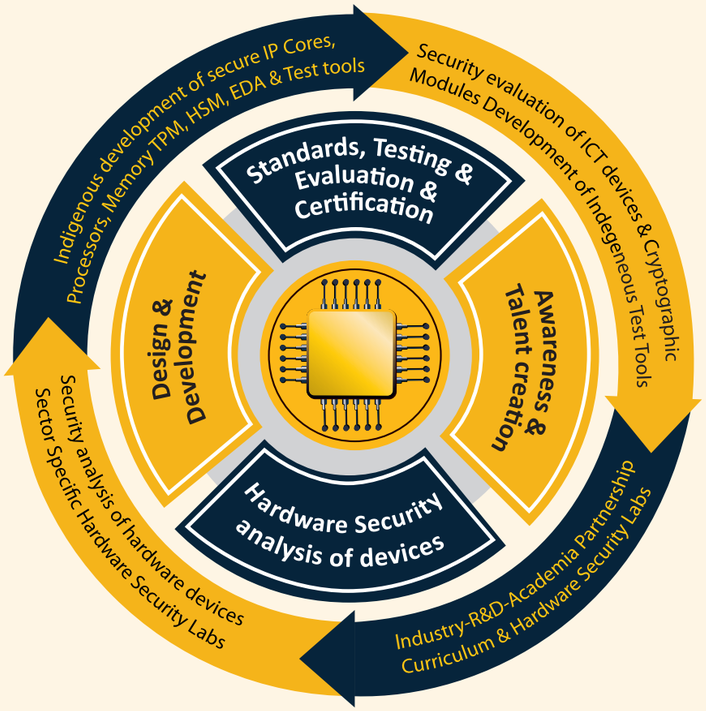
Based on the guidance from the PSA, SETS has prepared the roadmap for (a) Transition to Post Quantum Cryptography and (b) Hardware Security.

Transition to Post Quantum Cryptography (PQC)

SETS along with Controller of Certifying Authorities (CCA), MeitY under the guidance of the PSA have jointly prepared a roadmap. The roadmap brings out the approach towards research in PQC, PQC enabled application, Protocol systems & libraries, Crypto-agility, R&D PoC implementation, Hybrid / Pure PQC approaches, Awareness and capacity development.

Hardware Security

Under the guidance of the PSA, National Roadmap for Hardware Security is prepared by SETS involving an expert committee from R&D organisations (Meity, BEL) and academic institutions (IIT Madras, IIT Bombay, IIT Kharagpur) and by conducting stakeholder consultative workshop and closed group workshop with strategic agencies.



As digitalisation rapidly expands across all sectors, cybersecurity has become essential for ensuring trust and reliability in computing environments. The role of SETS continues to remain crucial to address these emerging cybersecurity challenges while driving research and innovation.

Charting India's Future in Mega Science:

The Mega Science Vision-2035

Large Hadron Collider (LHC) at CERN; source - BBC Science Focus

CONTRIBUTOR

Dr. Praveer Asthana
PSA Fellow

Over the past few decades, India has emerged as a committed participant in some of the most ambitious mega science endeavors around the world. From contributing to the Large Hadron Collider (LHC) at CERN to developing cutting-edge astronomy observatories like the Thirty Meter Telescope (TMT), India's involvement in Mega Science Projects (MSPs) signals its resolve to stay at the forefront of scientific discovery.

MSPs are large-scale, complex, and long-term scientific initiatives that typically span multiple decades, from conceptualisation and construction to operation and exploitation. These projects aim to tackle some of the most profound questions in science, whether it's probing the fundamental nature of matter, understanding the origins of the universe, or addressing the pressing challenges of climate change and environmental sustainability.

By their very nature, MSPs require massive financial investments, cutting-edge technology, and multidisciplinary expertise. They also demand extensive coordination among scientists, engineers, policy-makers, industry partners, and often, governments. Due to their scale and cost, no single institution or country can execute an MSP in isolation. These projects thus serve as global scientific ventures, promoting cooperation across borders.

India has actively recognised the value of these collaborations and has, over the years, supported both indigenous projects and international partnerships. However, selecting which projects to support, and aligning them with national priorities, requires foresight, strategy, and consensus. OPSA took up shaping India's participation in mega sciences as a key initiative and established the Mega Science Vision -2035 (MSV-2035) Exercise. In the Indian context, by 2020, many of the MSPs identified in earlier vision exercises had moved closer to realisation. This progression, coupled with the evolution of scientific frontiers and a more ambitious Indian scientific community, made it necessary to launch a new, more inclusive, and structured exercise. Given the OPSA's overarching role in science-policy interface and inter-agency coordination, this move helped bring in a broader perspective and facilitate synergies across disciplines and institutions.

The Mega Science Vision (MSV) Exercises

India's plans for setting up national, as well as participating in international MSPs have always been made after careful nation-wide consultations. These consultations have come to be known as Mega Science Vision (MSV) Exercises. The latest MSV-2035 Exercise is being undertaken by OPSA in six areas:

High Energy Physics	Nuclear Physics
Astronomy & Astrophysics	Accelerator Science & Technology and Applications
Climate Research	Ecology & Environmental Science

The Year 2035 has been chosen keeping in view the timelines of similar exercises undertaken elsewhere in the world and the expected timeframe for establishment and utilisation of various national and international facilities at the present time. The MSV-2035 Exercise will result in Roadmap Documents in the six areas after widespread national stakeholder consultations. These exercises bring together stakeholders from across scientific domains to evaluate emerging opportunities, assess India's readiness, and formulate long-term roadmaps.

Scientific Institutions like the Department of Atomic Energy (DAE), the Department of Science and Technology (DST), and the Department of Space (DOS), etc. play pivotal roles in steering the MSV Exercises, especially in disciplines like high energy physics, nuclear physics, and accelerator science and they continue to do so. Similarly, the Astronomical Society of India has periodically conducted consultative efforts in the domain of astronomy and astrophysics.

Each domain under MSV-2035 will produce a detailed Roadmap Document outlining:

- Priority scientific questions for the next decade and beyond
- Existing and emerging global MSPs relevant to India
- India's current capabilities and readiness in these domains
- Required infrastructure, partnerships, and institutional mechanisms
- Recommendations for participation, leadership, or initiation of MSPs

The exercise has involved extensive consultations with national and international stakeholders, including scientific institutions, industry representatives, funding bodies, and government departments. The goal is to ensure that the outcomes are aligned not only with India's scientific aspirations but also with broader national goals in innovation, diplomacy, and sustainability.

One of the turning points in India's MSP journey was its involvement in CERN. This partnership not only demonstrated India's scientific and technological capabilities but also boosted the confidence of the Indian research ecosystem to engage with similarly large and complex international projects. Since then, India has ramped up participation in numerous projects, including the Square Kilometre Array (SKA), the Laser Interferometer Gravitational-Wave Observatory (LIGO), and FAIR (Facility for Antiproton and Ion Research), among others.

Recently, India also celebrated the 2025 Breakthrough Prize in Fundamental Physics awarded to the co-authors of publications based on CERN's LHC Run-2 data released between 2015 and July 15, 2024. It comes from the experimental collaborations of ATLAS (A Toroidal LHC Apparatus), CMS (Compact Muon Spectrometer), ALICE (A Large Ion Collider Experiment) and LHCb (Large Hadron Collider beauty experiment). From detector development to data analysis, various Indian researchers have been involved in every stage of the experiments. India's involvement spanned across layers of the LHC program, from accelerator technology to major physics experiments. Indian scientists and institutions are also represented on prominent CERN boards and committees,

including Research and Resources Board (RRB), Advisory Committee of CERN Users (ACCU) and the Scientific Council.

Mega Science Projects are more than just scientific enterprises, they are nation-building exercises aimed to foster technological ecosystems, and inspire innovation with far-reaching societal impacts. The MSV-2035 roadmap, once finalised, is expected to provide a coherent strategy for India's investments and collaborations in this domain over the next decade. Under MSV-2035 Exercise, three Mega Science Vision Reports have been completed (in Astronomy & Astrophysics; Nuclear Physics; Accelerator S&T and Applications).

As India deepens its engagement with global science, the MSV-2035 exercise reaffirms India's commitment to contributing meaningfully to humanity's collective scientific endeavor, while ensuring that the benefits of these efforts cascade into national development.

Accelerating Electric Mobility:
India's EV Mission

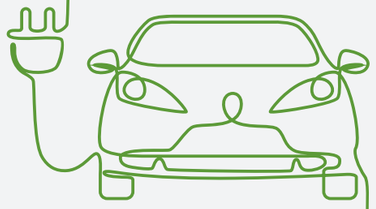
The global push towards sustainable development has placed electric vehicles (EVs) at the centre of transformative shifts in mobility. EVs not only offer a path to decarbonise the transport sector but also reduce dependence on fossil fuels, improve air quality, and support energy security. In India, the push for electric mobility has gained momentum through a series of missions and policies that aim to accelerate adoption, enhance manufacturing, and foster innovation. A key part of this journey is the Electric Vehicle (EV) Mission, steered by the Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC), with the active facilitation of OPSA.

The EV Mission was formally approved at the first meeting of PM-STIAC on October 9, 2018. It is a critical step towards reducing fossil fuel consumption and emissions by enabling the economic production of electric vehicles in India. The mission focuses on developing vehicle sub-systems and components that meet India-specific requirements to make EV adoption both viable and scalable. OPSA has supported this initiative by facilitating multi-stakeholder consultations, forming the Consultative Group on Future Technology (CGFT), and driving efforts on standardisation. The final CGFT report was concluded on September 16, 2021.

Aligned with India's ambitious goal of achieving 30% EV penetration by 2030 and the broader vision of a developed India (Viksit Bharat) by 2047, the OPSA constituted the Core Group on e-Mobility (CGeM) on August 12, 2022. Chaired by Prof. Ajay K. Sood, PSA to the Government of India, CGeM is a panel of experts from government, academia, and industry. It has developed several Technical Roadmaps (TRMs) and policy advisories that chart the course for zero-emission transport (ZET) in the country.

These include:

- TRM versions V1 and V2, focusing on exploratory research and pilot ZET deployments
- An R&D roadmap on surface transportation and e-mobility
- The Bharat Zero Emission Trucking Policy Advisory



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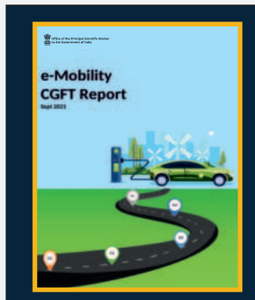

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- Prof. Karthick Athmanathan
Honorary PSA Fellow

There is a lot of ground that is yet to be covered to enable eMobility in India. We have done good work so far- we can do better and more- and need to do all that as we go forward. The Office of PSA has offered superb support to focus on work that is required for the long term- for eMobility in general and for Zero Emission Trucking in particular- after all, we use nearly 40% of imported fuel for trucking. We have been able to bring in experts, think and debate on different topics, formulate action plans and are now executing almost all of them- be it in eMobility R&D or in Zero Emission Truckin Policy or Technical actions. And the support from other Ministries and Industry has also been good for these initiatives. I am sure we will continue to hear more news from this Office on the topic of eMobility.

Additionally, a comparative study of ZET technologies was carried out along the Delhi–Jaipur corridor in collaboration with Rocky Mountain Institute (RMI) as a knowledge partner. This study evaluated the costs and operational dynamics of various ZET options and will inform technology selection and infrastructure development for scaled ZET deployment in India.

