

Science, Technology, and Innovation Policy



सत्यमेव जयते
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Science, Technology, and Innovation Policy (STIP)

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Science, Technology, Innovation Policy (STIP)

Executive Summary

Science, Technology and Innovation (STI) are the key drivers for economic growth and human development. For India to march ahead on a sustainable development pathway to include economic development, social inclusion and environmental sustainability for achieving an “Atmanirbhar Bharat”, a greater emphasis will be given on promoting traditional knowledge system, developing indigenous technologies and encouraging grass root innovation.. The emergence of disruptive and impactful technologies poses new challenges and simultaneously greater opportunities. The COVID-19 pandemic provided a compelling opportunity for Research and Development (R&D) institutions, academia and industry to work in unison for sharing of purpose, synergy, collaboration and cooperation.

The new Science, Technology, Innovation Policy aims to bring about profound changes through short-term, medium-term, and long-term mission mode projects by building a nurtured ecosystem that promotes research and innovation on the part of both individuals and organizations. It aims to foster, develop, and nurture a robust system for evidence and stakeholder-driven STI planning, information, evaluation, and policy research in India. The policy will identify and address strengths and weaknesses of the Indian STI ecosystem to catalyse socio-economic development of the country and also make the Indian STI ecosystem globally competitive.

A broad summary of Science, Technology and Innovation Policy (STIP) is given as under-

1. STIP will lead to the establishment of a National STI Observatory that will act as a central repository for all kinds of data related to and generated from the STI ecosystem. It will encompass an open centralised database platform for all financial schemes, programmes, grants and incentives existing in the ecosystem. The Observatory will be centrally coordinated and organized in distributed, networked and interoperable manner among relevant stakeholders.
2. A future-looking, all-encompassing Open Science Framework will be built to provide access to scientific data, information, knowledge, and resources to everyone in the country and all who are engaging with the Indian STI ecosystem on an equal partnership basis. All data used in and generated from publicly-funded research will be available to everyone under FAIR (findable, accessible, interoperable and reusable) terms. A dedicated portal to provide access to the outputs of such publicly-funded research will be created through Indian Science and Technology Archive of Research (INDSTA). Additionally, full text of final accepted author versions of manuscripts (postprints and optionally preprints) supported through public funding will be deposited to an institutional or central repository. The policy will create pathways for

the Government to negotiate with journal publishers for a “one nation, one subscription” policy whereby, in return for one centrally-negotiated payment, all individuals in India will have access to journal articles.

3. Strategies to improve STI education making it inclusive at all levels and more connected with the economy and society will be developed through processes of skill building, training and infrastructure development. Engaged Universities will be created to promote interdisciplinary research to address community needs. Higher Education Research Centres (HERC) and Collaborative Research Centres (CRC) will be established to provide research inputs to policymakers and bring together stakeholders. Online learning platforms will be developed using Information and Communication Technology (ICT) to address the issue of accessibility and to promote research and innovation at all levels. Teaching-learning centres (TLCs) will be established to upskill faculty members which in turn will improve the quality of education.
4. With an aim to expand the financial landscape of the STI ecosystem, each department/ ministry in the central, the state and the local governments, public sector enterprises, private sector companies and startups will set up an STI unit with a minimum earmarked budget to pursue STI activities. Extramural funding will be diversified and enhanced to double the share of extramural R&D support of the Central government agencies in the Gross Domestic Expenditure on R&D (GERD) in the next five years. Each State will earmark a percentage of the state allocation for STI-related activities under a separate budget head. Foreign Multi National Companies (MNCs) will collaborate with domestic private and public sector entities on projects aligned to national needs and priorities. STI investments will be increased through boosting fiscal incentives, enhancing support to industry, especially Medium Small Micro Enterprises (MSMEs), for pursuing research through innovation support schemes and other relevant means on a need basis. Hybrid funding models with enhanced participation from public and private sectors will be created through the Advanced Missions in Innovative Research Ecosystem (ADMIRE) initiative. To ensure systematic governance of the expanded STI financing landscape, an STI Development Bank will be set up to facilitate a corpus fund for investing in direct long term investments in select strategic areas on various long and medium-term projects, commercial ventures, start-ups, technology diffusion and licensing etc. General Financial Rules (GFR) will be suitably amended for large scale mission mode programmes and projects of national importance and to facilitate ease of doing research. Efficient disbursement, communication, monitoring and evaluation mechanisms (time-bound peer reviews along with technical and transactional audits) will be set up to support conducive investment.
5. The policy aims to create a fit for purpose, accountable research ecosystem promoting translational as well as foundational research in India in alignment with global standards. Research and Innovation Excellence Frameworks (RIEF) will be developed

to enhance the quality of research along with promotion of engagements with relevant stakeholders. Proper guidelines will be formulated to enhance the operating and safety protocols related to R&D. Research culture will be reoriented to recognize social impacts along with academic achievements.

6. The policy envisions strengthening of the overall innovative ecosystem, fostering Science & Technology (S&T)- enabled entrepreneurship, and improving participation of the grassroots levels in the research and innovation ecosystem. An institutional architecture to integrate Traditional Knowledge Systems (TKS) and grassroots innovation into the overall education, research and innovation system will be established. Collaborations between grassroots innovators and scientists will be facilitated through joint research projects, fellowships and scholarships. Grassroots innovators will also be supported for registration, claiming the Intellectual Property Right (IPR), filing of patent, or any type of legal claim with the help of Higher Education Institute (HEIs). Advanced tools based on Artificial Intelligence (AI) and machine learning will be used for curation, preservation and maintenance of heritage knowledge.
7. The policy will promote technology self-reliance and indigenization to achieve the larger goal of “Atmanirbhar Bharat”. A two-way approach of indigenous development of technology as well as technology indigenization will be adopted and focused upon in alignment with national priorities, like sustainability and social benefit, and resources. International engagements will be facilitated to gain essential know-how towards creation and development of indigenous technologies. A Technology Support Framework will be created to facilitate this development. A Strategic Technology Board (STB) will be constituted to act as a link connecting different strategic departments. A Strategic Technology Development Fund (STDF) will be created to incentivize the private sector and HEIs. Spin-off technologies resulting from the larger projects will be commercialized and used for civilian purposes. Knowledge and evidence driven approach will be used for identifying critical sectors for the development of disruptive technologies.
8. The policy provides renewed impetus to the mainstreaming of equity and inclusion within the STI ecosystem. An India-centric Equity & Inclusion (E&I) charter will be developed for tackling all forms of discrimination, exclusions and inequalities in STI leading to the development of an institutional mechanism. An inclusive culture will be facilitated through equal opportunity for women along with candidates from rural-remote areas, marginalised communities, differently-abled individuals including Divyangjans, irrespective of their socio-economic backgrounds, proportionate representation of women in selection/ evaluation committees, addressing of ageism related issues and consideration of experienced women scientists for leadership roles and regular gender and social audits in academic and professional organizations. The Lesbian, Gay, Bisexual, Transgender, Queer (LGBTQ+) community will be included

in gender equity conversations with special provisions to safeguard their rights and promote their representation and retention in STI.

9. The policy will work towards mainstreaming science communication and public engagement through the development of capacity building avenues through creative and cross-disciplinary platforms, research initiatives, and outreach platforms. Locally relevant and culturally-context-specific models will be developed along with promoting cross disciplinary research in Science Communication. To improve Science teaching, the engagements between science communication and science pedagogy will be facilitated. Entertainment platforms such as television (TV), community radio, comics etc. will be explored to take science to the last mile. Non-Governmental Organizations (NGOs) and Civil Society groups will be involved through popular science programmes and citizen science projects at local and regional levels. Science Media Centres will be established at national and regional levels to connect scientists with media persons and science communicators.
10. STIP charts pathways to a dynamic, evidence-informed and proactive international S&T engagement strategy. Engagement with the Diaspora will be intensified through attracting the best talent back home through fellowships, internships schemes and research opportunities expanded and widely promoted across different ministries. Appropriate facilitating channels will be created for remote contribution as well. An engagement portal exclusively for the Indian scientific diaspora will be created. 'S&T for Diplomacy' will be complemented with Diplomacy for S&T'. International Knowledge Centres, preferably virtual, will be established to promote global knowledge and talent exchange. The number of S&T Counsellors will be increased with redefinition and revitalisation of their roles.
11. A decentralized institutional mechanism balancing top-down and bottom-up approaches, focussing on administrative and financial management, research governance, data and regulatory frameworks and system interconnectedness, will be formulated for a robust STI Governance. Appropriate mechanisms will be set up at the highest levels for the overall (including inter-sectoral, inter-ministerial, Centre-State and inter-State) governance of the STI ecosystem. A robust Research and Innovation (R&I) governance framework will be set up to facilitate, stimulate and coordinate R&D activities across the sectors. A Capacity Building Authority will be set up to help plan, design, implement and monitor capacity building programmes at the national and state level. A strong STI collaboration framework to strengthen existing channels and create new ones for enhanced interconnectedness among all relevant stakeholders at the domestic and global levels will be created, promoting inter-institutional, inter-ministerial, interdepartmental and cross-sectoral vertical and horizontal linkages and multi-stakeholder partnerships, to pursue projects in alignment with the national priorities.

12. The policy outlines the institutional mechanism for STI policy governance along with the implementation strategy and roadmap and monitoring and evaluation framework for the policy and programs and their interlinkages. To serve all the aspects of STI policy governance and to provide the knowledge support to institutionalised governance mechanisms, a STI Policy Institute will be established to build and maintain a robust interoperable STI metadata architecture. It will conduct and promote nationally and internationally relevant STI policy research and strengthen the science advice mechanism at national, sub-national and international levels. It will develop long term capacity building programs for STI policy through training and fellowships. An implementation strategy and roadmap will be devised for STI policy and programs along with continuous monitoring and timely evaluation mechanisms.

The Science, Technology and Innovation Policy will be guided by the following broad vision;

- (i) *To achieve technological self-reliance and position India among the top three scientific superpowers in the decade to come.*
- (ii) *To attract, nurture, strengthen and retain critical human capital through a 'people centric' science, technology and innovation (STI) ecosystem.*
- (iii) *To double the number of Full-Time Equivalent (FTE) researchers, Gross Domestic Expenditure on R&D (GERD) and private sector contribution to the GERD every 5 years.*
- (iv) *To build individual and institutional excellence in STI with the aspiration to achieve the highest level of global recognitions and awards in the coming decade.*

To capture the aspirations of a new, future-ready India, by ensuring active participation, shared responsibility and equitable ownership of all stakeholders; transforming the national STI landscape maintaining the delicate balance between fortifying India's indigenous capacity and nurturing meaningful global interconnectedness.