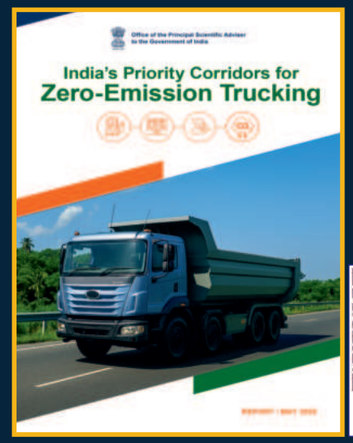
Further, recognising that India's automobile market is still largely dominated by fossil fuel-powered vehicles, the government has set up ambitious targets and created National missions and programs to ensure that electric mobility becomes the mainstream mode of transport. The National Electric Mobility Plan (NEMMP) 2020 envisioned 6–7 million annual sales of hybrid and electric vehicles starting in 2020. In addition, the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) - II scheme and the Production Linked Incentive (PLI) scheme for Advanced Chemistry Cells provide incentives to the customers for purchasing electric vehicles, and incentives to the manufacturers for manufacturing electric vehicles, batteries, and storage systems. The Green Hydrogen Mission also complements this effort by supporting fuel cell manufacturing to promote the use of green hydrogen in the transport sector.

Building on this foundation, the Government of India also launched the PM-Electric Drive Vehicle Incentive and Ecosystem (PM-EDRIVE) scheme on March 13, 2024. This initiative focuses on catalysing EV adoption, including high-impact segments like e-buses and e-trucks. It seeks to overcome residual barriers by offering targeted incentives, strengthening domestic manufacturing capacity, and promoting localised innovation throughout the electric mobility value chain.

In alignment with the PM-E-DRIVE scheme, the CGeM was reconstituted on April 23, 2025 to initiate the next phase of action. As outlined in the TRMs, an extensive evaluation of over 100 short-haul freight corridors across India was undertaken to assess their readiness for e-truck deployment. The top 10 corridors were identified based on technical, commercial, and operational criteria, and a comprehensive report was released on May 9, 2025 to guide stakeholders in accelerating the transition to zero-emission freight transport.

Furthermore, an e-Truck Adoption Projections report is currently under preparation. This document will support stakeholders, including OEMs, financiers, operators, and government bodies, in ecosystem planning and decision-making for e-truck deployment at scale.

Through decisive initiatives, robust policy frameworks, and expert-driven roadmaps, OPSA continues to play a central role in shaping India's electric mobility ecosystem. With strong inter-ministerial collaboration, stakeholder engagement, and research leadership, the EV Mission holds promise to not only meet the country's decarbonisation goals but also drive innovation, manufacturing, and sustainable economic growth.



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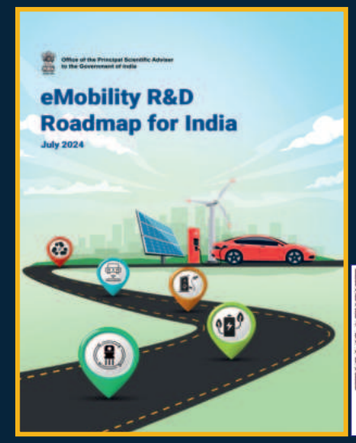

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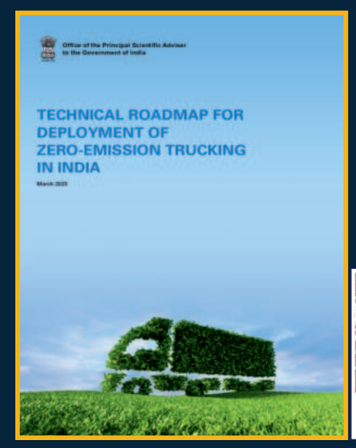

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India's Quantum Leap:
To be among the Global Leaders in Quantum Technology

CONTRIBUTOR

Dr. Praveer Asthana
PSA Fellow

Quantum Technology is the next technology frontier. Starting with the birth of Quantum Mechanics, the scientific and technological developments over the past 100 years or so have brought us to a stage where we can engineer quantum systems per se. And it is the engineering exploitation of quantum systems that Quantum Technology is all about. From exponentially fast computers to secure communications to extremely sensitive sensors – human civilisation is at the cusp of seeing revolutionary technologies emanating from the behaviour of such quantum systems. This turning point is so important in the development of this emerging field that the United Nations has declared 2025 as the International Year of Quantum Science and Technology (IYQ).

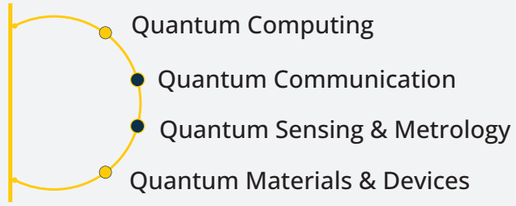
Given the wide-ranging and profound potential of Quantum Technology, and the extremely fast pace of global developments, it became imperative for a scientifically-mature nation and an emerging global economy like India to take quick and concrete steps towards becoming a leading nation in this domain to ensure its strategic autonomy.

And, India did not lose time in latching on to these momentous changes on the technological scene. In many ways, the advent of Quantum Technology happened at a right time for India. The Government of India had been promoting research & development (R&D) in a number of relevant areas like condensed matter physics, low temperature physics, nano science and technology, etc. for over three decades when Quantum Technology emerged. We already had a decent number of researchers, and relevant scientific infrastructure at a number of places, to undertake Quantum R&D. The Department of Science & Technology (DST) quickly supported projects under its National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) and the Quantum Enabled Science & Technology (QuEST) programme, and other agencies like Ministry of Electronics and Information Technology (MeitY), Department of Atomic Energy (DAE), Department of Space (DOS), Defence Research and Development Organisation (DRDO), etc. also launched sector-specific R&D programmes. At this stage, the PM-STIAC also identified the National Quantum Mission (NQM) as one of the missions of national importance, to be launched to give a significant boost to R&D in this critical area.

The NQM was accordingly launched with the approval of the Union Cabinet on April 19, 2023. Spanning eight years (2023–31), the Mission makes a globally competitive investment of INR 6,003.65 crore to position India among the leaders in the quantum era.

Led by the DST and guided by the advice of OPSA, NQM is designed to accelerate research, foster indigenous innovation, and translate scientific breakthroughs into real-world applications. Collaboration across ministries has been built into the very structure of NQM. DRDO, DOS, DAE are all partners, in close collaboration with MeitY and Department of Telecommunications (DoT).

The activities of the NQM have been distributed in the four broad verticals of Quantum Technology:



NQM is not a typical capacity-building programme. It has clear deliverables, arrived at after extensive stakeholder consultations and careful assessment of the national strengths and capability gaps. The deliverables are:

- Develop intermediate scale quantum computers with 20-50 physical qubits (3 years), 50-100 physical qubits (5 years) and 50-1000 physical qubits (8 years) in various platforms like superconducting and photonic technology.
- Develop satellite based secure quantum communications between two ground stations over a range of 2000 kilometres within India as well as long distance secure quantum communications with other countries.
- Inter-city quantum key distribution over 2000 km with trusted nodes using wavelength division multiplexing on existing optical fibre.
- Multi-node quantum network with quantum memories, entanglement swapping and synchronised quantum repeaters at each node (2-3 nodes).
- Develop magnetometers with 1 femto-Tesla/sqrt(Hz) sensitivity in atomic systems and better than 1 pico-Tesla/sqrt(Hz) sensitivity in Nitrogen Vacancy-centers; Gravity measurements having sensitivity better than 100 nano-meter/second2 using atoms and Atomic Clocks with 10^{-19} fractional instability for precision timing, communications and navigation.
- Design and synthesis of quantum materials such as superconductors, novel semiconductor structures and topological materials for fabrication of quantum devices for development of qubits for quantum computing and quantum communication applications, single photon sources/detectors, entangled photon sources for quantum communications, sensing and metrological applications.

Since its launch, the NQM has made significant progress. Four Thematic Hubs (T-Hubs) have been established in leading institutions:

T-Hub on **Quantum Computing** at the Indian Institute of Science (IISc), Bengaluru

T-Hub on **Quantum Communication** at IIT-Madras and C-DOT, New Delhi

T-Hub on **Quantum Sensing and Metrology** at IIT-Bombay

T-Hub on **Quantum Materials and Devices** at IIT-Delhi

These hubs operate under a "Hub-Spoke-Spike" model, and connect with other leading academic and research institutions. 17 multidisciplinary Technical Groups will work cohesively as part of these T-Hubs to deliver the identified goals of the Mission. These bring together a total of 152 researchers from 43 institutions. Collaboration among multi-disciplinary and multi-institutional teams has been ensured from the very beginning. Building human resource capacity, promoting

industry collaboration, as well as strengthening international partnerships, all form part of the activities of the T-Hubs without losing sight of the time-bound deliverables of the Mission.

NQM is also assisting in the growth of Quantum Startups in the country. It has extended financial support to 8 startups after careful evaluation. Some of these startups such as QNu Labs and QpiAI are showing early signs of commercial success and noteworthy market visibility.

To address the critical need for skilled professionals, the NQM has designed courseware for engineering students that will be adopted through AICTE. To guard the security of our massive digital systems in the emerging quantum era, the NQM has also developed a "Concept paper on Quantum Safe Ecosystem in India", outlining the steps required for navigating the transition to a quantum-resistant future.

The OPSA played a valuable role in the conceptualisation, formulation and approval of NQM. With PSA as a member of the NQM Governing Board and the chair of the NQM-Mission Technology Research Council, OPSA continues to facilitate its implementation.

On the international cooperation front, the OPSA is playing the lead role from India in bilateral or multilateral governmental engagements such as the Indo-US-TRUST (erstwhile Indo-US-iCET) and QUAD. Under the Indo-US umbrella, the SN Bose National Centre for Basic Sciences, Kolkata has joined as a member of the Quantum Economic Development Consortium (QED-C), and India has joined the (Quantum) Entanglement Exchange, at the advice of OPSA. An Indo-US Workshop was also organised at UCLA (University of California, Los Angeles) in September 2024. Under Quad, a Quad Investors Network (QUIN) was created that brings together investors, corporations, and public institutions across Australia, India, Japan, and the US. QUIN has formed a Centre of Excellence in Quantum Information Sciences (QUIN CoE) with PSA as the co-Chair from India. As a first step, the CoE has come up with a report titled "Quantum Science & Technology in the QUAD Nations-Landscape and Opportunities" in July 2024. It has been disseminated further for possible follow-up actions.

Further, OPSA has also brought out a report titled "International Technology Engagement Strategy-Quantum (ITES-Q)" in April 2025. It summarises the status and evolving horizons in Quantum Technology globally and in India, based on available data. This report is intended to be useful, especially when looking for strategies and avenues for bilateral cooperation.

It is India's resolve to remain among the leading nations to harness quantum's transformative potential, become a key contributor to the worldwide quantum revolution, and at the same time, leverage its enormous potential for advancing the nation's developmental ambitions.

India's National AI Mission,
Empowering 'AI for All'

Artificial Intelligence (AI) offers transformative opportunities to complement human intelligence and enhance how we live and work. With its vast and growing range of applications, AI and machine learning are now deeply embedded in nearly every facet of modern technology.

India has been proactive in recognising the potential of AI and is actively advancing its development across key sectors such as healthcare, finance, education, and beyond. The country has placed a strong emphasis on research and innovation in AI, backed by critical government initiatives. In 2018, the Government of India launched the National Strategy for Artificial Intelligence, focusing on sector-specific applications and laying the foundation for AI-led transformation. In October 2018, AI was also identified as one of the missions in the PM-STIAC meeting.

Building on this momentum, a draft for Responsible AI was introduced in 2021, outlining voluntary guidelines to ensure ethical deployment of AI. These guidelines emphasise transparency, accountability, and fairness, reaffirming the government's commitment to harness AI in an inclusive and equitable manner, embodied in the guiding principle of AI for All.

Taking it further, the INDIAai Mission, a national initiative to develop a robust and inclusive AI ecosystem, was introduced. The Cabinet approved the IndiaAI Mission on 7th March 2024. The mission aims to harness AI's transformative potential across sectors and democratise access to computational resources, improve data quality, foster indigenous AI capabilities, attract top talent, support startups through risk capital, encourage industry collaboration, promote socially impactful AI projects, and ensure ethical AI development and use.

The IndiaAI Mission (with an outlay of over INR 10,000 Crore), is structured around seven foundational pillars:

01 IndiaAI Compute Capacity:

Establishing a robust AI infrastructure with over 10,000 GPUs through public-private partnerships to provide AI services and resources.