Science, Technology, Innovation Policy (STIP)

I. Building a robust Science, Technology and Innovation Ecosystem for an Atmanirbhar Bharat

Science, technology and innovation (STI) are the key drivers for economic growth and human development. As India marches ahead on a sustainable development pathway that includes economic development, social inclusion and environmental sustainability towards achieving an “Atmanirbhar Bharat”, a greater emphasis will be given on promoting traditional knowledge systems, developing indigenous technologies and encouraging grassroots innovations.. The emergence of disruptive and impactful technologies poses newer challenges but brings great opportunities. A compelling lesson from COVID-19 has been an unprecedented sharing of purpose, synergy, collaboration and cooperation that R&D institutions, academia and industry have demonstrated. The new Science, Technology and Innovation Policy (STIP) must harness the learnings and synergies from the new scenario to take India on a new path of rapid economic and social development aligned with national priorities and global competitiveness.

This policy aims to bring about profound changes through short-term, medium-term, and long-term mission mode projects. The aspirations of the STIP policy in building a nurtured ecosystem that promotes research and innovation on the part of both individuals and organizations are:

1. To foster, develop, and nurture a robust system for evidence and stakeholder-driven STI planning, information, evaluation, and policy research in India.
2. Enhancing financial resources for STI activities with a long-term vision through public and private financing.
3. To address the transformative strengths and weaknesses of the Indian R&D ecosystem in order to create a purposeful and accountable research ecosystem that addresses the socio-economic need of the country and at the same time make the country globally competitive.
4. To accelerate research (including multidisciplinary and interdisciplinary research) and innovation in the HEIs in the country, and make education at all levels more inclusive and connected with the economy and the society. In this regard, STIP fully endorses the new National Education Policy (NEP) 2020, and wishes to ensure synergetic efforts of both policies towards this goal.
5. To enhance capacity development for inculcating and promoting scientific temper across the country’s people through equity, gender parity and inclusiveness catering to the diverse needs of the country.
6. To develop scientific literature and media across Indian languages and geographies to maximize the number of people that participate in and contribute to the scientific discussions and processes in the country.

7. To promote open science and enable access to all outputs and data from public-funded research and empower STI through means of effective ethical and regulatory frameworks.
8. To facilitate interconnectedness and collaboration between the different stakeholders in the STI ecosystem which will enable the addressing of complex issues requiring a multidisciplinary approach, efficient utilization of resources, and translation of research into applications.
9. To aim for collective and inclusive global development through international S&T engagement, by maximizing the scope for indigenization, sustainability, and global competitiveness.
10. To strengthen technological development to address the socio-economic needs of the country and leverage India's position at the global level in all technology areas with special emphasis on sustainable technologies, strategic technologies, and mega-science and thereby reduce the dependence on import of technologies.
11. To strengthen India's competitiveness in STI and promote science diplomacy internationally / at a global level so that the nation continues to maintain a competitive edge in science, technology, innovation and research, globally.
12. To strengthen the STI ecosystem to build resilience for the future social and economic disruptions.
13. To ensure a clean environment for the country's people and its future generations, through green initiatives based in science that promote sustainability and clean energy, water, air, rivers, forests, parks, and neighborhoods.
14. To build an enabling ecosystem for seeding, sustenance, and growth of STI-enabled entrepreneurship in India.
15. To strengthen national water, agriculture, food, and nutrition security as well as ensuring employment generation through a robust STI enabling the environment to ensure better lives for citizens, enhancing incomes for farmers, labourers and artisans, and to create resilient and liveable human settlements, while sustaining natural resources and safeguarding public health.
16. To catalyse the application of science to create a secure, clean, inclusive and equitable energy system, reduce energy poverty, increase resilience against supply disruptions and climate risks, and enable the transition to a cost-effective carbon future.
17. To enable innovation for better health outcomes and assured universal healthcare, that is responsive to the needs of the people and that ensures the health security of the nation
18. To strengthen India's domestic supply chain management system in order to reduce its reliance on imports of goods and services, improve its exports capacity and ultimately improve its global value chain.
19. To seed, fund, and foster suitable and robust initiatives at HEIs, including collaborations with government and with industry, in order to promote all these critical aspirations.

II. Evolution of STI Policies in India

STI plays a significant role in fostering socio-economic and political development globally and benefitting all the sectors through scientific and technological advances. STI acts as a key determinant in addressing socio-economic challenges related to critical sectors such as health, environment, education, food, energy, climate change, water etc. Indian Science and Technology policies post-independent India were predominantly rooted in the ideas of self-reliance and indigenous development across the sectors. Through such endeavours India's capacity for inclusive and cost-effective innovation has been recognized in the global innovation discourse.

Four national S&T policies, Scientific Policy Resolution, 1958 (SPR1958), **Technology Policy Statement (TPS)** 1983, STP2003, STIP2013 have guided the evolution of India's STI ecosystem. The first policy on science was adopted by India through the (SPR1958) which laid the foundation for scientific enterprise and scientific temper in India. S&T were seen as vehicles for the onward journey towards socio-economic transformation and nation-building. By 1980, India had developed advanced scientific and technological infrastructure in the areas of space, industrial research, nuclear energy, defence research, biotechnology, agriculture, and health. Subsequently, with a focus to achieve technological competence and self-reliance through the promotion and development of indigenous technologies, the **TPS** was launched in **1983**. It resulted in the establishment of the Technology Development Fund and the formation of Technology, Information Forecasting, and Assessment Council (TIFAC). These S&T policies took recourse to mass education and cultivation of science and scientific research in HEIs for attaining technological competence. Economic liberalization and globalization brought new challenges and opportunities in Science and Technology. From 2000 onwards, India focused on the conversion of knowledge into wealth and value, addressing socio-economic needs of the country and to amalgamate science, technology, and innovation (STI). Accordingly, **Science and Technology Policy 2003** brought together the areas of S&T with the aim of increasing the investment required for R&D and innovation in the areas impacting the economy and society. This led to the emergence of a strong institutional mechanism through the creation of Scientific and Engineering Research Board (SERB) under the ambit of DST to promote scientific and engineering research in the country. The period following the S&T Policy 2003 is marked by a significant increase in R&D Investment, a rise in publication ranking, and a steady increase in institutional and human capacity. As a result, the decade of 2010 to 2020 was declared as the 'Decade of Innovation' with the agenda to create a 21st Century National Innovation Ecosystem, to build innovative institutions and mindsets for national progress. **Science, Technology, and Innovation Policy 2013 (STIP 2013)** was formulated with the aim of positioning India among the top five global scientific powers. The key features of this policy were to promote a S&T -led innovation ecosystem in the country, attracting private sectors into R&D and linking STI to socio-economic priorities. The 12th Five-year plan (2012-17) focused on the

creation and development of R&D facilities, building technology partnerships with states, large scale investment in Mega Science projects, etc.

India is rapidly evolving with changing national and international dynamics. In the past decade, the scope of policy instruments and regulatory environment has changed significantly, resulting in a rise in the country's performance in terms of per capita R&D expenditure, publications, patents, and quality of research publications, etc. Private sector investment is also consistently rising in STI activities. There has been a notable rise in the participation of women in R&D. A plethora of schemes have been implemented by the government to support and stimulate R&D culture among students and young researchers.

Through previous S&T policies, India has been successful in building a robust STI ecosystem. However, the new challenges today necessitate a different policy making approach. The current pandemic has catalysed the need for a new policy instrument that amalgamates profound and incremental approaches. Such a policy must adequately prioritize and strategize across the STI landscape in alignment with United Nations - Sustainable Development Goals (UN-SDGs) through a balance of short term mission-mode projects along with long-term ones. There is a need to increase public funding and private investment in R&D, boost existing FTE, build and empower critical infrastructure, improve governance of STI initiatives, intensify global linkages in the STI sector, develop indigenous technologies in key areas such as health, agriculture, energy, environment etc. Additionally, technology capacity also needs to be enhanced to make India scientifically self-reliant and ready for unpredictable exigencies. Thus, this policy instrument in its design and objective aims to be evidence-driven, inclusive and bottom-up for the well-being of the nation and its people with socio-economic and environmental considerations.

III. Chapters

Chapter 1: Open Science

- 1.1 National STI Observatory**
- 1.2 Indian Science and Technology Archive of Research**
- 1.3 Open Data**
- 1.4 Open Access**
- 1.5 One Nation, One Subscription**
- 1.6 Indian Journals**
- 1.7 Research Facilities**
- 1.8 Open Educational Resources**
- 1.9 Libraries**
- 1.10 Learning Spaces**

Priority Issues

To promote open science, the public will have the right to access all outputs from research funded by the central government or the state governments, either directly or through funding agencies, or institutions supported by the central government or the state governments (hereinafter referred to as “publicly funded research”). The right to access will include, but not be limited to, scholarly publications, research data¹ and resources such as research infrastructures², instruments, computing facilities, libraries, learning spaces, etc.

Background

Open Science fosters more equitable participation in science through diverse steps like increasing access to research outputs, more transparency and accountability in research, inclusiveness, better resource utilisation through minimal restrictions on reuse of research outputs and infrastructure, and ensuring constant exchange of knowledge between producers and users of knowledge. It is important to make publicly-funded research output and resources available to all to foster learning and innovation. STIP aspires to build an ecosystem where research data, infrastructure, resources and knowledge are accessible to all.

¹ Research Data: The term research data is defined as “recorded factual material/data that is obtained from observations, experiments, surveys, analysis and other research activities of government-funded research projects and deemed as objective and necessary to validate research findings,” as per the the definition of research data in US OMB Circular A-110 (Steering Committee of the National Science and Technology Council 2018).

² Research Infrastructure is not a universally defined term. Research infrastructure means facilities, resources and related services that are used by the scientific community to conduct research. (European Commission: Legal framework for a European Research Infrastructure Consortium – ERIC Practical Guidelines, DOI: 10.2777/79873)

A future-looking, all-encompassing **Open Science Framework** will be built to provide access to scientific data, information, knowledge, and resources to everyone in the country and all who are engaging with the Indian STI ecosystem on an equal partnership basis. This framework will be largely community-driven and supported with necessary institutional mechanisms and operational modalities. Supporting tools and applications will be developed in all regional languages to widen the scope of accessibility and for meaningful use of data. Interoperability and shared ownership, among the national stakeholders and international partners, will be the key characteristics of this framework.

1.1 A National STI Observatory as a central repository for all kinds of data related to and generated from the STI ecosystem will be established. The observatory will be centrally coordinated and organized in distributed, networked and interoperable manner among the stakeholders. Cross-cutting interoperable digital platforms within the observatory will be organized into verticals, including but not limited to: (i) establishing knowledge and data repositories; (ii) setting up a computational grid; (iii) developing a virtual communication and interaction platform; (iv) enabling virtual access of equipment, laboratories and other physical resources, talent mapping; (v) conducting analyses on projects, funding, outcomes, technological capabilities, Technology Readiness Levels and Business Readiness Levels (TRLs & BRLs); and (vi) establishing evaluation, accreditation, ranking and rating protocols for benchmarking.

1.2 A dedicated portal, Indian Science and Technology Archive of Research (INDSTA), will be developed to provide access, specifically, to the outputs of all publicly-funded research (including manuscripts, research data, supplementary information, research protocols, review articles, conference proceedings, monographs, book chapters, etc.). INDSTA will be an integral part and connecting channel of the proposed national STI observatory. INDSTA will be an open-access portal, interoperable with other repositories and will facilitate interactions between researchers and users of the platform. It will have state-of-the-art facilities, including storage, and features to facilitate flexible text and data mining, querying, and visualization.

1.3 Open Data Policy for Publicly Funded Research: All data used in and generated from public-funded research will be available to everyone (larger scientific community and public) under FAIR³ (findable, accessible, interoperable and reusable) terms. Wherever applicable, exceptions will be made on grounds of privacy, national security and Intellectual Property Rights (IPR). Even in such situations, suitably anonymised and/or redacted data will be made available. In all cases, where the data cannot be released to the general public, there will be a mechanism to release it to bonafide/authorised researchers.

³ FAIR "Facets": Data should be Findable, Data should be Accessible, Data should be Interoperable, Data should be Re-usable (<https://www.force11.org/fairprinciples>).

1.4 Open Access: Full text of final accepted author versions of manuscripts (postprints⁴ and optionally preprints⁵) along with supplementary materials, which are the result of public funding or performed in publicly funded institutions, or were performed using infrastructure built with the support of public funds will be deposited, immediately upon acceptance, to an institutional repository or central repository.

1.5 One Nation, One Subscription: The Government of India will negotiate with journal publishers for a “one nation, one subscription” policy whereby, in return for one centrally-negotiated payment, all individuals in India will have access to journal articles. This will replace individual institutional journal subscriptions.

1.6 Indian Journals: Proactive steps will be taken to improve awareness and visibility of Indian journals, and where required, will facilitate the creation of digital versions of print journals to make them more accessible to the international scientific community. Concentrated efforts will also be made to prevent the publication of fake journals.

1.7 Research Facilities: All public-funded scientific resources will be made shareable and accessible nationally with the use of digital platforms. These scientific resources include, but are not limited to research infrastructures, laboratory facilities and instruments, ICT and AI-based resources and high-performance computing facilities.

1.8 Open Educational Resources: Public-funded open educational resources will be made available under minimally restrictive open content license, with the right of attribution preserved and translations (especially regional languages) permitted.

1.9 Libraries: Libraries at public-funded institutions will be accessible to the public, subject only to reasonable security protocols. The public library system will be expanded to all districts with the help of technological interventions.

1.10 Learning Spaces: Learning spaces will be made universally accessible, based on international guidelines and standards, especially for people with special needs. Open and equitable access to all learning spaces (including conference rooms and other infrastructure to exchange and combine ideas) will be facilitated through a meaningful balance of traditional methods and modern approaches. Emphasis will be given to create and strengthen more community-driven learning spaces.

⁴ Post-Print- A “postprint” is any version approved by peer review.

<https://mitpress.mit.edu/books/open-access>

⁵ Pre-print- A “preprint” is any version of an article prior to peer review, such as a draft circulating among colleagues or the version submitted to a journal. <https://mitpress.mit.edu/books/open-access>

Chapter 2: Capacity Development

2.1 Education and Research

2.2 Skill Building and Training

2.3 Infrastructure

Priority Issues

The aspirations of STIP are to fulfil multifarious responsibilities to function collaboratively with all stakeholders; to promote holistic growth and development by developing scientific temperament, quality, access, equity, incorporating citizenship education; to promote linkages between higher education and industry to revamp economic systems; and to build R&D infrastructure, its effective usage with easy and equitable access, is another aspect of strengthening the STI ecosystem. Effective use of advanced technologies is much needed for capacity building to improve learning outcomes, quality of science education, and equitable access, leading to excellence in research and development and innovation. Promoting a more significant interface between science and technology, humanities, and social sciences disciplines is the need of the hour, which will enhance collaboration between S&T departments, the industry as well as educational institutions to promote entrepreneurial skills in vocational education.

Background

STIP aspires to reach towards sustained investments in science and technology that are necessary to inculcate and promote scientific temper, nurture innovations, and cater to the diverse needs of the country. The policy aims to give an impetus to individuals and institutions in achieving top global awards and recognitions over the next decade. This section outlines strategies to accelerate research and innovation in the country, improve our education system and teaching-and-learning through research, and make education at all levels more inclusive and connected with the economy and society. This includes as well as adds to the initiatives in these directions described in NEP 2020.

2.1 Education and Research

There is a need to build an ecosystem in India that is neither dependent nor borrowed but reliant on its own resources, strength and resolution with a pyramidal structure resting on a broad base and not on its apex. Education and research should provide that foundation against failure by inculcating true scientific temper, discipline and honesty, national pride, adherence to the principles of justice, gender parity, ethical practices and spirit of fair competition and brotherhood.

A new culture of Atmanirbharta (self-reliance) that includes Atmavishwas (self-confidence), Atmasamman (self-respect) and Atmachintan (self-assessment) must be inculcated among students at all educational levels.

2.1.1. Cluster School and Innovation hubs in partnership with higher education institutes, private industries and local communities will be created, for sharing resources and capacities relevant to curriculum renewal and faculty development. Innovation and Design Thinking will be introduced in the curriculum. Upcoming and existing innovation related programmes [such as Atal Tinkering Labs and Million Minds Augmenting National Aspirations and Knowledge (MANAK)] will be developed synergistically across schools for better results. Such programmes will be scaled up with a 10 year future looking strategy. These networked initiatives should focus upon addressing different concerns of society.

Innovation and Entrepreneurship Centres will be established starting from the undergraduate level of university education. Research in innovation practices will be made a mandatory component of university/college teachers' professional development programme; The programme will provide faculty development programmes in Innovation and Design Thinking. It will encourage and facilitate university/college teachers for international research collaborations/exchange programmes in STI.

2.1.2 Creative processes to encourage and engage students in science and technology education will be designed. A focused strategy will be developed to inspire pursuing of science and technology education at all levels through a significant cultural transformation within the ecosystem. To enhance Innovation quotient of the country, idea generation and idea transformation ability right from early education will be encouraged.

2.1.3. The policy recommends **representation of the ministries of S&T in the working groups** constituted for the revision of the National Curriculum Framework (NCF) of National Education Policy (NEP) 2020. This would ensure designing appropriate curricula for promoting science education early on in schooling. Similarly, curricula of the teacher education programmes must be synced appropriately to the new learning paradigm.

2.1.4. A National School and Higher Education Mentorship Program will be institutionalized through university-school linkages, showcasing a concerted focus on innovation-oriented education at the school and the college levels. This special vehicle programme will help the process of scouting and nurturing early talent by providing a clear path for career building in science with aspirations for greater achievements. Innovative learning programmes like DHRUV maybe widened in scope and scaled up.

2.1.5 For children with extraordinary intellectual abilities in a specific sphere of activity or knowledge having limited opportunities to enter mainstream education, alternative pathways will be charted to fully realize the achievement of their potential.

2.1.6 Students of all educational levels will be given opportunities to get exposure to be part of leading science laboratories during the period of end-term breaks as part of Scientific Social Responsibility Policy (SSR 2020).

2.1.7. Distance learning programmes will be strengthened with appropriate technological means, in order to improve their quality and reach. Provisions will be made for virtual classrooms, equipped with adequate resources and infrastructure.

2.1.8. National research and innovation programme on Assistive Technologies and Learning Resources to be created. The programme will promote the use of technology to create interactive personalized learning environments, for students with specific learning disabilities at school as well as in Higher Education.

2.1.9. Research Excellence Framework for HEIs in India (REFI) will be evolved, which aims for research assessment to secure the continuation of a holistic, dynamic and responsive research base across the full academic spectrum within India's higher education ecosystem. **REFI** will assess the overall research contributions of HEIs every few years, based on parameters of importance for India. Based on the performance in this assessment, block research grants are given, with the value of such grants calibrated to provide an incentive for HEIs to improve their performance and global standing.

2.1.10. Facilitate **Internationalization of R&D** in India to foster brain gain. More innovative programmes in line with Visiting Advanced Joint Research (VAJRA) and GIAN (Global Initiative of Academic Networks) to be introduced and their scope may be widened for international faculty as well as students. Collaborations will be promoted especially across the global south, to create an environment for global citizenship education.

2.1.11. The transition of education to research will be strengthened by including **basic know-how** – and of skills in science communication – of research as a part of every Doctorate of Philosophy (PhD) course curriculum. A framework for appropriate training and skill building in this realm will be developed for postdoctoral researchers. This will enable them to independently build their career in the STI ecosystem.

2.1.12. Studies will be conducted to analyse and forecast the sectors of demand and scope of career building for PhDs and Postdocs to establish a complete mechanism. HEIs will be encouraged to design integrated programs in Science, Technology, Engineering and Mathematics (STEM) (such as MS-PhD, MD-PhD) to catalyze optimum utilization and retention of human resources in the country.

2.2 Skill Building and Training

2.2.1. To leverage the engagement of higher education systems with the economy and community, all universities will be encouraged to be responsive and respectful to the needs of

the community by conducting interdisciplinary projects involving scientific and technological and social science-based interventions.

2.2.2. ICT and online platforms for skill building are to be leveraged for active learning practices, to promote research and innovation at all levels. Consortiums will be developed for the creation of new online courses, simulations, virtual and remote labs for enabling immersive experiential learning. A library of virtual resources will be developed through community participation for remote areas. National institutes with advanced lab facilities will be invited to develop such resources and make it available for others. Virtual Reality repository can also be developed for this purpose. The repository will be supported with interactive tools, viz. open-source collaborative development platform inviting data visualization, data presentation, data analytics, AI, etc. for easy access.

2.2.3. Development of sector-specific skill-based knowledge support mechanisms for regional communities to sustain the traditional skill and geographical indication.

2.2.4. Inclusion of various groups based on gender, geography, language, disability and social order, to be promoted through special schemes, scholarships, need-based training and orientation programmes.

2.2.5. Innovation and Entrepreneurship centres will be established at regional levels in a collaborative approach with the participation of local Academic and R&D institutions, industries, MSMEs, Startups, etc

2.2.6. Vocationally certified workforce will be employed and recognised by the industry. Such kind of workforce will be incentivised through community grant schemes, by involving independent communities and civil society organisations.

2.2.7. Teaching-Learning Centres (TLCs) will be created in urban and rural areas for upskilling of faculty members, to enhance learning experience and engagement, for effective outcomes. These centres will research on pedagogy as well as design and implement faculty development programmes to improve the quality of learner engagement. Initiative will be developed to recognize and nurture talent at an early age by creating roadmaps with the help of a network of mentors at state and regional levels.