02 IndiaAI Innovation Centre:

Focusing on the development and deployment of indigenous large multimodal models and domain-specific foundational models.

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03 IndiaAI Datasets Platform:

Streamlining access to high-quality non-personal datasets to spur AI innovation.

04 IndiaAI Application Development Initiative:

Promoting the development and scaling of impactful AI solutions for socio-economic transformation.

05 IndiaAI FutureSkills:

Expanding AI education across academic levels and setting up Data and AI Labs in Tier 2 and 3 cities to nurture talent.

06 IndiaAI Startup Financing:

Accelerating deep-tech AI startups by facilitating access to funding for innovative projects.

07 Safe & Trusted AI:

Ensuring responsible AI development and deployment through indigenous tools, frameworks, and governance structures.

An Advisory Group, chaired by the Principal Scientific Adviser (PSA), is also shaping a robust ethical AI framework for India. The draft AI Governance Guidelines outline a hybrid, lifecycle-based, whole-of- government approach that includes incident reporting mechanisms and embedded regulatory responsibilities, overseen by an inter-ministerial committee. These efforts support the vision of Sovereign AI, ensuring that intellectual property and sensitive data remain within national boundaries while developing AI solutions tailored to India's specific needs. The national advisory committee aims to develop actual policy guidelines to operationalise and ensure the responsible and safe deployment of AI across the country.

India's AI Mission is as much about fostering social equity, linguistic diversity, startup innovation, and global collaboration as it is about technological advancement. OPSA is playing a key role in international AI ethics discussions as well. In partnership with the Indian Institute of Science (IISc), Ministry of Electronics and Information Technology (MeitY), OPSA has organised high-level AI policy roundtables, convening senior policymakers, researchers, and leaders in innovation.

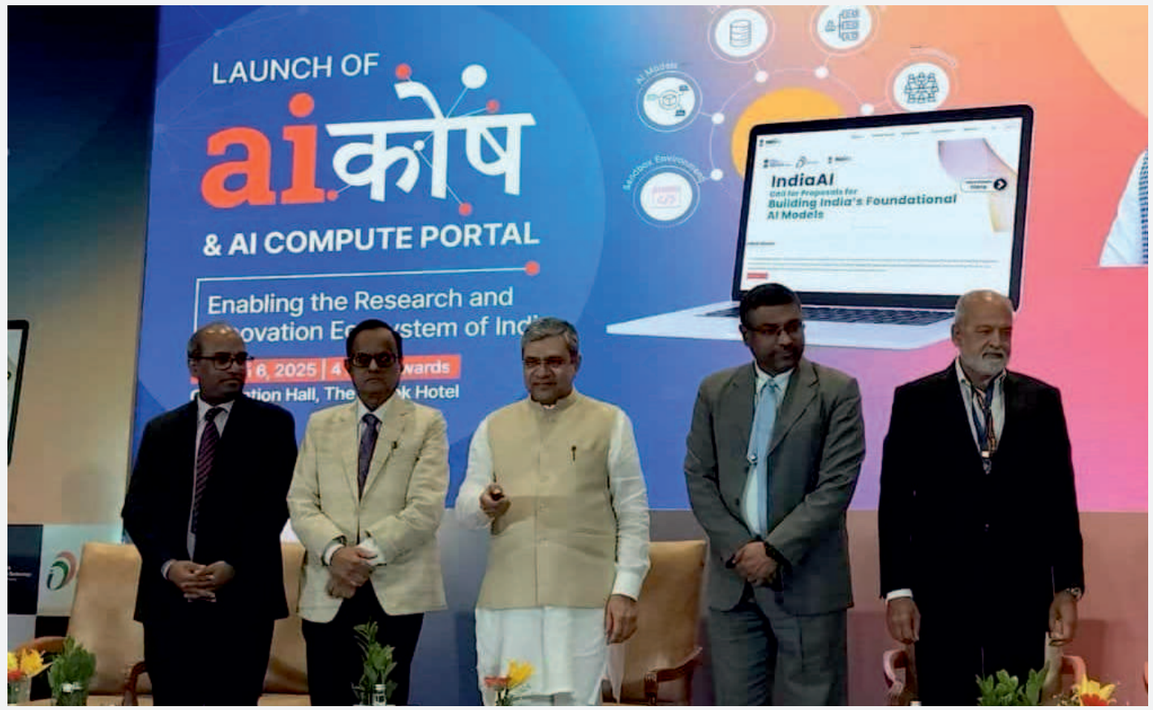
The Mission also features initiatives like the AI Competency Framework for public sector officials, the IndiaAI Startups Global Acceleration Program, and the IndiaAI FutureSkills initiative to expand AI education and talent development across the country. The IndiaAI Mission is focused on developing and deploying indigenous foundational models to reduce reliance on foreign technologies and data, the expansion of compute capacity and the emphasis on ethical, inclusive, and safe AI practices, contributing to not just tech but also large-scale socio-economic transformation.

The IndiaAI Mission has accelerated its momentum with several advances. The Mission launched AIKosh, a national platform featuring over 300 high-quality datasets, more than 80 fine-tuned AI models, and sandbox environments with APIs and tutorials. As a secure platform, AIKosha offers a repository of datasets, models, and AI sandbox capabilities for researchers, startups, and enterprises.

In April 2025, Sarvam AI was selected to build India's first sovereign large language model (LLM), backed by approximately 4,000 GPUs from the compute pool. This was quickly followed by the inclusion of Soket AI, Gnani.ai, and Gan.ai to develop multilingual LLMs tailored to Indian needs. On May 30, 2025, MeitY announced the expansion of the national AI compute pool to 34,333 GPUs (up from 18,400) through Public-Private Partnerships. This democratises access to high-performance computing resources for innovation and research. In October 2024, Meity had selected 8 responsible AI projects focusing on AI safety tools and benchmarks, out of which four are slated for deployment on AI Kosh by December 2025.

Meanwhile, the Digital India Bhashini initiative reported 67 proposals (including 22 for LLMs/LMMs and 45 for domain-specific models) by mid-February 2025, advancing AI translation across 22 scheduled languages.

AI is no longer a distant possibility; it is a transformative force reshaping governance, economies, and public services worldwide. Through missions like IndiaAI Mission, the nation's approach is set on building a future that is responsible, inclusive, self-reliant, and globally respected.



Launch of AI Kosh under India AI Mission

Unlocking the Blue Economy

India's Deep Ocean Mission for Pioneering Underwater Exploration

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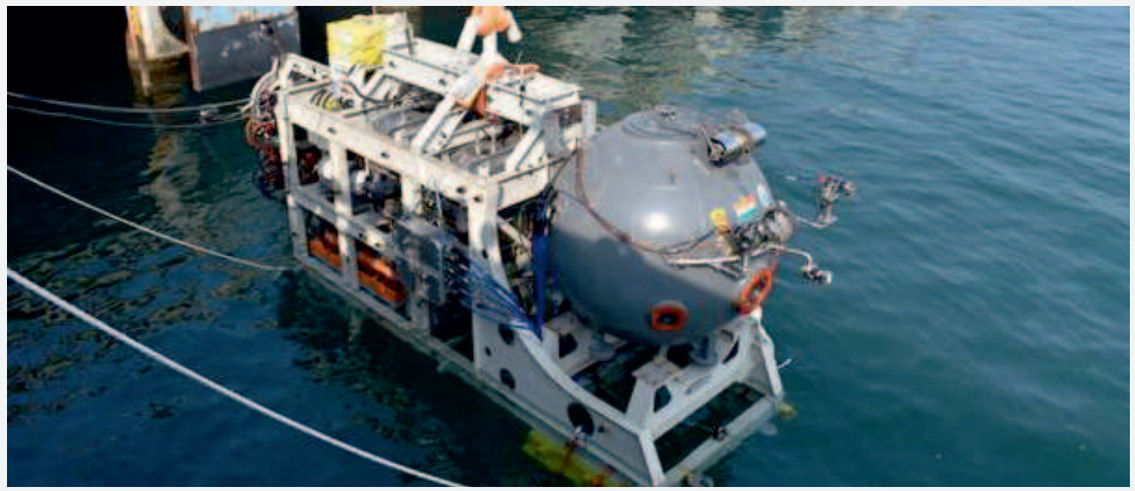
Oceans, covering 70 per cent of the globe, are a vital part of our lives. Remarkably, about 95 per cent of the deep ocean remains unexplored. India's unique maritime position features 11,098 kilometres (km) of coastline spanning nine coastal states and 1,382 islands. For India, with three sides bordered by the sea, roughly 30 per cent of its population residing in coastal regions, and its Exclusive Economic Zone (EEZ) of 2.37 million square km presents the ocean as a major economic driver, which supports fisheries, aquaculture, tourism, livelihoods, and blue trade. Oceans also serve as reservoirs of food, energy, minerals, and medicines, act as regulators of weather and climate, and are fundamental to life on Earth. Recognising the oceans' importance for sustainability, the United Nations (UN) has declared 2021–2030 as the Decade of Ocean Science for Sustainable Development.

The Government of India's Vision of New India by 2030, articulated in February 2019, also identified the Blue Economy as one of the ten core dimensions of growth. To explore the deep ocean for resources and develop deep-sea technologies for sustainable use, the Cabinet Committee on Economic Affairs (CCEA) approved the Ministry of Earth Sciences' (MoES) proposal for the Deep Ocean Mission (DOM).

The DOM under PM-STIAC will operate as a mission-mode project to support the Government of India's Blue Economy initiatives, with MoES serving as the nodal ministry for this ambitious, multi-institutional effort. The mission, with an estimated cost of INR 4,077 crore over five years, will be implemented in two phases. The first phase (2021–2024) is budgeted at INR 2,823.4 crore.



Matsya 6000; an Indian crewed deep-submergence vehicle intended to be utilised for deep-sea exploration

The Deep Ocean Mission comprises the following major components:

Development of Technologies for Deep Sea Mining and Manned Submersible:

A manned submersible will be developed to transport three people to depths of 6,000 meters in the ocean, equipped with a suite of scientific sensors and tools. An integrated mining system will also be developed for extracting polymetallic nodules from the central Indian Ocean basin. Mineral exploration studies will pave the way for potential commercial utilisation, once the International Seabed Authority, a UN organisation, establishes the 'Mining Code'. This component supports the Blue Economy priority area of exploring and harnessing deep-sea minerals and energy.

Development of Ocean Climate Change Advisory Services:

A suite of observations and models will be developed to understand and provide future projections of important climate variables on seasonal to decadal time scales under this proof-of-concept component. Coastal Vulnerability maps at a 1:25000 scale have been developed, and deep ocean observation systems comprising 50 Argo floats, 57 wave drifters, and 11 glider missions have been deployed in the Bay of Bengal and the Arabian Sea. This component will support the Blue Economy as a priority area of coastal tourism.

Technological Innovations for Exploration and Conservation of Deep-Sea Biodiversity:

The main focus will be on isolating and characterising deep-sea flora and fauna for bioprospecting industrially useful molecules ensuring their sustainable use. This supports the Blue Economy priority area of marine fisheries and allied services.

Deep Ocean Survey and Exploration:

The primary objective is to explore and identify potential sites of multi-metal hydrothermal sulphide mineralisation along the Indian Ocean mid-oceanic ridges. An indigenous all-weather multi-purpose ship is being commissioned. This component will also support the Blue Economy priority area of deep-sea exploration of ocean resources.

Energy and Freshwater from the Ocean:

This proof-of-concept proposal includes studies and detailed engineering design for offshore Ocean Thermal Energy Conversion (OTEC) powered desalination plants. It supports the Blue Economy as a priority area of offshore energy development.

Advanced Marine Station for Ocean Biology:

This component aims to develop human capacity and enterprise in ocean biology and engineering. It will translate research into industrial applications and product development through on-site business incubator facilities. An Advanced Marine Station for Ocean Biology is being set up in Nemmeli, Tamil Nadu, supporting the Blue Economy priority areas of marine biology, blue trade, and blue manufacturing.