2.2.8. Administrative and management training programmes will be organized for faculties and scientists to overcome functional silos and enhance efficiency of administrative and research activities.

2.2.9. Increased focus will be put upon skill-building through hands-on training. For this purpose, academic institutions will be encouraged to create long-term working relationships with regional MSMEs to address locally relevant issues. Skill development opportunities will be created in mega-science and related futuristic technology development engagements.

2.2.10. Formation of a trained management cadre at the national level for planning, assessing, communicating and executing educational and research activities in HEIs and research organisations. Conducive environment will be created by removing administrative and other barriers for talented young people to take up appropriate leadership roles and participate in critical decision-making.

2.3 Infrastructure

2.3.1. Higher Education Research Centres (HERCs) will be established in reputed research-focused universities/institutes in different parts of the country. These centres should also assess the overall direction of the higher education system in the country, and provide research inputs to policymakers and higher education leaders.

2.3.2. Collaborative Research Centres (CRCs) will be established, that bring together industries, MSMEs, startups, R&D institutions and HEIs with the government. This will provide a long term ongoing collaboration between different STI stakeholders, to improve industrial research and innovation and enhance global competitiveness.

2.3.3. Transforming existing R&D institutions to research universities. This will foster better linkages between research and education and also enable effective utilization of research infrastructure.

2.3.4. Centre and state governments will adopt a **coordinated approach for building and enhancing infrastructure** for science laboratories, computer labs, language labs, libraries etc. This will be achieved through centre-state partnership in order to improve the research competency.

2.3.5. A mechanism for the maintenance of existing R&D infrastructure in academic and R&D institutions will be developed ensuring the more efficient and effective utilization of existing equipment facilities.

2.3.6. Establishing independently and professionally managed, self-sustaining equipment infrastructures across the country. This will provide easy access and assistance on using the Sophisticated and Analytical infrastructure to the Academics, R&D institutions, Industry, MSMEs, NGOs, etc.

2.3.7. In line with the NEP 2020, a mechanism will be created to allow greater academic, intellectual and functional autonomy to HEIs; one that is linked to accountability and also strengthens Academia-R&D-Industry collaborations.

Chapter 3: Financing STI

3.1. Expansion of the STI financing landscape

3.2. Incentivization for STI investments

3.3. STI collaborative funding model

3.4. Governance of STI financing landscape

Priority Issues

India's Gross Domestic Expenditure on R&D (GERD) is low in comparison to the developed nations and most of the developing countries. There is inadequate private sector investment along with inadequate enablers such as direct financial support to the private sector, public procurement strategies, incentives to carry out and participate in R&D activities and mechanisms for hybrid funding models. There is limited leveraging of foreign STI investment and weak overall financial management of the ecosystem.

Background

A robust cohesive financial landscape remains at the core of creating an STI-driven Atmanirbhar Bharat. It is imperative for this policy to work in tandem with the Fiscal and Industrial policies of the Government to attract public as well as private sector contribution to the national STI ecosystem leading to its strengthening. This section outlines financial strategies to achieve such self-reliance and technology competitiveness in alignment with national priorities and aspiration. It recommends the widening of financial outlay through enhancement of public and private (domestic and international) STI investments along with academic participation with a pivotal role of collaborative funding mechanisms. Fiscal incentives and financial support have to be strengthened to stimulate private sector participation in the national STI ecosystem. In order to drive strategic technological growth, STI investments should be aligned with the critical areas of national priority through a centralised programme as outlined in Advanced Missions in Innovative Research Ecosystem (ADMIRE) programme. This process will be strengthened by a national STI Financial Authority through efficient governance aimed at financial autonomy.

3.1 Expansion of the STI Funding Landscape

3.1.1. An STI unit with a minimum earmarked budget will be set up by every department of the central, the state and the local governments, public sector enterprises, private sector companies and startups to pursue STI activities with the larger goal of uplifting socio-economic conditions of all citizens. Each unit will have an operational mechanism and dedicated manpower and will develop plans that align with national priorities.

3.1.2. Diversification and enhancement of extramural funding in alignment with national priorities is critical for expanding the STI landscape with respect to R&D activities. The aim is to double the share of extramural R&D support of the Central government agencies in the GERD in the next five years.

3.1.3. States will intensify participation in the STI ecosystem through enhanced financial engagements. Each State will earmark a percentage of the state allocation for STI-related activities under a separate budget head. Interlinkages will be strengthened between the central and the state governments in terms of resource mobilization and budget sharing.

3.1.4. Public financial assistance is essential to invigorate the STI ecosystem through increased allocation for innovation ecosystems, infrastructure and critical human resource development with a special alignment towards critical sectoral growth.

3.1.5. Private financing: To build a robust innovation ecosystem, private enterprises along with building in-house research capacity, will be encouraged to contribute and collaborate with knowledge institutions to pursue market-relevant research through mutually decided agreements. Industry clusters will be encouraged and incentivized wherever necessary, to engage in collaborative R&D with a special focus on higher TRL projects to aid their transition into equivalent BRLs. It is also recognized that Corporate Social Responsibility (CSR) funds, as well as voluntary financing by big corporates and Indian multinational companies (MNCs) will play a pivotal role as they are utilized to spur contribution to the national STI ecosystem and specifically stimulate the research ecosystem in our education sector.

3.1.6. Foreign MultiNational Companies (MNCs): Foreign MNCs play an integral role in boosting India's economy. To gainfully measure and assess the contributions made by foreign MNCs in the STI financing landscape, innovative methods to capture them will be developed. Opportunities for foreign MNCs to invest in the country's STI landscape will be strengthened and made more accessible. Partnerships and collaborations will be encouraged with domestic private (Small and Medium Enterprises [SMEs] and start-ups) and public sectors entities (HEIs and research organizations) to work on projects aligned to national needs and priorities. The immense potential of foreign MNCs in STI human resource development will be explored through envisaging joint training and skill-building programmes.

3.2 Incentivisation for STI investments

Government-mediated incentivisation mechanisms act as a key stimulator for enhancing R&D and innovation in both the private as well as in the public sectors. The incentivisation instruments can be understood through its funding and execution patterns. Some of the key incentives are underlined below:

3.2.1. Boosting fiscal incentives for industries investing in STI through incremental R&D based tax incentives, tax credit for investing in facilities for commercialization, tax holidays, tax waivers, target-based tax incentive for specific domains, tax deduction, expatriate tax regimes, remodelling of patent box regime etc. There will be a reassessment of the possibility of reviving weighted deduction provisions (of expenditure incurred on in-house R&D).

3.2.2. Enhancing financial support to industry, especially for MSMEs, for pursuing research through innovation support schemes such as matching grants, small business innovation grants (under fast track mode), innovation vouchers (SMEs), direct innovation grants, risk guarantees, with special focus on high risk projects, revenue-based financing, seed grants, loans, research subsidies, equity, research and IPR credits, open innovation scheme etc. Innovation bonds along the lines of social impact bonds could be conceptualized to incentivize the private sector to invest in STI-based startups. All funding agencies will fix portions of their R&D budget to support MSMEs and other technology-oriented start-ups with innovative business models in alignment with national needs and priorities. It is recommended that financial incentives are provided based on stages of innovation involving idea generation, prototype development, pilot innovation and its commercialization.

3.2.3. Flexible mechanism for supplier development programmes for public procurement in all sectors (especially earmarked for Small & Medium Enterprises - SMEs and Start-ups).

3.2.4. Reassessment of regulatory control on STI landscape to promote innovative enterprises. It is recommended that the Central Government re-examine and widen the scope of R&D expenditure. Further, the government may determine the right mix of loan, equity and grants to assist Indian industries for technology up-gradation and commercialization. Further, to attract Foreign Direct Investment (FDI) in STI, reduction in corporate tax rates for foreign MNCs, fast track clearances, easing land acquisitions, adequate means for incorporating FDI etc. will be explored on a need basis.

3.3 STI Collaborative Funding Model

The ADMIRE- Advanced Missions in Innovative Research Ecosystem programme is envisaged to achieve greater socio-economic self-reliance and STI leadership. It will be characterised by portfolio based funding mechanisms which support distributed and localized collaborative mission-oriented projects through a long-term investment strategy with Key Performance Indicators (KPI). All stakeholders of the STI ecosystem including public, private (local and MNCs), academic and other non-governmental sectors will be impactfully engaged in the programme to ensure holistic participation and development of interlinkages. The programme will extend to cross-cutting and critical domains that include but are not limited to (with special emphasis on critical infrastructure support) strategic areas, areas of economic and social security, emerging, sustainable and indigenous technologies and traditional knowledge. The programme will also assist and direct public-private partnerships for the development of STI knowledge-based infrastructure and creative assets. Under the

aegis of ADMIRE, industry-led R&D, with government support wherever necessary, will be introduced. A Ministry or a group of Ministries in consultation with industry/industry bodies will design and execute projects through co-funding mechanisms where they participate equally. National laboratories and academia will be made part of the engagement.

3.4. Governance of STI Financing Landscape

To undertake efficient governing mechanisms for the STI funding landscape, a national **STI Financing Authority** will be created. The centralised authority will play the following roles:

3.4.1. Strengthening financial outlay. A corpus fund will be established for investing in various long and medium-term projects, commercial ventures, start-ups, technology diffusion and licensing etc to address identified priority areas in the STI ecosystem. Central ministries and associated departments lacking dedicated R&D units will establish concerned divisions to augment the overall R&D budget and scope of allocation. An **STI Development Bank** will be created to direct long term investments in select strategic areas.

3.4.2. Streamlining STI financial ecosystem through strengthening and providing greater autonomy to existing funding organisations with the objective of promoting sector specific research along with interdisciplinary and multidisciplinary research. Appropriate mechanisms for funding decisions based on accountable peer review and a balanced expert committee composition in terms of experience, age and gender will be strengthened. The incentivisation system will be characterized by efficient governance to ensure ease in accessibility for private players.

3.4.3. Modification/waiver of General Financial Rules, for large scale mission mode programmes and projects of national importance will be explored. A new model for funding, implementation and monitoring of such programmes will be developed, either as an overarching mechanism or through obtaining cabinet approvals in respect of individual programmes. In addition, certain GFRs will be required to be amended for funding of R&D projects to facilitate ease of doing research.

3.4.4. Time-bound peer reviews along with technical and transactional audits will be conducted from time to time to monitor public financing across various stakeholders of the STI ecosystem. Efficient monitoring and evaluation mechanisms will be put into place for gap analysis to support conducive investment in critical S&T areas. Selection of projects and release of grants will be based on robust evaluation supported by innovative monitoring mechanisms.

3.4.5. Formulation of a mechanism for timely disbursement of grants and regular networking and communication among funding agencies: The disbursement of research grants for scientific projects, fellowships to research scholars and stipends to students carrying out advanced research and higher education are crucial measures to ensure excellence in scientific research,

education and innovation. Timely disbursement of such grants and funding is most important recognition for good research work. In this respect, a fixed annual evaluation cycle of grants and funds disbursement would be effective. Regular interactions and engagements among funding agencies also bridge the gaps in communications and disbursement of funding.

3.4.6. In the Higher Education sector, centralised norms for **allocation of overheads** will be formulated by funding agencies.

3.4.7. The **National STI Observatory**⁶ will encompass an open centralised database platform for all financial schemes, programmes, grants and incentives existing in the STI ecosystem.

⁶Refer to Chapter 1 Section 1.1

Chapter 4: Research

4.1. Expanding S&T system: Promoting foundational and translational Research

4.2. Enhancing the quality of research

4.3. Engaged research

4.4. Ease of doing research

Priority Issues

India should emerge as a globally competitive country in strategic fields of research, while simultaneously focusing on unaddressed and under-addressed nationally important problems. A special emphasis on R&D activities in the priority areas will address the current weaknesses in Indian research and ensure strengthening of key areas relevant to the well-being and prosperity of India and its people.

To become a research leader, India should focus on mission-mode programmes, in priority sectors, with technology and innovation deliverables built on a strong foundation of basic science; ensure that the research is fit for purpose; enhance the quality of research and also increase the ease of doing research.

Background

During the last decade, India emerged as a major knowledge producer, ranking in the top five countries. However, in terms of impact, India's scholarly citations helped it gain a place in only the top ten countries. Similarly, India also featured in the top ten countries in the total number of patent applications filed. However, the research output from India should also be seen in the light of the fact that India has significantly lower FTEs (per million population) engaged in R&D activities and GERD than the leading countries such as the USA and China. The strengths and weaknesses of the Indian R&D ecosystem need to be holistically addressed.. This Chapter outlines strategies to transform and create a fit for purpose, accountable research ecosystem in India within the ambit of a rapidly changing world.

4.1. Expanding S&T system: Promoting foundational and translational research

India will strive to expand its share in the global research output. Apart from continuing to invest in inputs, it would also strive to create a seamless STI ecosystem by adopting a holistic approach that addresses all stakeholders of the ecosystem. To make the R&D system forward-looking, seeding of new research fields in advanced areas will be encouraged such as Mission on Integrated Child Protection Scheme (ICPS). To address key challenges in fields of priority areas of national importance, profound research will be promoted and advocated across the STI ecosystem. Quality foundational research in areas of disruptive potential will

be encouraged. Simultaneously for the relevance of translational research, early direction from government and industry and society would be sought.

Expansion of the S&T system will be done through a focus on 1) priority areas in which India should emerge as a world leader, 2) addressing local problems, and 3) engagement and participation of industry to ensure R&D also aligns with industry needs.

4.1.1 Mission mode programmes with deliverables for technology and innovation will be established in the priority sectors (e.g. Agriculture, Water, Health, Energy and Environment) along with identification of challenges and opportunities in these sectors based on current and future needs. Pathways to leverage the resources in order to achieve the goals will also be identified.

4.1.2. Strong collaborations that build quality science for national problems will be encouraged and frameworks for such mutually beneficial collaborations will be encouraged at both individual and institutional level.

4.1.3. Team science collaboration will be facilitated between industry and academia, with shared financial resources, and risks and benefits. Industry-led R&D programmes in priority sectors will also be encouraged through ADMIRE⁷. Specific technology areas for development can be identified by a ministry or a group of ministries in consultation with industry/industry bodies.

4.1.4. Domestic manufacturing capacity in specific areas of priority sectors will be enhanced through R&D and technology upgrade.

4.2. Enhancing the quality of research

4.2.1. Through Research and Innovation Excellence Frameworks (RIEF)⁸ , research quality will be enhanced by expanding the talent pool and through international benchmarking exercise. Joint appointments across government, academia and industry at both the national and the international levels will be facilitated to attract the best talent into the research ecosystem. Mentoring programmes and supplementary incentivization mechanisms will be developed to guide and motivate early career researchers and young scientists to realize their potential to conduct meaningful research. Risk-taking in R&D will be incentivized and suitably rewarded at the individual and the institutional levels.

4.2.2. Research culture will be reoriented wherein the quality of research will be assessed, recognized and rewarded on the basis of both academic achievement as well as social impact. Research ethics will be given due importance.

⁷Refer to Chapter 3 Section 3.3

⁸Refer to Chapter 11 Section 11.2

4.2.3. Operating and safety protocols related to R&D will be enhanced through the formulation of proper guidelines. Minimal safety requirements for labs will be mandated for upcoming R&D infrastructure.

4.3. Engaged research

The STI ecosystem needs a focus on delivering what is needed, which requires strong engagement with stakeholders (industry, academia, R&D labs and social actors). Research solutions should address a plurality of solutions for different regions/socio-economic strata including a focus on rural problems in the country. It also requires the development of products, processes, technology etc. that incorporates engagement, testing and feedback from the end-user from an early stage in order to ensure uptake, impact and benefit to the society. In addition, a lot of publicly-funded research is largely invisible to target stakeholders such as the line ministries who often contract out research that has already been carried out, but of which they are unaware. Therefore, indigenous utilization of research outputs will be promoted by user-tested development and dissemination of information to the relevant stakeholders. To achieve this, a function will be created to scan and share indigenous research with stakeholders and promote programmes and approaches that are relevant to line ministries. It will also identify gaps and communicate them to research funders. The function will also ensure that user-stakeholders are engaged from an early development stage, particularly for technology projects.

4.4. Ease of doing research

Apart from the primary activity of doing research, researchers also have to spend a considerable amount of their time (and resources) on administrative activities related to research projects. Journal paywalls, and lack of data and knowledge sharing further hampers their ability to freely and easily conduct research activities. To reduce the administrative burden on the researchers, digital platforms and e-governance will be used for grant-management -all activities from award, funding and utilisation of grants to measurement of research outputs. International best practices of grant management will also be explored. Access and sharing of knowledge and resources will be improved through the use of online platforms such as INDSTA⁹, implementing open data¹⁰ and open access policy¹¹, and by enabling access to journals and databases¹². Benchmarks for ‘ease of doing research’ will be developed so that research activities are adequately funded, are less bureaucratic and accountability is in both directions i.e. the donor and the receiver.

Connecting the invention ecosystem with the innovation ecosystem will be emphasised. Further, weakness in the invention and innovation ecosystem will be identified to take research into the market and to the community. Both knowledge pull from the invention system as well as the knowledge push from the innovation ecosystem are necessary to achieve the goal of a vibrant R&D ecosystem in India

⁹ Refer to Chapter 1 Subsection 1.2

¹⁰ Refer to Chapter 1 Subsection 1.3

¹¹ Refer to Chapter 1 Subsection 1.4

¹² Refer to Chapter 1 Subsection 1.5

Chapter 5: Innovation and Entrepreneurship

5.1. Strengthening Innovation Ecosystem

5.2. Fostering S&T-Enabled Entrepreneurship

5.3. Integrating Grassroots Innovation with the Research and Innovation Ecosystem

Priority Areas

Strengthening the innovation ecosystem to attain sustainable economic progress and global competitiveness. Creating an enabling ecosystem for seeding, sustenance, and growth of science and technology entrepreneurship in India. Integrating Traditional Knowledge Systems (TKS) and grassroots innovations into the education, research and innovation system.

Background

Systemic investments in STI are not only critical for creating, shaping, and sustaining the future industrial sectors of the nation but also crucial for delivering the benefits of scientific research for the economic development of the society at large. There is a need for a comprehensive support framework for strengthening and enhancing India's innovation and entrepreneurship landscape by encouraging wider participation in innovation activities, broad basing the funding ecosystem, enhancing interconnectedness and streamlining regulatory regimes. This Chapter outlines strategies for strengthening the overall innovative ecosystem, fostering S&T-enabled entrepreneurship and improving participation of the grassroots levels in the research and innovation ecosystem.

5.1. Strengthening Innovation Ecosystem

The innovation landscape emanating from the socio-cultural, geographical, economic, historical and political contexts will be systematised, strategised and synergised to attain sustainable economic progress and global competitiveness. STI efforts and interventions will be aligned with policies of different sectors and themes, including education, skill development and industrial growth.

5.1.1. The distinct roles of multiple stakeholders including higher-education institutions, research and development organisations, funding agencies, regulatory bodies, non-governmental organizations and business enterprises in the innovation ecosystem, will be recognised and their inter-linkages are to be strengthened, at the national, the subnational and the sectoral levels.

5.1.2. Industry –Academia linkages will be deepened by joint programmes for both academic experts and young scholars with industry practitioners, to harness the expertise and get

practical exposure. Such linkages at the school and the undergraduate levels will further strengthen the foundation laid by the NEP 2020 to foster critical thinking and scientific temper. Provisions for extended sabbaticals in academia and industry will be widely promoted to support knowledge and expertise exchange between industry and academia.

5.1.3. Innovation clusters and technology parks will be developed and leveraged for collaborative activities, cost sharing and Intellectual Property (IP) creation. The stakeholders in these spaces will be incentivised based on performance and periodic assessments.

5.1.4. Theme-based distributed virtual incubators and accelerators will be created in different parts of the country using cluster-based approaches. Such new models of incubators will be supported by adequate financial incentives, mentoring and expertise.

5.1.5. Mission-oriented efforts will be incentivised for tackling various local and/or region-specific issues of societal relevance. Cross learnings across states will be encouraged. This will address developmental challenges and help in realising Sustainable Development Goals.

- i. The investment will be prioritised in “core R&D” rather than “peripheral R&D” especially in the manufacturing sectors.
- ii. Frameworks, scales and measurements will be developed and utilised for assessing innovation. These frameworks/surveys will facilitate integration and diffusion of innovation-led activities at regional and national levels as well as enhance global value chains and networks.
- iii. An ecosystem of R&D and innovation will be created in rural and remote areas, particularly in North East, islands and tribal areas. Research and academic institutions as well as innovation clusters will be built in such geographical locations.
- iv. For promoting gender inclusion in entrepreneurship, avenues will be created to access resources and opportunities for training and mentoring. Equitable provisions will be created for the participation of women in entrepreneurial networks/clusters.

5.1.6. Special focus will be given to creating a conducive environment for sector-specific innovation. Overarching bodies with focus on sector-specific-policies, regulation and trade agreements will be created/strengthened, that can work as a synergistic agency to bring all others on a single platform and push forward the sector-specific agenda with support from the government, the academia, the non-profits, the private partners and the industry. This will help in avoiding overlaps and in developing connections with all the agencies involved in innovation. This will also enable the monitoring and evaluation of the activities. A mechanism for coordination on innovation will be developed among various departments and ministries such as agriculture, animal husbandry, veterinary sciences, entomology, wildlife and forest conservation, health department and related organisations.