Under the Samudrayaan project of Deep Ocean Mission, the MATSYA-6000 manned submersible design and integration have been completed, and successful wet harbour trials were conducted in Katupalli near Chennai in 2025. Under the Mission, a Deepwater Autonomous Underwater Vehicle (AUV), namely Ocean Mineral Explorer (OMe 6000), has been deployed for exploration. Demonstration of deep-sea extraction of polymetallic nodules from 1000m depth was completed in the Andaman Sea in 2025. About 14 sq km area has been surveyed with all scientific payloads to generate high-resolution seabed features to understand and validate the resource potential at exploration sites.

In January 2025, the successful trials of India's first human underwater submersible (Deep-Sea Manned Vehicle) were announced as a step towards strengthening the commitments to the Blue Economy. The initial submersible will operate at a depth of up to 500 meters, with a subsequent goal of reaching a staggering depth of 6,000 meters by 2027. The entire initiative is based on indigenous technology, showcasing the nation's self-reliance in cutting-edge science. The mission also aims to enhance understanding of deep-sea ecosystems, contributing to sustainable fisheries and biodiversity conservation. By tapping into these underwater treasures, India is poised to secure long-term benefits for its economy, scientific community, and environmental resilience.

Successful high-resolution deep-sea imaging of hydrothermal sulphide fields at 4500m depth along the Central & SW Indian Ridges was carried out by National Institute of Ocean Technology (NIOT) & National Centre for Polar and Ocean Research (NCPOR) scientists.

The initiatives and missions mentioned above are unified by their role in advancing India's technological sovereignty, socio-economic resilience, and the approach to lead with science. They reflect India's commitment to leveraging science and innovation as pillars of national development, guided and facilitated by the OPSA under PM-STIAC. India's technological and socio-economic advancement is linked to the thoughtful integration of science advice into national policy. From strengthening research connectivity through the NKN, to pioneering cyber security with SETS, launching Mega Science Projects, driving sustainable mobility via the EV Mission, and advancing technological frontiers in quantum, AI, and deep ocean exploration, each initiative underlines a commitment to excellence in Science, Technology & Innovation as well as socio-economic progress. While this article spotlights some key missions, India's portfolio of transformative projects expands beyond these, including the likes of National One Health Mission (that has been covered further in the magazine), National Language Translation Mission, Advanced Ultra Supercritical technology, and many more. Over the years, these have been examples where science advice through OPSA has either initiated, led, facilitated or supported these transformative missions towards solving societal concerns. These flagship endeavours demonstrate how science advice, when institutionalised and action-oriented, becomes an asset for national development. As India navigates a pivotal decade in its transformation towards Viksit Bharat @2047, the integration of scientific thinking into governance is essential and OPSA's journey stands as a historic proof that when science leads, progress follows.

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Science Advice in Action:

Advancing the National One Health Mission

"*The difference between species is one of degree and not of kind*" is a profound insight by Charles Darwin. This observation reframes the way we understand life, not as a discrete hierarchy but as a continuum where viruses to humans are connected through small variations.

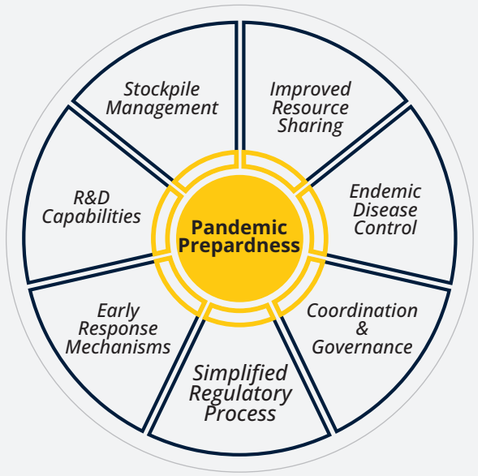
This recognition, that life is interconnected, dynamic, and intricately woven, is not just an important thought but has implications for our everyday living.

The One Health Approach

Ancient civilisations intuitively grasped this interconnectedness. Communities thrived in alignment with the rhythms of their environment; understanding that human health, animal welfare, and environmental balance co-exist. However, industrialisation and urbanisation have brought in a drastic change to how we live and how we interact with our broader surroundings, which by itself has undergone disruption. The need to restore not just the holistic view, but a pragmatic way to implement it in our actions has never been more urgent, and that is the essense of One Health approach .

Building Synergies for Integrated Health

While the concept itself is profound and timely, there is a need to put it to work through policies and practices. To put a pragmatic structure and application to this concept of 'One Health', the Office of the Principal Scientific Adviser to the Government of India (OPSA) convened a high-level PM-STIAC meeting on July 7, 2022. It brought together diverse stakeholders across human, livestock, wildlife sectors to set up the National One Health Mission (NOHM) as a response to PM's call on 'One Earth, One Health' (which presciently predates Covid pandemic) as well as the emerging need for creating an ecosystem around it. Various One Health related initiatives were being undertaken across various Government of India ministries, private sector organisations, and global platforms. This cross-ministerial initiative's aim was to unify, support, and streamline ongoing One Health efforts across the country while addressing unmet needs wherever necessary.



Taking note of this diverse landscape and the valuable opportunity to assess each initiative's focus, identify areas for collaboration, and address any existing gaps, PM-STIAC, in its 21st meeting, approved the establishment of NOHM. The implementing agency for One Health Mission is the Indian Council of Medical Research (ICMR).

> *India has a unique heritage of 'One Health' when we look back. We have an equally unique opportunity and responsibility to build on it going forward. It is time to move it to practice and to bind individual components to a better whole.*

Dr. Sindura Ganapathi
Visiting PSA Fellow

By itself, PM-STIAC has proved to be a very effective convening forum bringing together key stakeholders as needed for the topic and external members from both academia and industry. PM-STIAC's launch of the One Health Mission was a conscious decision to take on a few concrete issues that can be addressed in a meaningful timeframe as part of this mission. For instance, there have been legitimate questions on why the National One Health Mission focuses too much on diseases. However, this is only the beginning towards having concrete progress on a few priority issues such as integrated disease control and pandemic preparedness that will help build not only the framework, governance structure and initiatives but also confidence in the value of the very concept of 'One Health'.

For any successful national level programme, two ingredients are necessary: a clear policy framework and the resources to implement the policy. What was apparent during the landscaping leading up to the NOHM was that we are already spending a considerable amount of resources as part of various programmes across sectors. Hence creation of another standalone initiative was deemed to be counterproductive to the very nature of One Health, by creating yet another silo in the form of 'One Health Mission'. Therefore, all the activities under the mission have been consciously chosen to be focused on bridging existing programmes, as opposed to building new ones.

Another crucial missing element that is generally seen in One Health globally is that it is dominated by human health considerations, which is a result of historical bigger focus on this sector. Therefore, over the past several years, OPSA also helped build programs for the animal husbandry and wildlife sector so that we have strong pillars along with human health on which an overarching structure in the form of One Health can realistically be built. National Digital Livestock Mission (NDLM) or Bharat Pashudhan (https://bharatpashudhan.ndlm.co.in/), which forms the digital architecture backbone to handle the country's livestock population and the recently announced National Referral Center for Wildlife (NRC-W), both came up through close collaborations between OPSA and respective Ministries.

Moreover, One Health as a concept is only useful beyond being an abstract concept if it adds value over and above what is already being done under different names. The March Edition of Vigyan Dhara has elaborately focused on the details of the mission, overview of various activities undertaken and the status of these activities. This article is meant to supplement it with a context on how science policy and convening helped with the Mission's coming together so that we build on these lessons for other cross sectoral needs.

Scan the QR Code to access the March 2025 Edition of Vigyan Dhara on National One Health Mission

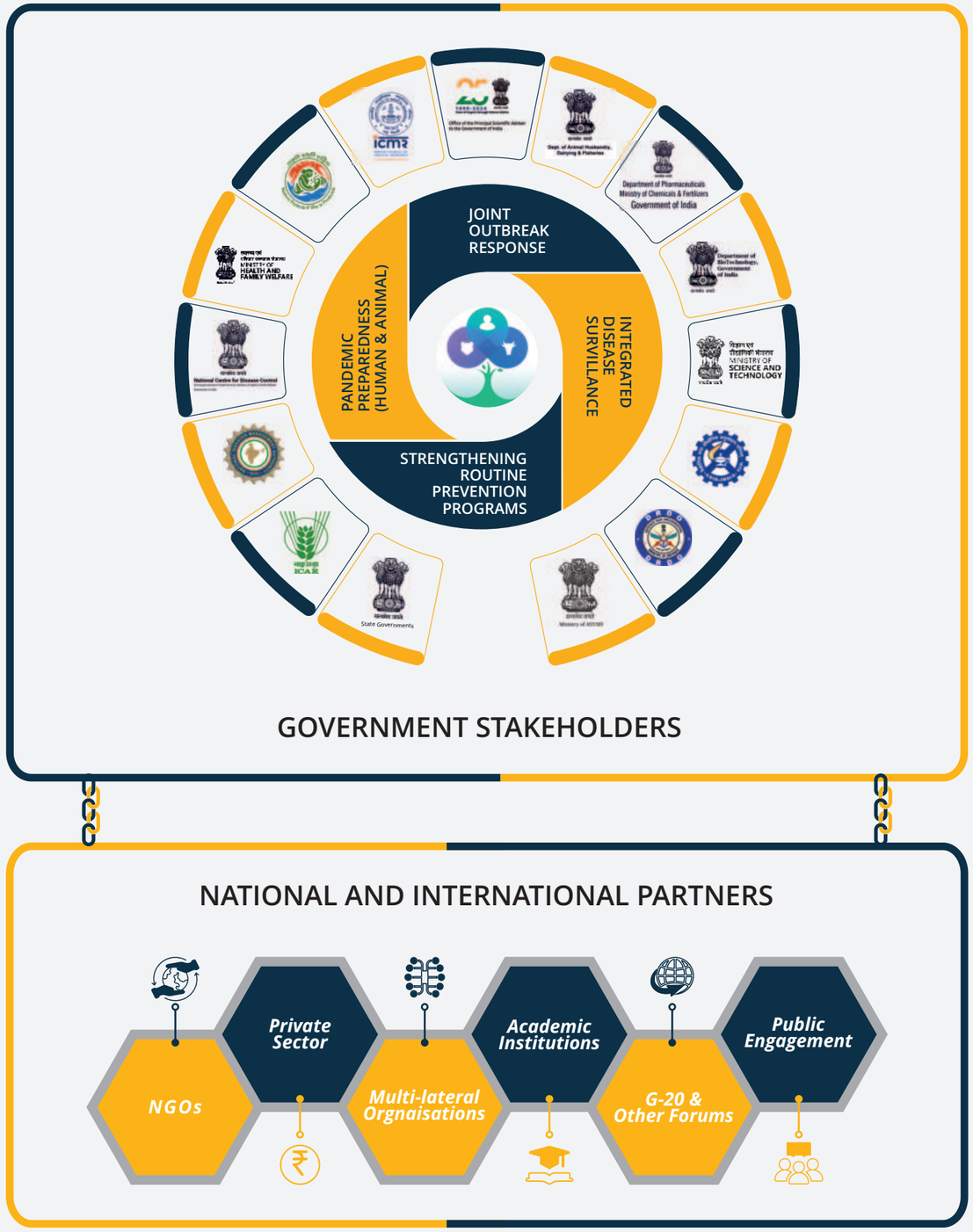
Stride towards Impactful Implementation

Under NOHM a diverse set of stakeholders (amounting to 14 ministries/departments, state governments, academic and private sector among others) have been working together. This is one of the largest such coalitions around a single issue, facilitating the development of a mission as a collaborative exercise, including cabinet approval and launch of several activities. In a true 'whole of Government approach' it was a consultative, collaborative process that saw the Departments coming together to integrate their efforts for a greater outcome. Going beyond the usual consultations, NOHM was developed through a 'co-creative' approach where a group of cross-ministerial representatives regularly met and shaped the vision, activities and milestones. A high-level committee consisting of all the secretaries, Chaired by PSA reviewed the progress on a regular basis.

With the mission now launched and the activities just getting started, we are at a crucial juncture. Sustaining it will require more energy so that important priorities that have been identified can lead to continued results. The Mission now has a well-defined governance system and high-level committees involving experts from across sectors from within and outside the government to guide them. However, progress requires follow-up and consistent attention on the next steps.

The most important next frontier for the Mission is integrating these into State governments' priorities. As challenging as it appears, the progress made in key states such as Kerala, Gujarat, Meghalaya and many others, shows a way forward. Therefore, the emphasis now should be on continuing to run the governance machinery so that it becomes well oiled, while at the same time pushing for implementation by working with state governments so that we learn by doing. The Mission is also supporting sector specific programs and building a network of trained professionals across the human, animal and environmental health sectors to enable integrated response at field level. In line with this, OPSA convened a focused workshop on June 9th, bringing together representatives of State governments and all concerned stakeholders, leading to a fruitful engagement and the creation of a forum for exchanges between the Centre and the States on One Health.

An evolutionary or adaptive process happening over a long period allows time for subtle adjustments and apparent harmony. Rapid changes result in disruptions to the equilibrium as we saw during COVID-19 that are more difficult to manage. Although these interconnectedness among various life forms evolved over millions of years, the disruptions are happening in a matter of years and months. Therefore, our cognizance and response to that will also need to be with the same urgency and time frame. The daunting considerations and implications can, with the right policy built on the willingness to work together, catalyse action. We hope One Health Mission can help provide a framework for such policy informed action for an urgent need for not just India but around the world.



07

Co-Creating Rural Technologies:

Science Advice and Society

Varas Duggu
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In the last few decades, India has seen a rapid transformation powered by technology and entrepreneurship. With rural India housing 65% of the population (2021 data), it still holds immense potential to further contribute to this growth story. The familiar challenges are persistent: fragmented access to essential services, limited market linkages and purchasing power, underutilised human capital, and a model that views rural areas as recipients rather than co-creators of innovation.

The rural India need not just be a site of implementation of urban know-hows, it can be an ideation spring for tailored & demand-led frugal innovation, community knowledge and untapped demographic strength. The imperative is to connect the dots between problems and solvers, research and relevance, and technologies with grassroot aspirations. The Government has also emphasised on improving the quality of life in rural areas to ensure more equitable and inclusive development.

This is where the Quadruple Helix Model offers a powerful framework.

The traditional triple helix describes the interaction between Government, industry, and academia, outlining how the collaborative innovation model can be institutionalised. However, in the rural context, the model carries a disproportionate impact not just with industries in the picture but also the fourth thread comprising civil societies, NGOs and rural communities playing an active role in co-creating innovations for local challenges via local knowledge systems. Their participation, feedback and ownership are critical to the design and adoption of rural technologies.

Bringing these actors together requires intent, facilitation and strategic coherence – a role that the Office of the Principal Scientific Adviser (OPSA) to the Government of India plays through its science advice and policy.

The Office expanded its attention with specialised S&T interventions and support for rural areas, with India's ecosystem increasingly recognising the need for products based on the demands of grassroots development. This article explores how a series of initiatives by the OPSA: Rural Technology Action Group (RuTAG), RuTAGe Smart Village Centres (RSVCs), Manthan and Science & Technology (S&T) Clusters bring various actors of the quadruple helix together and work towards this evolving vision.

RuTAG

Rural Technology Action Group

Empowering rural India through demand-driven S&T intervention

Sustaining rural technology development is a balance between economic viability, cultural appropriateness, and environmental responsibility. The Rural Technology Action Group (RuTAG) initiative, was conceptualised in 2003-04 by OPSA under the visionary leadership of former PSA, Dr. R. Chidambaram, as an institutional mechanism to bridge high-end research with rural needs for context-driven solutions.

RuTAG's unique strength lies in leveraging the elements of the quadruple helix model, combining the capacities of academia, government, and civil society.

RuTAG began with seven centres established across IITs of Madras, Bombay, Delhi, Kanpur, Roorkee, Kharagpur, and Guwahati to function as regional innovation hubs partnering with local ecosystems and develop appropriate technologies for rural India.

The initiative focuses on understanding the needs of rural communities to co-develop affordable, culturally inclusive and easy to use technological solutions. Over the years, it evolved into a force for decentralised innovation, contributing significantly to India's rural innovation ecosystem. OPSA coordinates these efforts, offering advice, guidance and seed support to the Centres for implementing rural development initiatives.

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IIT Madras RuTAG centre conducted workshops on reusable sanitary pads across North East Regions.

Sanitary Napkin Micro-Enterprises in the Northeast

One of RuTAG's most impactful projects emerges in the northeastern states, where scarce access to hygienic menstrual products and taboos around it contributed to health complications in women and also school absenteeism among adolescent girls.

The technology intervention introduced through RuTAG's centre at IIT Madras was a semi-automated and cost-effective machine that could be operated with minimal training. The centre established 17 sanitary napkin manufacturing units across Assam, Arunachal Pradesh, Meghalaya and Manipur. Beyond technology dissemination, RuTAG worked with local NGOs to build awareness on menstrual hygiene, provide training and support branding.

Each manufacturing unit employed 5–10 women, many of whom never held paid employment, turning access to personal hygiene into a platform for enhancing public health, economic empowerment and social change. This collaboration was a successful example of how the scientific intervention and support through RuTAG have helped in integrating technology solutions to local challenges.

Sanitary Napkin Manufacturing Units in the North Eastern Region of India.

RuTAG has aligned with multiple government initiatives supporting rural development also reaching international platforms. Collaborations include technology outreach to Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) member nations with the Ministry of External Affairs. The engagement with the African-Asian Rural Development Organisation (AARDO) involved sharing technologies with Namibia, Sudan, Zambia and Ghana. The initiative has also received support from State Ministries, such as the Tamil Nadu State Rural Livelihood Mission, Maharashtra State Tribal Ministry, the Kerala Khadi Village Board. These efforts present RuTAG's commitment to comprehensive rural development.

RuTAG 2.0

In 2023, RuTAG entered a new phase with renewed focus, expanding on its scope and targeted impact. Building on its initial emphasis on problem identification and technology development, RuTAG 2.0 marks a shift toward scalability, commercialisation and impact-driven implementation.

The focus of RuTAG 2.0 includes:

- To strengthen the partnership with private industries and grassroot organisations.
- Promoting rural entrepreneurship and social enterprises.
- Supporting innovators in commercialising proven technologies.

RuTAG 2.0 emphasises accelerating the deployment of technologies, ensuring the sustainability and replicability of solutions. By fostering ties with industry players and investors, the OPSA aims to make RuTAG solutions self-sustaining in the long run.

Way Forward

RuTAG's 20+ years of journey has also reflected the limitations experienced at the grassroots. Low awareness and limited finances are pertinent issues that require concentrated efforts to bridge technology and rural development. Many successful prototypes still struggle to reach mass production without deeper market linkages.

To address this, a new mechanism has been developed: the RuTAGe Smart Village Centres (RSVCs).

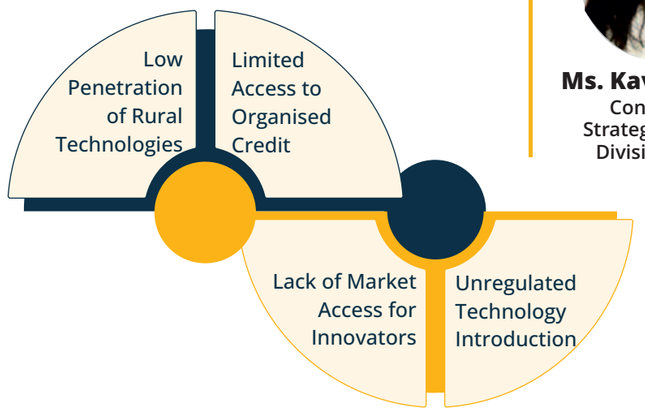
These panchayat-level hubs are designed to bring technologies developed by RuTAG institutions and those hosted on national platforms such as Manthan, to the last mile through live demonstrations, entrepreneurship training, sustained hand holding and enabling marketlinkage.

RuTAGe Smart Village Centres (RSVCs)

Bringing rural innovation to its doorstep

The RuTAGe Smart Village Centres (RSVCs) was born out of a vision that began in 2004, when OPSA launched the RuTAG initiative. RSVCs builds on the legacy of RuTAG, which has supported rural technologies for over two decades and the PURA (Providing Urban Amenities to Rural Areas) initiative, also envisioned by former PSA Dr. A.P.J. Abdul Kalam. The addition of the "e" in RuTAGe signifies a focus on entrepreneurship and employment.

RuTAG focused on developing simple, cost-effective, and locally relevant technologies in collaboration with IITs and other academic institutions. While Phase 1 yielded 34 technologies that were selected for wider dissemination and scale-up, uptake was observed to be limited largely due to bottlenecks such as:



Some of the nation's most prestigious institutions work on developing tailored technologies for rural needs, still the adoption in rural areas remains low. This highlights the issue that while innovations are available, the systems required to deliver them at scale and adapt effectively are lacking.

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In response to this, OPSA has introduced RSVCs as a targeted intervention. The initiative is conceptualised to address the challenge of technology adoption in rural areas, created through initiatives like RuTAG and facilitated by national-level platforms like Manthan. The model aims to establish physical infrastructure that promotes technology dissemination among rural communities providing space for market linkage, technology demonstrations and regional entrepreneurship development.

There are three distinct types of RSVCs:

01 RSVC with 12 Tracks of Rural Development:
Deployment through technologies on Agriculture, RuTAG Technologies, Livelihood & Entrepreneurship, Renewable Energy, EdTech/Education, Affordable Housing, WASH, FinTech, Capacity building and research of Tier-2&3 colleges through RSVCs, Govt. Schemes/Citizen Centric Apps, Assistive Technologies, Village baseline problem statements and solutions.

02 RSVCs for Local Entrepreneurship Development:
These centres will focus on developing livelihood and entrepreneurship opportunities through liberal technology transfers, local fabrication, manufacturing and democratisation of technologies with support from the National Rural Livelihood Mission and any other funding.

03 RSVCs with capacity building of 'Techpreneurs':
To train the youth to sell and promote rural innovations and technologies.

The 6-month-old program aims to operationalise 25 RSVCs across the nation with the deployment of technologies this year. OPSA plays a key role in selecting the not-for-profit implementation agencies that can deploy technologies, train the villagers and help them with funding collaborations. The Office provides strategic leadership to the RSVC initiative by guiding its conceptualisation, implementation, and scaling. It anchors the evaluation framework through tools like AMRIT on the Manthan Platform, enables access to rural innovations, captures grassroots problem statements, and tracks centre-level progress via standardised Key Performance Indicators (KPIs) and reporting templates.

RSVC Mandaura, Haryana

Mandaura village in Sonipat district, Haryana is becoming a model for integrated rural development under the RuTAGe Smart Village Centre initiative. RSVC Mandaura is implemented by the Modern Village Foundation in partnership with Chalis Gao Vikas Parisad is an example of Type 1 RSVC with successful implementation of all 12 Tracks. Additionally, based on the village baseline data, RSVC Mandaura introduced a microbial blend developed by Indian Oil Corporation Ltd. for rapid in-situ stubble decomposition, enhancing soil health within 15 days. Using IIT Kanpur's lignocellulosic biomass-based fermented organic manure technology, a biofertilizer unit was also established to convert cow dung and agricultural waste into natural inputs. A pilot model is being developed at Gaushala with 5 identified technologies including Bio energy, Bio fertiliser, Bio flock (fisheries), cow lift technology and breeding technologies. This model shall be adopted by Gaushalas across the country.

Technology solutions backed by academia and industry can effectively address rural challenges, as underscored by RSVC Mandaura. The village is evolving into a self reliant ecosystem with community engagement, institutional collaborations and oversight from the Office of PSA, serving as a scalable blueprint for rural development.