5.2. Fostering S&T-Enabled Entrepreneurship

S&T-enabled entrepreneurship-technology-driven, innovation-focused enterprises - is critical for creating, shaping, and sustaining the future industrial sectors of the country as well as delivering the benefits of scientific research for socio-economic development of the society. An enabling ecosystem for seeding, sustenance, and growth of science and technology-enabled entrepreneurship calls for:

5.2.1. Investing in basic, foundational, and reliable physical and social infrastructure for S&T -enabled entrepreneurship to thrive. This includes investments in key infrastructure in HEIs, Scientific R&D laboratories, hospitals, ICT across the country as well as complementary mission driven investments in research and development with S&T-enabled entrepreneurship in critical technology areas. This also includes promoting entrepreneurship education programmes across the country by involving local communities i.e. schools, higher educational institutions, non-profit organizations, scientists, entrepreneurs, and other stakeholders.

5.2.2 The policy will put in position enabling mechanisms for development and growth of a start-up culture by proactive empowerment, infrastructure building and funding opportunities. Incentivization mechanisms will be set up to aid the expeditious conversion of ideas into start-ups.

5.2.3. Inculcating a culture of S&T-enabled entrepreneurship by ensuring provisions for an end to end support to promote enterprise creation. This includes creating a continuum of well-integrated funding and technology support programmes to support science and technology-enabled entrepreneurship from the ideation, proof of concept, and prototype development stages to the testing, validation, and manufacturing stages of innovative enterprises. This also includes enhancing public procurement, supplier development programmes, and corporate open innovation schemes to incentivize innovation from a wide range of participants.

5.2.4. Creation of a nurtured and supportive environment for S&T-enabled entrepreneurship and entrepreneurial ideas to flourish and thrive. This includes encouraging wide-based participation from stakeholders in the STI ecosystem (private sector, public sector enterprises, non-profit organizations, cooperatives, industry associations etc.) but also in leveraging existing domain knowledge and expertise of highly successful STI-based enterprises and entrepreneurs in reaching scale and impact.

5.2.5. Reducing systemic risks in S&T-enabled entrepreneurship through clear, accessible, and current regulatory guidance and providing funding support across all stages of innovation. This includes streamlining overlapping regulatory regimes to ensure compliance for meeting product standards, setting quality controls, reducing barriers to risk capital by innovation-focused enterprises, and fostering wide-based stakeholder support for funding science and technology-enabled entrepreneurship.

5.2.6. Enhancing consistency, speed, clarity, and transparency in programme delivery for early-stage S&T-enabled entrepreneurship. This includes streamlining and consolidation of overlapping schemes, enhancing awareness, and reducing bureaucratic hurdles in accessing existing schemes. A centralised database on all forms of financial incentives will be made available to promote incentives for innovation and enable continuous monitoring and evaluation of program performance.

5.2.7. Creation of globally competitive innovative enterprises by stimulating investment towards building indigenous technological capabilities across a diverse range of S&T-based entrepreneurial activities. This includes a national level strategic approach to incentivize geographical concentrations of interconnected companies and institutions in technological and product markets which complements a focussed localized strategy to enable flexible structures, incentives, processes and culture towards improving commercial viability in science and technology areas.

5.3. Mainstreaming Grassroots Innovations and Traditional Knowledge Systems

For integrating Traditional Knowledge Systems (TKS) and grassroots innovation into the overall education, research and innovation system, an institutional architecture will be established in different technical and research institution campuses, to recognise and involve grassroots innovators, which in turn will inspire students to innovate. Avenues for collaborations between grassroots innovators and scientists will be initiated/facilitated through joint research projects, fellowships and scholarships. Also, crowdsourcing will be encouraged, wherever possible, to improve the innovative capabilities and productivity.

5.3.1. Advanced tools based on machine learning and AI will be used for curation, preservation and maintenance of heritage knowledge. Scientific and technical collaborations of the Ministry of Culture with scientific ministries will be promoted to find solutions for recreating and maintaining the heritage and TKS.

5.3.2. Assessment, testing and vetting of various kinds of traditional knowledge applicable in agriculture, biodiversity, healthcare, climate change and other locally relevant thematic areas, will be encouraged.

5.3.3. National strategic resource management through the Medplant E-Consortium of vital plants will be created for distribution, availability, sustainability, and vulnerability of vital medicinal plants. A focus to secure and sustain the demand-and-supply succession of vital medicinal plants of commercial use for allopathic medicines will be facilitated.

5.3.4. The Grassroots innovators will be supported for registration, claiming the IPR, filing of patent, or any type of legal claim with the help of HEIs. Training for marketing their

innovations, establishing start-ups and market networks in the territories of tribal hamlets and placing adequate systems for quality control and standardisation will be developed to support grassroots innovations.

5.3.5. Avenues for entrepreneurship development will be created to foster a vibrant grassroots startup ecosystem. Incubators and accelerators will be incentivised to support scaling up and commercialisation of grassroots innovations, developed by social R&D organisations. This would generate opportunities to innovate full-fledged alternative solutions to local problems.

5.3.6. Technology Parks will be built to serve as a centre for demonstration, communication and technology transfer. It will also be responsible to train personnel on locally relevant technology development and management.

5.3.7. New funding mechanisms will be developed and investment in knowledge intermediaries/Extension and Advisory Services (EAS) will be made and knowledge sharing platforms will be expanded.

5.3.8 New fiscal incentives, financial schemes, subsidies will be examined to commercialise innovation and catalyze investments into R&D.

5.3.9. Research efforts will be encouraged for developing cost-effective technologies and encourage grassroots innovations to reduce drudgery, address the scarcity of farm labour, and improve efficiency in sectors like agriculture, water, and energy.

Chapter 6: Technology Development and Indigenisation

6.1. Technology Indigenisation for Atmanirbhar Bharat

6.2. Technologies and Sustainability

6.3. Strategic Technologies

6.4. Disruptive Technologies

6.5. Critical Sectors and possible approaches

6.6. Enhancing technology development in the academic sector

Priority Issues

India is largely dependent on the import of technologies in the priority sectors. The TRLs in the country is low as compared to its global counterparts due to lack of interface systems, inadequate technology capacity, poor quality of research outcomes, weak linkages and procurement policy clauses. There are additional challenges in leveraging India's participation in mega-science projects in terms of building technological core competence domestically and translating those know-hows to benefit other sectors.

Major hurdles for India in achieving technology indigenisation are: unbalanced allocation of resources between academic and Post-academic Research (PAR), unavailability of trained human resources, weak interconnect between stakeholders, lack of effective strategy for development, deployment and commercialisation.

Background

This chapter outlines strategies for strengthening India's STI ecosystem to achieve the larger goal of "Atmanirbhar Bharat" through technology self-reliance and indigenisation. This will play a vital role in enhancing our capability to successfully tackle socio-economic and environmental challenges. To achieve this, India needs to embrace a culture which respects industrial work by faculty and students, and new technology tools such as artificial intelligence, biotechnology, green manufacturing, cybersecurity, and collaborative robotics, relearn, implement and build upon traditional methods that are proven in the national context and intensify systemic interlinkages to catalyse technology scaling up and mass deployment.

6.1. Technology Indigenisation for Atmanirbhar Bharat

Aligned to national priorities along with the aim of achieving a self-reliant economy, a two-way approach to technology development will be adopted: a) developing indigenous technologies and b) adapting imported technologies. There will be increased focus towards promoting efforts in the development and demonstration of indigenous technologies, development of capital goods and absorption of imported technologies. Further engagement

of Indian diaspora in the development of technology through reverse brain drain, circulation, and skill transfer will be encouraged.

A facilitating policy environment will be created to strengthen and scale-up the on-going as well as forthcoming large technology missions such as waste-to-wealth, deep sea exploration, quantum frontier, AI mission, translation technologies for Indian language and biosciences for human health, etc.

6.1.1 Indigenous Development of Technology

The policy will focus on the indigenous development of technology premised upon assessment and understanding of societal needs keeping in context evolving solutions to people-centric problems. Indigenous innovation/development of critical products/components will be strengthened by the sharing of work between collaborating agencies, technology institutions and industry with funding raised primarily from the stakeholders. Indigenous technologies will also be promoted even if better technologies exist internationally.

Key products or components imported by Indian companies for their manufacturing plants will be identified and a provision will be made to fund such product-based R&D with industry-academia collaborations or through industry – academia consortiums. Existing mechanisms will be strengthened or new mechanisms, if needed, will be evolved to bring in Indian industry-both private as well as Public Sector Undertakings (PSUs) to help bridge the gap from lab to indigenous manufacturing capacity. This will enhance India's export capacities and strengthen its global value chain.

6.1.2. Technology Indigenisation

To strengthen India's local R&D capabilities in the production of technologies that are largely being imported¹³, infrastructure will be set up and existing mechanisms will be strengthened to adapt existing technologies to suit the local needs. This will primarily meet the needs of technology production as well as reduce large scale import in selected sectors of domestic importance such as electronic hardwares for home appliances, railways, intelligent transport, cleantech, defence, etc. Initiatives like building a robust semiconductor ecosystem will strengthen India's position in the strategic sectors.

6.1.3. International Engagement for Technology Development and Adaptation

More focus on gaining access to the international knowledge base by importing technology in disembodied form as technological know-how will be ensured. All institutions involved in

¹³ Indigenization of technology will focus on two major categories:

- a. Indigenization of product (eg. aircrafts, warships, etc.) in large platforms by national R&D labs like DRDO, DAE, and so on
- b. Indigenization of individual subcomponents of system (eg. turbines, sensors, etc.) by academic labs, industry, and startups

Mega Science Projects will be required to invest in effective collaboration modality from conceptualisation to delivery to acquire the scientific capability which would promote indigenous development of technology. Adapting and commercialising technologies based on mega science IP can create the momentum needed for the Indian ecosystem with a focus on domestic demands and environment. Further, institutional mechanisms will evolve to encourage collaborations with the diaspora for technology development. Promotion of global to local linkage can only strengthen the Atmanirbhar strategy of the Government.

6.2. Technologies and Sustainability

India needs to develop and deploy **sustainable technologies** at a faster rate to successfully tackle the major socio-economic challenges and changing aspirations of the people. Along with this India has to **develop and deploy those technologies indigenously which aim for bringing sustainability and inclusive growth benefiting the society at large**. Thus, there is a need to create a conducive environment which ensures that sustainable development and technological progressions complement each other and enable inclusive and bottom-up innovations with collective efforts of various stakeholders including knowledge generators and knowledge user agencies and institutions. The policy aims to bring interplay between technology and sustainability and its impact on society, environment and economy. It attempts to provide pathways to promote sustainable technology development as well as achieve sustainability through effective process approach of technology delivery for green and affordable technology solutions and absorption for mass application leading to a better quality of life and services.