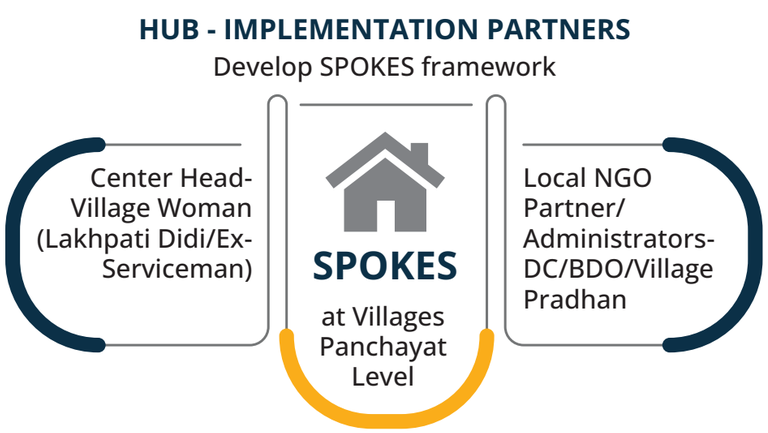
What's Next?

As the RSVCs expand, the next focus is on establishment of a Centre of Excellence (CoE) to serve as the operational hub driving its success. This CoE will encompass key verticals including technology validation, monitoring, impact assessment, funding and market linkages.

The RSVCs are designed to have a Panchayat level presence, to provide handholding and cater to the technological needs of villages surrounding it. The centre aims to build confidence among rural communities, ensuring the adoption of innovative solutions and acts as a one-stop shop for rural technology deployment.

Building on the foundation laid by RuTAG, RSVCs represent a shift towards ensuring that innovation reaches rural communities and is infused in society through local ownership. Through this initiative, the OPSA envisions a new era of technology-driven rural development, where the community, local entrepreneurs, and various stakeholders work together to bridge the rural-urban divide.

Conceptualised by the Office of PSA, the RSVC framework was the winner of the Social Stock Exchange at Varanasi in September 2024



Manthan

India's Platform for Research and Innovation

During COVID-19, India surged with innovation across domains, driven by urgent public health needs and a robust Science, Technology, and Innovation (STI) ecosystem. The OPSA with its Strategic Alliances Division, enabled several partnerships leading to the indigenous development of diagnostic kits, PPE, ventilators, and the essential oxygen infrastructure through the initiative of Project O_2 for India. However, this massive volume of innovations and research outputs required systematic evaluation, alignment with industry and societal needs, that too in real time, considering the time-sensitive needs during COVID. The absence of a centralised mechanism to efficiently vet, match, and scale innovations became a limitation, potentially hindering the impact of many promising solutions. That is where the idea of Manthan was born as a national-level platform to institutionalise innovation discovery, evaluation, and deployment.

To enable this, OPSA spearheads a holistic approach by creating close collaborations with numerous stakeholders, backed by Central Line Ministries, State Governments, and PSUs. The Manthan Platform was launched on 15th August 2022 by PSA Prof. Sood, calling it "a pivotal step in building, nurturing, and celebrating the outcome of partnerships between various stakeholders of the STI ecosystems in India."

The idea isn't the first with Research Innovation Network Kerala (RINK) and BHEL's SanRachna sharing a similar intent. Yet what sets Manthan apart is its national vision, integration with other digital platforms and data privacy architecture, which builds confidence among stakeholders. Manthan encourages industries to submit problem statements, while academia and startups propose solutions in a democratised process. Institutions offering the relevant solutions are selected for funding, leading to joint research and innovation development.

Manthan operationalises the Triple Helix model by fostering collaboration between academia, industry, and government to co-create solutions for national development. By crowdsourcing challenges and enabling partnerships across startups, researchers and policymakers, the platform accelerates the deployment of transformative technologies to the grassroots. It also has a dedicated section called AMRIT: Accelerated Medium for Rural Innovation, for monitoring the RSVCs and sharing cross learning between them.

This collaborative ecosystem has enabled Manthan to source more than INR 8312 Crore for research and innovation addressing 860 problem statements, supporting 285 R&D projects fostering 138 early-stage innovations. The platform has facilitated 66 market-ready challenges, 57 business R&D projects, and 35 implementation projects, while also awarding 2354 scholarships to support young researchers and innovators (till May 2025).

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Vision for the Future

For future upgrades, the platform looks to integrate AI into it, enhancing its experts' network and its matchmaking capabilities between industry needs and research solutions. Manthan would also focus on a section to connect PhD students with I ndustry, helping them find research jobs that match their interests and skills.

Manthan's global ambitions are equally sound. It is exploring partnerships with foreign governments, embassies, international science forums, and strategic cooperation platforms such as European Union, World Bank, CERN and others. The platform aims to drive global knowledge exchange, collaborative research, and cross-border innovation deployment. Promoting collaborative opportunities for Indian research and academia to leverage global technologies utilising Manthan, to co-develop, co-patent and indigenise such technologies. This expansive collaboration brings India's R&D ecosystem to the world stage, fosters technology adaptation for social impact, and accelerates cross-border research. Manthan reflects the OPSA's efforts to enable innovation by systematising collaboration for scale.

Science & Technology Clusters

Regional Stakeholder Synergy for Atmanirbhar Bharat

While India has significant Science and Technology (S&T) strength, research efforts are often uncoordinated across stakeholders. Many times, industries remain disconnected from public R&D, local governments and communities are rarely part of the conversation either. The Office sought to change this by establishing local innovation consortia, where academia, industry and government agencies could converge around region-specific goals.

These clusters follow a **three-tiered approach:**

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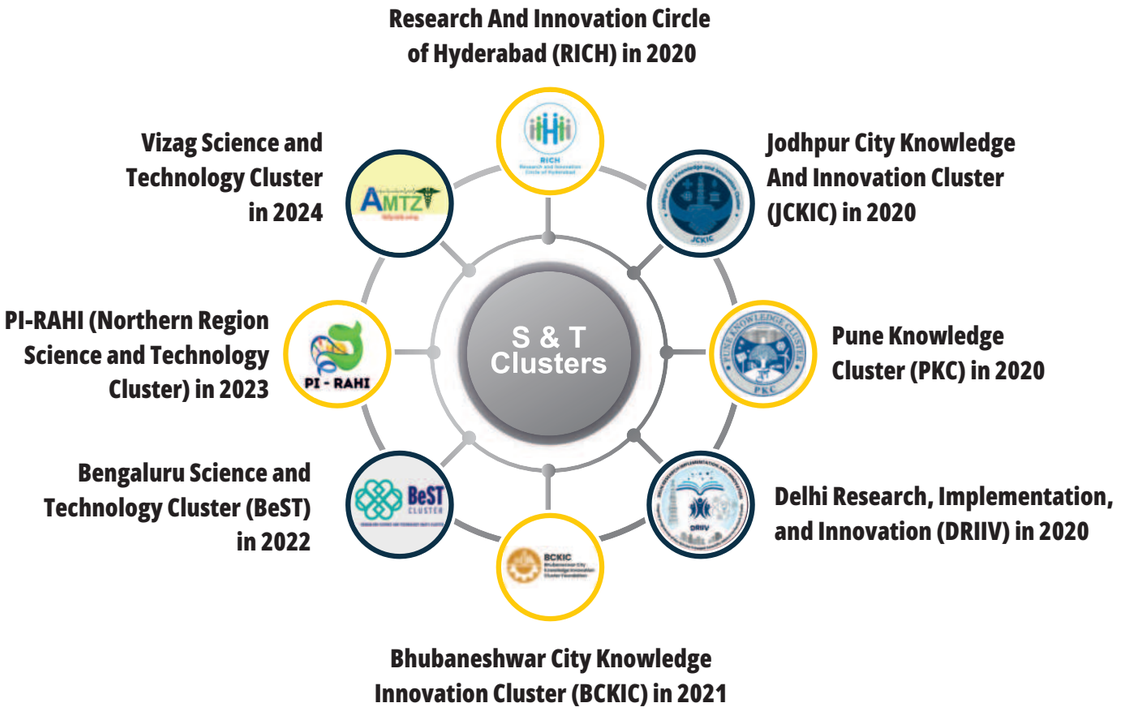
The concept of Science & Technology (S&T) Clusters originated from the Prime Minister's meeting with Council members on 13th November 2018, during which the need for closer inter-ministerial cooperation in the planning and executing key national S&T missions was emphasised. This concept was subsequently formalised as a recommendation during the third meeting of the Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) on 11th December 2018, chaired by former PSA, Prof. K. VijayRaghavan, thereby marking the genesis of this initiative.

Since 2020, the City S&T Clusters have been established as formal umbrella structures for S&T stakeholders in various regions to come together and drive a purpose-driven partnership whilst having better synergy and retaining their autonomy. Currently, eight S&T Clusters, each with themes specific to its local needs, are active across India:



The Cluster Committee is embedded within the OPSA, which has played a pivotal role in shaping the S&T Clusters framework. Beyond coordinating with initial partners, the Office has provided sustained advisory and policy support, helping to build institutional trust, alignment, and long-term governance mechanisms. It continues to offer thought leadership on how such platforms can evolve to address national priorities and regional needs.

Weaving Heritage into the Digital Future: The Kalaanubhav Story

JCKIC and IIT team field visit at Barnawa Jageer for GI Tagging of Sindhi Sarangi.

The Indian handicraft industry employs over 70 lakhs artisans (2019 data), inheriting indigenous knowledge and techniques. However, they have been overshadowed by dynamic alternatives of globalised markets on the internet. Leveraging technology frugally to benefit these communities can streamline visibility and enhance their livelihood.

Acknowledging this gap, the Jodhpur City Knowledge and Innovation Foundation (JCKIF, established to carry out and sustain the activities of Jodhpur City Knowledge and Innovation Cluster) has established a 3D virtual space, Kalaanubhav.in – an e-commerce platform, an initiative by IIT Jodhpur and OPSA to empower artisans with a platform to directly showcase in virtual reality and sell their handloom and handicraft products to customers.

PSA Prof. Ajay Sood, inaugurated the Innovation Gallery and Livelihood Support Initiatives on October 26, 2023 at IIT Jodhpur.

With 536 products from five craft (Bone & Horn, Block Printing, Leather Mojari, Salawas Durry, and Tie & Dye) clusters by 23 artisan families and over 400 associates displayed, the e-commerce platform serves as a digital marketplace for artisans to connect with customers, instilling a sense of recognition and empowerment in the artisanal community. JCKIF and IIT Jodhpur have also organised several need assessment workshops and interaction sessions, particularly with the artisans from the unorganised sectors.

Outlook

For Phase 2.0 of the S&T Clusters initiative, the emphasis is on industry connections. The interplay between industry and science enhances practical application of research and ensures that scientific endeavours are aligned with market needs. Industries are envisioned to take different roles in the success of this cluster model, as seekers of cutting-edge solutions, implementers of technologies, and funders supporting the translation of research into real-world applications. These clusters are pivotal in enabling the quadruple helix model and facilitating collaborative research to solve local challenges to realise the vision of Atmanirbhar Bharat.

Sustaining the Momentum

Across initiatives like RuTAG, Manthan, S&T Clusters, and RSVCs, rural innovation has thrived on contextual relevance and collaboration. While the Triple Helix model formalised innovation structures, the opportunities with rural ecosystems add a fourth dimension to include local communities, NGOs and civil society as essential partners. The success of these initiatives stemmed from recognising communities as active co-creators rather than passive beneficiaries. Faculty from IITs, representatives from NGOs, cluster leads, and local panchayats all played a role in shaping and sustaining the efforts on the ground.

These initiatives rooted in trust and co-creation, demonstrated how inclusive science advice built on continuous dialogue, mutual respect and effective communication across stakeholders can connect rural needs with institutional expertise, siloed traditionally within academia. OPSA translated regional issues into well-defined problem statements, enabling research institutions to engage effectively. The collaboration with industries and local stakeholders ensured that solutions remained demand-driven, accessible and affordable.

However, challenges still remain. As grassroots innovation expert Prof. Anil Gupta highlights,

> “We need to support intermediate organisations to generate data that will help link innovators with other stakeholders.
> This support has been missing, and this gap needs to be filled. We have enough data and innovations to keep scientists busy for the next hundred years. What we lack is a systematic programme to bridge the gaps.