There will be a **technology support framework** that will build on the excellence of India's basic level research expertise through assisting small and large public and private players to innovate, commercialize and deploy need-based technologies, including indigenous technologies, at speed, scale and effectiveness to meet UN-SDGs and national priorities. Sector-specific working groups will be formulated to advise on the assessment of key sustainable technologies and prioritize UN-SDGs deficits to bridge the systemic gaps across the stakeholders. There will be a focus on technologies with a potential for large scale change, either in numbers or in enhanced resource use efficiency or management and utilization of wastes for a circular economy. This will require the **establishment of Guidance and Tools to assess technologies across sectors through the Sustainability Guidance Platform** at national and regional levels, which assesses their social, environmental and economic value impacting sustainability at the evolution, deployment and adoption stages. Development and promotion of better resource management in priority sectors like water, agriculture, climate change, and energy will also be taken up. Both in the urban and rural sectors, partnerships to enhance technology investments in smart and sustainable communities will be facilitated to ensure CSR and social scientific responsibility together.

On the other hand, the development of sustainable technologies should be of paramount importance for India's ICT sector. **Institutional mechanisms for development and**

promotion or flow of sustainable technologies will be created across the country to promote development as well as up-gradation of existing indigenous and traditional technologies directed towards the attainment of UN-SDGs and national priorities as well. These institutional mechanisms will play a vital role in the **validation and certification of sustainable technologies for mass scale replication, predictive analytics and adoption at the users' level**. Sustainable technology development addressing social and environmental concerns will also aim at **financial sustainability** that will lead to the creation of affordable and accessible technologies with a specific focus on **frugal innovations** and frugal technologies with triple bottom line impact. In addition, the use of sustainable technologies for resource efficiency will be widely adopted and advocated. This process will involve the creation of standard guidelines for collection, handling, processing and recycling of waste along with efficient and sustainable use of natural resources by nurturing local skills and capacities to the next level.

6.3. Strategic Technologies

Acquiring technological capabilities is a dynamic process which is essential for the development of a country. The regional and global geopolitics along with the economic dynamics and fast-changing technologies trigger the concept of Strategic Technologies for a State. India being a fast-developing country and aspiring to become a global superpower faces difficult and bigger geopolitical and economic challenges. It is vital for the country to increase its technology potential in strategic sectors such as space, nuclear, cyber, biotechnology, etc. and hence needs a careful policy approach. Also, whenever India acquires technology from abroad, there should be an indigenisation plan for the product so as to avoid the import of the same item including its versions in future. This is to emphasize that the Country cannot depend on the import of strategic technologies from abroad forever. Strategic technologies can be bought only if they are inevitable once but not as a routine. The expertise of academic and industry needs to be effectively utilized in the strategic sector and an overarching body can play an important role to have better coordination in technology selection, development, utilization, commercialization and also establishing coordination with different stakeholders.

6.3.1. Strategic Technology Board (STB)

An overarching body, “Strategic Technology Board (STB)” will be constituted to act as a connecting bridge between different strategic departments and to monitor and recommend technologies to be bought or indigenously made in the strategic departments or in private sector or in academic institutions in line with self-reliant India. The Board will have the responsibility to prepare a roadmap for the strategic requirements of the country and also monitor its implementation. The roadmap will guide the development processes leading to technology development. It will also be chartered to ensure there is no duplication of technology development amongst departments, research institutions and deep participation of

academics and private sectors in strategic technology development. Both the requirements and the technologies will be benchmarked against global status.

6.3.2. Strategic Technology Development Fund (STDF)

A Strategic Technology Development Fund (STDF) will be created to encourage the private sector and HEIs to develop strategic technologies. It will be managed by the independent body Strategic Technology Development Board to avoid conflict of interest. The funding will follow a clear policy on the innovation life cycle. Appropriate policy in consultation between the Department of Higher Education and the strategic departments will be framed to enable the students who have experience in strategic projects more than three years, to have the necessary weightage to join the strategic departments.

Public agencies sponsoring the effort behind any innovation have to play a role in identifying an industry partner to take the innovation to market. The STDF will fund twice a year for pre-specified goals, provide guidance, and monitor the progress of the project/s continuously, while STB will review the project and ensure it is taken for a logical conclusion to utilize the technology. An e-platform for selection of innovators and beneficiaries to meet and interact will be created to facilitate this process. Identified academic institutions will have a number of project posts to work in this area and an appropriate policy may be framed to enable the students who have considerable experience in strategic projects to get necessary weightage to join the strategic departments.

6.3.3. Partnership with HEIs and Private Sectors for Strategic Technology

The strategic sectors will be extended beyond the government departments to HEIs and private sectors to enhance innovation in the strategic sector. Departments like the Department of Atomic Energy (DAE), Department Of Space (DOS), and Defence Research and Development Organization (DRDO) will be tasked to undertake certain developments only with industry and academic partners. The induction of industry and HEIs will be restricted with protection clauses, in order to enhance the nation's growth and to avoid dependence on other nations for strategic technologies. Institutions will put up necessary infrastructure such as security measures to start with. They will be required to follow minimum acceptable scientific or ethical standard and safety certification protocol. **The potential expertise of the academics and industry will be tapped to undertake the design and developments with necessary non-disclosure agreements, for the benefit of the country.** Further, private sectors will be encouraged to compete in the global market space under national guidance. **A strategic export policy to enable private players to thrive in the international market will be formulated.**

6.3.4. Spin-off Technologies for Civilian Use

Mission oriented projects and technologies developed for the strategic sector lead to a lot of spin-off technologies and there is an opportunity for start-ups and government to add commercial value to it. **A peer group under the guidance of the STB will decide which technologies are suitable for such transfer, possibly with the involvement of the appropriate industry for cost effectiveness.** While all strategic sectors have a mechanism to progress spin-off technologies, they will be strengthened to give a boost to the process.

6.3.5 Strategic technologies and critical data resources: Application to society

Several strategic technologies and critical data sets such as those produced from geospatial activities and studies will have wide ranging applications to the society. Considering the country's rich demographic dividend, concentrated efforts will be made to utilize the potential of such critical resources to indigenize and innovate key tools, infrastructure and applications.

6.4. Disruptive Technologies

Emerging technologies that are disruptive in nature have transformational impact on society, economy and environment. The focus will be on innovative strategizing, development, standard setting and governance of such technologies keeping in background the lessons drawn from other technological interventions.

6.4.1. Mission mode schemes/programs will be launched to propel the development and deployment of frontier disruptive technologies such as blockchain, AI, 3Dimensional (3D) printing, Quantum Internet of Things (IOT), etc. that impact society and the economy across the sectors.

6.4.2. A coordinated technology governance mechanism will be put in place to synergize the policy decisions among various stakeholders, national as well as global, about technology development, procurement and deployment, and involve industry, academia and government.

6.5. Critical Sectors and possible approaches

Keeping in mind national priorities, in some key sectors such as agriculture and animal husbandry, water, education, biotech, pharma and health, biodiversity, climate change and environment, and manufacturing and small-level starts up will be encouraged. **The Government will use the knowledge and evidence-based approaches by developing a cadre of practising scientists and technologists who are dedicated full time to curating and updating knowledge and its application in emerging sectors.** These teams of scientists can work to collect and present the most relevant and important information to address current challenges. One possible approach to frame it, could be in the form of fifty prestigious science policy fellowships at the mid-career senior level, where academics, industry personnel and NGO scientists/technologists will be encouraged to undertake such challenges.

6.6. Enhancing Technology Development in HEIs

Indian universities normally do not pursue R&D beyond TRL-1. There is a huge gap in the domain of commercialisation. **Funding mechanisms will be created to pilot the technologies developed in academic/research institutes.** Understanding of TRL among scientists, researchers, developers are different, the languages, risks, and scales of funding are different at various levels - university level, industry level, and the grassroots. Communication and collaboration gaps among the levels will be bridged to create a conducive environment for translational research. Novel ways with institutional linkages for translational research leading to new startups and scaling-up opportunities will be recreated wherever necessary. Additionally, the funding agencies will be encouraged to introduce sector agnostic, but stage-specific schemes supporting all stages of innovation. A provision allowing stage-specific lateral entry into the schemes will ensure that a scientist/researcher has the clarity and liberty to reach out for support based on the 'Readiness Level' of the project. In accordance with India's policy priorities, a balanced approach in inducing efforts and investments across the TRLs and BRLs will be undertaken.

Chapter 7: Equity and Inclusion (E&I)

7.1. Mainstreaming Equity and Inclusion

7.2. Institutionalising Equity and Inclusion

7.3. Assessing Equity and Inclusion

Priority Issues

There is an inequitable participation in STEM with respect to gender, social, regional and economic diversity in India. Moreover, there is also an absence of an inclusive culture in the practice of science, besides inadequate incentives and institutional arrangements. Lack of E&I related assessment indicators, frameworks and instruments also exist.

Background

In the Indian context, equity and inclusion in STI originate from the wide socio-cultural and economic settings and contexts. The need for Equity and Inclusion in STI is an addition to India's on-going efforts to build equitable STI capacity and capability as well as to create social, industrial and territorial inclusivity in the processes of STI. Drawing inspiration from some of the interventions like Stand up India (2016), Technology Vision 2035 (2016), Scientific Social Responsibility Policy 2020 (SSR 2020) and the recent National Education Policy (2020), the STI Policy aims to address discriminations and inequities based on gender, caste, religion, disability, geography and language for the advancement of STI.

While E&I is brought in an all-encompassing manner in earlier chapters, this chapter highlights some aspects of E&I which need explicit mention. It discusses policy interventions to bring about structural and institutional transformations for the participation, promotion, retention and incentivisation of excluded and marginalised groups, particularly the vulnerable sections of the society.

7.1. Mainstreaming Equity and Inclusion

E&I should be added as a *sub-text* to all STI policies and processes (*existing and upcoming*), designed to create and nurture a vibrant STI ecosystem, in an inclusive manner. It will be the foundational element of the STI ecosystem. The policy will foster equitable and effective participation, promotion, retention and incentivisation to do science and innovation, which include traditional knowledge and address inequities in STI, stemming out from the country's socio-economic and cultural landscape. E&I in STI is not only to be seen from the point of view of correcting historical injustices and compensating for earlier deprivations, but also to make real impacts such as to increase the number of FTE researchers and to contribute to socio-economic development.