Prof. Anil K. Gupta
Founder
Honey Bee Network

that bridging is precisely where institutions like the OPSA can lead, from conveners to stewards of innovation ecosystems. Its advice has served as a design compass, enabling systems thinking, creating adaptive frameworks and fostering synergistic engagement among the quadruple helix constituents. As reflected, the OPSA's goal with its science advice is not just limited to “delivering” grassroot innovation – it is also to “embed” it in society, so that rural India becomes not a site of development but a source of it.

08

Expanding Access to

Scientific Infrastructure, Scholarly Knowledge and Funding Opportunities

Publicly funded scientific research yields the greatest value when it is accessible, inclusive, and widely disseminated - enabling its benefits to serve the broader interests of society. However, inequitable (or restricted) access to scientific infrastructure, scholarly resources, and research funding remains a significant global challenge, limiting the advancement and equitable growth of scientific ecosystems.

In a large and diverse country like India, these challenges are further compounded by linguistic plurality, geographic disparities, variations in institutional capacity, and the influences of cultural and historical contexts. Addressing these multifaceted barriers is a national priority.

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The Government of India is committed to fostering an inclusive scientific environment by ensuring broader, democratised access to resources and opportunities. This commitment is grounded in the understanding that equitable participation in science is key to driving socio-economic progress and scientific excellence.

Evidence-based decisionmaking and robust analytical frameworks are essential to overcoming these challenges. In this context, the Office of the Principal Scientific Adviser (OPSA) to the Government of India has conceptualised and is leading several strategic initiatives through multi-agency coordination and informed science advisory processes. These include:

01 I-STEM (Indian Science, Technology, and Engineering Facilities Map):

A national platform to map and facilitate access to publicly funded scientific instruments, testbeds, and infrastructure.

02 One Nation One Subscription (ONOS):

A initiative to provide countrywide access to scholarly research articles and academic journals for all Higher Education Institutions (HEIs) and Research & Development (R&D) organisations.

03 Anusandhan National Research Foundation (ANRF):

A transformative effort to democratise access to research funding and enhance the governance of scientific research across India.

These initiatives collectively aim to lower systemic barriers, foster greater collaboration, and support an inclusive scientific enterprise, ensuring that every individual and institution has the opportunity to contribute to and benefit from the nation's scientific advancement. In this article, we explore in detail how these initiatives were conceptualised and are being shaped with concerted efforts jointly by OPSA and relevant stakeholders.

I-STEM:
Enabling Equitable and Efficient Use of R&D Infrastructure

Hon'ble Prime Minister Narendra Modi dedicating the I-STEM portal to the nation during 107th Indian Science Congress, Jan 2020, Bengaluru.

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India's research and development (R&D) landscape has evolved significantly over the past few decades, marked by the rapid growth of academic institutions, research laboratories, and the establishment of state-of-the-art scientific infrastructure. While this expansion has strengthened national scientific capabilities, it has also highlighted a persistent challenge: the need to optimise the utilisation of scientific infrastructure and to expand access for researchers, students, and innovators across the country, especially those outside major institutions and urban centres.

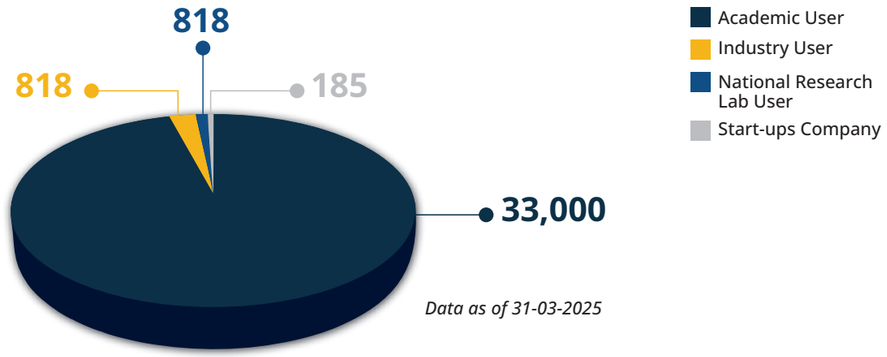
The genesis of the Indian Science, Technology, and Engineering Facilities Map (I-STEM) lies in the Indian Nano Electronics Users Programme (INUP), conceptualised under the leadership of former PSA, Dr. R. Chidambaram. The success of the INUP, which facilitated access to nano-fabrication and testing facilities at the Indian Institute of Science (IISc), Bengaluru, demonstrated the transformative potential and plausibility of opening up high-end scientific resources to a broader user base.

Building on this foundation, I-STEM was conceptualised and developed as a national-level platform for scientific resource sharing, with support from OPSA and in collaboration with IISc, starting in March 2018. The platform was formally launched by the Hon'ble Prime Minister Shri Narendra Modi at the 107th Indian Science Congress in January 2020.

> *State universities and affiliated colleges, where 95 percent of our students go, have little awareness of where they can access certain equipment needed for their experiments. We wanted to bridge that gap between researchers and resources*

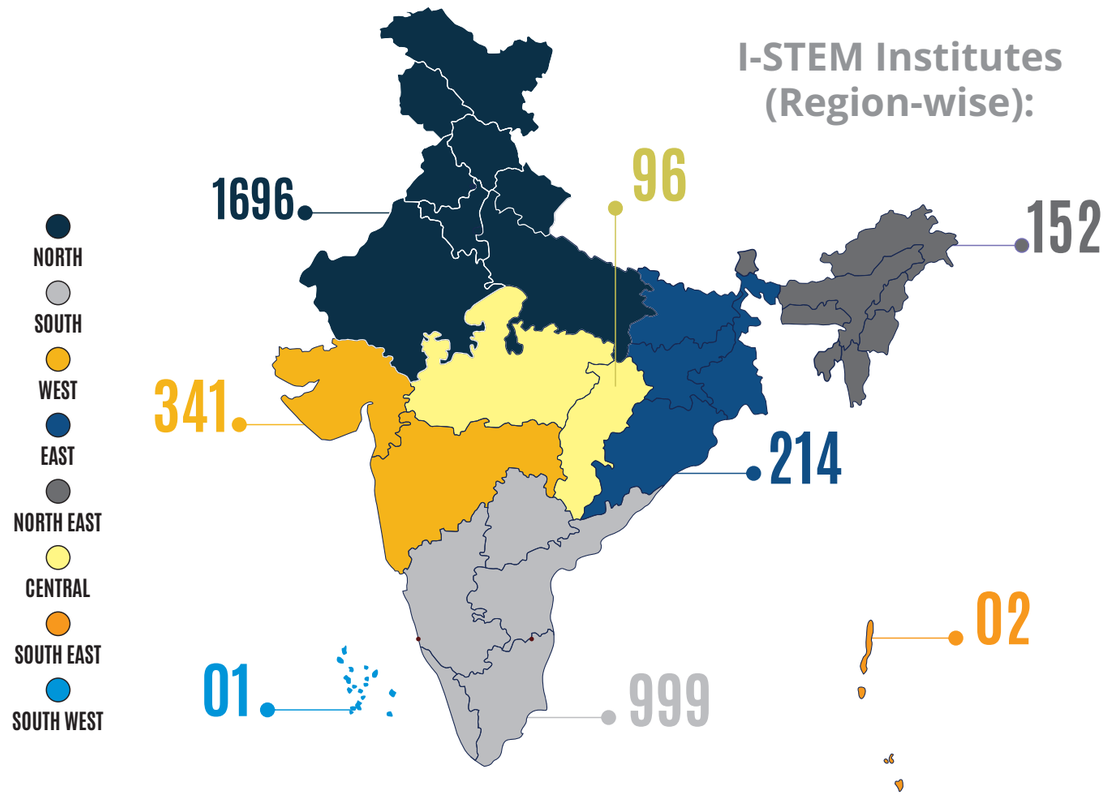
-Former PSA Prof. K. VijayRaghavan (Jan 2020)

I-STEM is designed to democratise access to scientific facilities by providing a user-friendly, searchable, and interactive portal that enables users to locate and book equipment, laboratories, and software tools hosted across public institutions in India.



Data as of 31-03-2025

As of now, I-STEM has registered over 38,210 users, with 28,750+ instruments listed across 3,472+ institutions nationwide. The platform has crossed 50,367 Facility Booking Records (FBRs). In addition to infrastructure access, the platform also includes a directory of domain experts who act as mentors and facilitators, enhancing the practical utility of the resources.



Key Features of I-STEM

01 **Centralised Equipment Database:**
A national registry of publicly funded, high-end scientific instruments accessible for shared use.

Booking & Billing System: **02**
Online reservation system integrated with usage tracking and secure payment mechanisms.

03 **Trained Personnel Directory:**
Lists qualified technicians and operators available at facilities to support research workflows.

Software Repository: **04**
Curated access to specialised research software for simulations, analysis, and modelling.

05 **Skill Development Modules:**
Training programs to promote hands-on experience and capacity-building among young researchers.

I-STEM complements and aligns with other flagship national initiatives such as ONOS and ANRF, with the overall aim to strengthen and democratise India's scientific ecosystem beyond Tier-I institutions and cities. By improving access and optimising the use of publicly funded resources, I-STEM not only enhances the efficiency of national R&D investments but also reduces redundant procurement, especially in resource-constrained institutions. Going forward, OPSA is actively focusing on expanding the scale and impact of I-STEM by integrating advanced digital technologies, maximising the user base, and conducting sensitisation and capacity-building initiatives. These efforts seek to encourage widespread adoption of the platform across Ministries, Departments, and institutions, enabling both the sharing and utilisation of infrastructure to achieve greater inclusivity and efficiency across the ecosystem.

ONOS:

Bridging the Knowledge Gap

Press conference on the One Nation One Subscription scheme held at National Media Centre, New Delhi.

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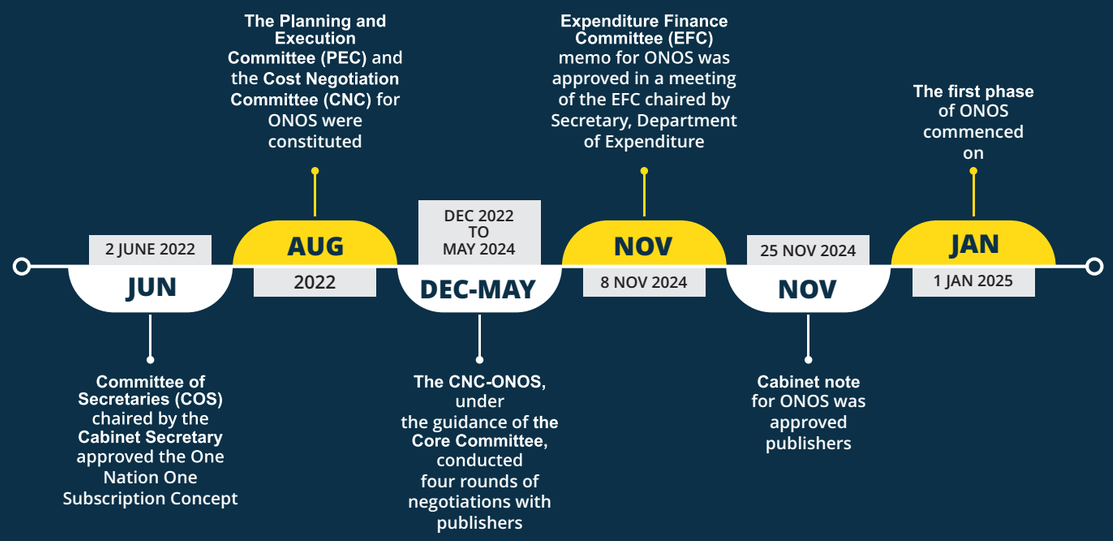
OPSA plays a catalytic role in shaping the national agenda on Open Science, advocating for greater inclusivity, accessibility, and transparency in research production and its dissemination. A key milestone in this journey is the launch of the One Nation One Subscription (ONOS) initiative - a bold policy intervention aimed at democratising access to scholarly research for India's vast academic and research community.

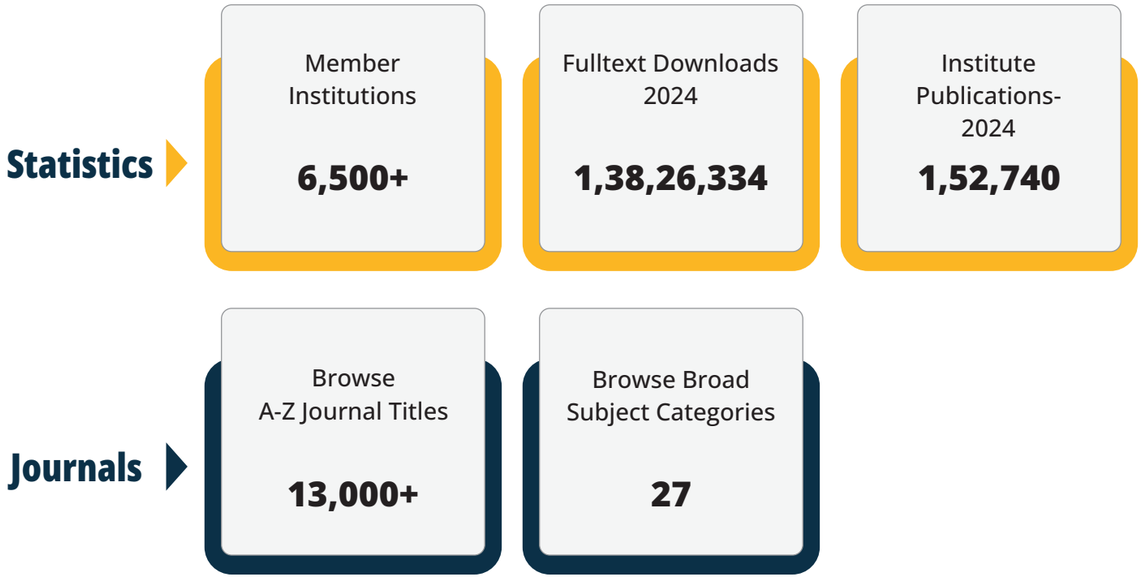
Recognising that access to high-quality scientific literature is essential for a thriving innovation ecosystem, ONOS marks a paradigm shift in how India engages with global knowledge systems. It consolidates journal subscriptions under a centralised, government-funded model, removing financial and institutional barriers that often limit access to research in smaller or under-resourced institutions.



In a major policy decision, the Union Cabinet, chaired by the Hon'ble Prime Minister Narendra Modi, approved ONOS as a Central Sector Scheme. It is being implemented by the Department of Higher Education (DHE) and anchored by the Information and Library Network (INFLIBNET) Centre - an autonomous body under the University Grants Commission (UGC). The scheme is being administered through a fully digital, user-centric platform (www.onos.gov.in), ensuring seamless access and monitoring.

With a financial outlay of INR 6,000 crore for the period January 2025 to December 2027, ONOS represents one of the largest publicly funded knowledge-access initiatives globally. This funding supports comprehensive national subscriptions and includes an annual provision of INR 150 crore to support Open Access (OA) publishing in select high-quality journals, thereby strengthening both access and OA authorship.

In its first phase (2025-27), ONOS provides access to over 13,000 scholarly journals published by 30 prominent international publishers, including Elsevier, Springer Nature, Taylor & Francis, and Wiley. The coverage spans a broad range of disciplines including STEM, medicine, social sciences, humanities, and management, ensuring that researchers from every field have access to the latest global literature.



Broad overview of ONOS Statistics

More than 6,500 publicly funded higher education and R&D institutions, including central and state universities and colleges, will be part of this national subscription, potentially benefitting over 1.8 crore students, faculty, and researchers. This represents a monumental leap in research equity and capacity-building for India's knowledge economy.

ONOS is built around four key pillars:

Access to Knowledge Resources: by consolidating subscriptions under a unified model, ONOS removes financial and institutional silos that have historically restricted access to knowledge, particularly for smaller institutions. **01**

Equity in Research Opportunities: ONOS integrates Tier-II and Tier-III institutions into the national research grid, promoting regional parity and enabling aspiring scholars from remote and underserved areas to engage in world-class research. **02**

Interdisciplinary Research Enablement: with universal access across disciplines, ONOS fosters an environment conducive to interdisciplinary collaboration, essential for tackling complex societal challenges. **03**

Promotion of Open Access Publishing: by funding publication fees for OA journals, ONOS empowers Indian researchers to share their findings globally, increasing visibility and enhancing the impact of India's research output. **04**

ONOS is a key component of the broader vision to drive an open access transformation in India. As the first step in a three-pronged strategy, ONOS expands nationwide access to scholarly literature through a unified subscription model. Subsequent efforts focus on strengthening the use and visibility of Indian journals and repositories, and reforming research evaluation frameworks to include not just journal-based metrics, but also the intrinsic quality of research and its relevance to innovation, entrepreneurship, and societal impact.

In India's march towards a robust knowledge economy, initiatives like ONOS play a foundational role in broadening the base of research participation and enhancing the quality, equity, and reach of Indian science. It is not just about accessing information -it is about enabling every student, researcher, and faculty member to contribute meaningfully to India's scientific and innovation journey.

ANRF:
Empowering Research and Innovation Ecosystem

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Hon'ble Prime Minister Narendra Modi chairs the first General Board meeting of Anusandhan National Research Foundation (ANRF) in New Delhi | 10 Sept 2024

On 10 September 2024, Hon'ble Prime Minister Narendra Modi chaired the inaugural General Board meeting of the Anusandhan National Research Foundation (ANRF) in New Delhi, marking a significant milestone in India's research and innovation journey.

The establishment of ANRF is rooted in two pivotal developments: the National Education Policy (NEP) 2020 and the vision of the Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC). The NEP 2020 was one of the most extensive policy formulation exercises undertaken in recent decades. It ushered in a paradigm shift across the educational landscape and laid the groundwork for transformative reforms in research funding and governance.

> *In order to seed, nurture, grow and transform universities into full-fledged research centres of excellence, the NEP 2020 has recommended the creation of National Research Foundation (NRF). It will support research programs in sciences, technology, social sciences, arts and humanities and many other areas including that of educational technologies*

- Prof. K. Kasturirangan,
Former Chairman ISRO; Chair of NEP 2020

The NEP recognised that one of the key deficiencies in India's higher education system was the absence of a coherent strategy for planning and implementing research at the university level. To address this, the NEP proposed the creation of a dedicated institutional framework - the National Research Foundation (NRF) - to support and fund research, especially within colleges and universities.

Acting on these recommendations, the PM-STIAC, in its 6th meeting held on 20 August 2019, conducted detailed deliberations involving all key stakeholders to evaluate pathways and considerations for establishing India's NRF.

Following extensive public consultation, and inter-ministerial as well as the apex level discussions in the 23rd meeting of PMSTIAC on 14 July 2023, the Union Cabinet approved the Anusandhan National Research Foundation Act, 2023 in August 2023. The Act officially came into effect on 5 February 2024, thereby operationalising the Foundation.

At the first General Board meeting, Hon'ble Prime Minister Narendra Modi emphasised the importance of removing systemic bottlenecks in the country's research ecosystem and setting ambitious goals for breakthrough innovations.

> *A new beginning has been made with the Anusandhan National Research Foundation. There is a need to identify and remove obstacles in the research ecosystem of the country. We need to set big targets, focusing on attaining them and doing path breaking research. Research should also focus on finding new solutions to existing problems. Problems might be global in nature but their solutions must be localised in accordance with Indian needs*

- Hon'ble Prime Minister Narendra Modi,
President of ANRF Governing Board
(10 Sept 2024)

The ANRF has been established with a substantial financial commitment of INR 50,000 crore for a five-year period (2023–2028). Of this, 72% (approximately INR 36,000 crore) is expected to be mobilised from the private sector through effective partnership models, while the remaining INR 14,000 crore will be contributed by the government - with an annual public expenditure of INR 2,800 crore.

The governance structure of ANRF reflects its national importance. The Governing Board, chaired by the Prime Minister, includes the Ministers of Science & Technology and Education as Vice Presidents, and the PSA as Member Secretary. The Board also comprises distinguished members from academia, industry, and public policy. The Executive Council, chaired by the PSA, oversees programme implementation, budget planning, and regulatory compliance. The Department of Science and Technology (DST) serves as the administrative department responsible for implementing ANRF programs and initiatives. As Chair of the Executive Council, the PSA ensures the development and coordination of a cohesive, multisectoral research strategy that spans across ministries and institutions.

ANRF is envisioned not merely as a funding agency, but as a catalyst for building a research ecosystem that is globally competitive and attuned to national development priorities. It aims to streamline research governance, track national research output, monitor funding trends, and evaluate outcomes to inform future policies and strategies.

अनुसंधान नेशनल रिसर्च फाउंडेशन
Anusandhan National Research Foundation

Transformative Programmes towards Early Impact

Since its inception, ANRF has launched five new programs, signalling a major transformation in how research is supported across India. Foremost among these is the Partnerships for Accelerated Innovation and Research (PAIR) program, developed to address deep-seated structural imbalances in the Indian research ecosystem.

The PAIR program follows a 'Hub and Spoke' model, wherein well-established research institutions (Hubs) partner with emerging institutions (Spokes) to provide mentorship and collaborative support. The program aims to (i) promote internationally competitive research with substantial impact, (ii) foster productive and diverse institutional collaborations, and (iii) strengthen partner institutions by:

While institutions like the IITs have made significant strides in building robust research ecosystems, many state and regional universities continue to lag behind. PAIR is designed to bridge this gap by enabling mentoring ecosystems where established institutions actively cultivate innovation and excellence in their partners.

With a total allocation of INR 1,500 crore over five years, each selected PAIR network can receive up to INR 100 crore, with 30% allocated to Hub institutions and 70% to Spokes. In its first phase, the program targets universities that have shown research potential through national rankings and demonstrable capacity for scale-up. Evaluation of proposals submitted under various ANRF calls is currently underway.

In addition to PAIR, the Mission for Advancement in High-impact Areas (MAHA) has been launched. A key component of MAHA is the Electric Vehicle (EV) Mobility Programme, aimed at developing indigenous technological solutions through academia-industry collaborations. To ensure accountability and commercial relevance, the programme mandates a minimum 10% cash contribution from industry partners.

Another critical scheme under ANRF is the Prime Minister's Early Career Research Grant (PMECRG), which empowers young researchers to initiate independent, high-impact scientific careers. Several other initiatives are also in progress, aimed at elevating institutions to global standards, promoting translational research, and supporting basic research through a structured funding framework.

In May 2025, ANRF opened applications for prestigious fellowships such as the National Post-Doctoral Fellowship (NPDF), Ramanujan Fellowship, and the ANRF National Science Chair (NSC). Additionally, the Advanced Research Grant (ARG) - a restructured successor to the Core Research Grant (CRG) - is expected to be launched soon, further expanding ANRF's funding portfolio.

Scan the QR code to access more information about these programs on ANRF's website

First Executive Council Meeting of ANRF

Marching Ahead

India's research and innovation ecosystem is entering a decisive phase of transformation - one that prioritises access, equity, and excellence as mutually reinforcing goals. Flagship initiatives like I-STEM, ONOS, and ANRF, along with complimenting programs of various other agencies, are collectively reshaping the contours of the scientific enterprise in the country. By democratising access to advanced research infrastructure, global scientific literature, and competitive funding, these platforms are ensuring that opportunities are no longer confined to select institutions but are extended to a broader spectrum of universities, colleges, and individual researchers. More than just policy instruments, I-STEM, ONOS, and ANRF represent a strategic shift towards building an inclusive, collaborative, and future-ready research ecosystem - one that not only nurtures centres of excellence but also unlocks the potential of emerging institutions and early-career scientists to contribute meaningfully to national and global challenges.

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