7.2. Institutionalising Equity and Inclusion

Taking into consideration inequalities stemming out from the country's socio-economic and cultural landscape, **an E&I Charter will be developed for tackling discriminations in STI, based on gender, caste, religion, geography, language, disability and other exclusions and inequalities.** The Charter will be India-centric, drawing essence from different E&I frameworks like the Athena SWAN (Scientific Women's Academic Network) Charter¹⁴. It will aim to create a cognitive thrust among STI related institutions, for recognising their commitments in promoting equity and inclusion and address hindrance in the advancement of STI.

7.2.1. Creating Inclusive Culture

- i. There will be equal opportunity in academics for women along with candidates from rural – remote areas, marginalised communities, differently abled groups, irrespective of their caste/creed/religion/race.
- ii. Enhanced representation of women, at least 30% of the total strength, in all decision making bodies including selection and evaluation committees will be mandated.
- iii. A specific highlight will remain upon promoting talented women scientists in leadership positions across research and science administration to create inspiration for women aspiring to pursue science careers.
- iv. The Lesbian, Gay, Bisexual, Transgender, Queer (LGBTQ+) community to be included into all the conversations related to gender equity. Provisions will be made to safeguard their rights and promote their representation and retention in STI.
- v. Differently-abled individuals, including Divyangjans, will be given special attention. Institutions are to be mandated to make structural and cultural changes for supporting such excluded groups, in order to pursue and practice STI.

7.2.2. Networks for Awareness, Outreach and Mentorship

- i. Efforts will be made to attract young women/girls and other excluded groups (in school – early college) and foster awareness and interest in STEM fields and eventually, careers in science.
- ii. Relatable, relevant role models are to be created and existing role models and mentorship programmes will be scaled up.
- iii. On-going initiatives in different public and private institutions, science academies, etc. are to be scaled-up. Partnerships will be created with existing agencies and institutions involved in such activities, at national and international levels. Adequate funding and resources can be allocated to promote and sustain such networks.

¹⁴ The Athena SWAN Charter is a framework established in 2005 in the United Kingdom (UK). It aims to help and encourage institutions in achieving gender equality. It supports the promotion of inclusive working practices that can increase retention of valued academics and professional and support staff, demonstrating the institution's commitment to an equitable working environment. The framework has been adopted by various countries like Ireland and Australia (the SAGE initiative). India is working towards contextualising a similar framework to mainstream and institutionalise E&I in STI.

7.2.3. Recruitment, Retention and Promotion

- i. Ageism-related issues and minimisation of career breaks are to be addressed for effective retention of trained women into the STI workforce. In this case, all professional career milestones, such as recruitment, awards and funding schemes, age cut-offs will be implemented considering academic age rather than biological/physical age. This will not restrict to gender but will include a broader context.
- ii. Dual recruitment policy will be encouraged in all governing bodies, funding agencies, so that couples do not face the challenge of ‘choosing’ a spouse's career over theirs. The aim is to bring gender neutrality through such interventions.
- iii. Flexibility in work timings and adequate parental leave will be provided to cater to maternity, childbirth, child care and other emergent needs. Childcare benefits should be gender-neutral.
- iv. The LGBTQ+ community will be entitled for spousal benefits (including retirement benefits) to any partner irrespective of their gender (specified by the STEM employee).
- v. All public-funded research institutions and universities to have a daycare centre for young children of employees and also provision for elderly care, wherever applicable.

7.2.4. Institutional Mechanisms

Based on the principle of the Charter/framework, an institutional mechanism will be created to bring about diversity, equity and inclusion in STI. It will aim to remove barriers to participation, promotion and incentivisation and ensure the recruitment, retention and effective engagements of the excluded groups and marginalised communities. The given mechanism will also take into account the following aspects:

- i. Provisions will be made for sensitisation, orientation, counselling with regard to gender, sexuality, ethnicity, language and disability, prior to initiation of training, education, recruitment and/or funding. Ethical training on sensitivities of various biases-invisible or otherwise- must be imparted to all.
- ii. Regulatory provisions are to be strengthened for ensuring examination and enquiry of complaints about discrimination, biases and harassment. It will be followed by disciplinary action proportionate to the severity of the offence, as is done for other forms of ethical misconduct.

7.3. Assessing Equity and Inclusion

7.3.1. Concerted and collaborative efforts are to be made with institutions having expertise and knowledge in E&I-related research. The collaboration of researchers in gender studies, social sciences and science policy with scientists will be encouraged to understand E&I-related gaps and barriers.

7.3.2. Frameworks, instruments, databases and indicators will be developed to understand E&I-specific issues in STI and provide evidence to related STI policies and practices.

7.3.3. Statistics will be collected on drop-out rates of women, Divyangjan community, socially and economically backward communities, individuals from remote areas and other marginalised groups in science education and research. E&I data will include, but not be limited to, sex-disaggregated data on STI, data on suicide rates and mental health issues in STI.

7.3.4. Academic and professional organisations will be encouraged to conduct gender audits and social audits, to propel the organizations to proactively promote gender neutral recruitment and retention of employees, for ensuring equitable, not necessarily, equal representation. These processes will have adequate representations from all marginalised and excluded groups, to address issues of E&I in a more cohesive manner.

Chapter 8: Science Communication and Public Engagement

8.1. Capacity building

8.2 Research

8.3 Outreach

8.4 Mainstreaming Science Communication

Priority Issues

There exists a disconnect between science and society at large with limited scope for citizen engagement in the STI ecosystem. The scarcity of professional and vibrant science outreach and education programmes, along with limited science communication¹⁵ systems for addressing language and regional diversity of India hampers the understanding of grassroots issues. The dearth of online and multimedia platforms for reciprocal engagement between scientists and society act as a barrier to taking science to the masses equitably and inclusively.

Background

It is the fundamental duty of every Indian citizen to "develop a scientific temper, humanism and the spirit of inquiry and reform". In alignment with this constitutional requirement, there is an overarching aspiration to address social problems using STI. Although there are several existing mechanisms and institutions for science popularisation, communication gaps still exist between scientists and society which hampers citizens' participation in scientific endeavours. Science communication has the potential to bridge these gaps. Hence there is a need for creating awareness and recognition for science communication as a field of practice, building a strong research ecosystem in the field, developing a mechanism for training and capacity building, networking and mentorship. STIP recognises the need for scientists to engage effectively with the general public and is keen to ensure that such engagements are fruitful. It aims to revitalise the science communication ecosystem and promote the reciprocal relationship between science and society by the democratisation of science through upstream engagement and a citizen-centric approach. This Chapter outlines strategies to mainstream science communication and public engagement through capacity building avenues, research initiatives and outreach platforms.

¹⁵ Science communication mentioned here includes science outreach (dissemination of scientific knowledge to non-expert audience through science popularisation activities and science journalism) and science inreach (expert to expert communication of research findings through scientific writings and deliberations).

8.1. Capacity Building

8.1.1 Creative and cross-disciplinary platforms of Science Communication will be promoted and facilitated to make STI accessible to all. Such platforms would enable dialogue and knowledge transfer between researchers, science communicators and the public, raising awareness on local issues and facilitating necessary behavioural change.

8.1.2 Citizen science projects, stakeholder consultations, co-creative experiences, and policy interventions will be supported. **Community-centric programmes and regional science centres will be encouraged to promote science communication in regional languages with** local and hyper-local contexts for last-mile connectivity.

8.1.3 Infrastructure for training and capacity development for science communication will be created to conduct and facilitate courses, workshops, internships, Massive Open Online Courses and mentorship. Short term courses in science communication will be introduced appropriately at all levels of education.

Science communication **skill sets** will be incorporated as a necessary component for different levels of scientific training starting from school level and progressing through undergraduate, graduate, postdoctoral, professorial, etc.

Appropriate incentives for career progression and continuous professional development opportunities for science communication professionals will be provided.

8.1.4 Dialogue will be facilitated and promoted to discuss themes at the intersection of science and society by developing centres, programmes, workshops, and talks. A dedicated national conference for science communication as well as science communication sessions within scientific conferences will be organised to build a network of science communicators and facilitate the exchange of knowledge, skill and experiences.

8.1.5 Publicly accessible, constantly updated, and searchable databases of science communication-related resources and opportunities will be facilitated.

8.2 Research

8.2.1. Cross-disciplinary research on science communication will be facilitated through national programmes, centres, research grants, fellowships, and positions. Themes like critical thinking, countering misinformation, promoting scientific temper, and frameworks for evaluating Science Communication will be encouraged.

Research would also involve **identification of the barriers** to science communication including **stereotypes** particularly for women involved in Science Popularisation activities, and mechanisms to promote engagement between scientists and social scientists.

High impact, open access academic journals for publishing science communication-related research will be popularised.

Science communication research requires **locally relevant and culturally-context-specific models** for public engagement in regional languages.

8.2.2 Learning and collaborations for intertwining science engagement and science pedagogy will be facilitated to improve science teaching and for the better incorporation of the history and philosophy of science, scientific method and critical thinking within science education.

8.2.3 The scope of **entertainment platforms** such as folk arts, theatre, dance, poetry, comedy, comics, maps, community radio, interactive digital platforms will be explored for the dissemination of scientific knowledge.

8.3 Outreach

8.3.1 In line with the national policy on *Scientific Social Responsibility (SSR 2020)*, scientists and researchers will be motivated and incentivised to engage in Science Communication and Public Engagement Activities. Institutes and organizations will be encouraged to earmark a percentage of allocated budget (SSR fund) for science communication and public engagement activities.

8.3.2 NGOs and other civil society groups will be involved for popular science programmes and citizen science projects at the local and regional level that include environment monitoring, biodiversity mapping, etc. Innovative ways of involving a variety of stakeholders such as politicians, NGOs, industry and social scientists, in such outreach programs and projects will be explored.

8.4 Mainstreaming Science Communication

Despite several attempts to popularise science, mainstreaming of science communication has met with little success. There is a need to bring such activities from the periphery to the forefront.

8.4.1 A national level science movement for popularising science among students and inculcating interest for the sciences among the masses will be launched. This will include organizing science festivals, exhibitions, plays, webinars and other creative modes of engagement to make science learning exciting. The focus of the movement is to motivate

children and youth to pursue science careers. Similar movements may be initiated by States and Union Territories (UTs) individually and in collaboration with the Central government.

8.4.2. The existing science museums infrastructure will be strengthened using advanced technologies such as augmented reality and virtual reality, etc. through collaborative efforts among relevant ministries. Efforts will be made to build a museum of natural history to make people, especially young individuals, aware and enthused to pursue learning in sciences.

8.4.3 Every public-funded institution and department will have a dedicated wing set-up for science communication and public engagement in STI-related activities.

8.4.4 Funding channels will be diversified through Public-Private Partnership (PPP) models to promote science popularisation activities.

8.4.5 Science Media Centres will be established at national and regional levels as an interface between media persons, scientists and science communicators that can enable mainstream media to increase its coverage of scientific topics.

Chapter 9: International STI Engagement

9.1. Participation in Global STI Agenda Setting and Governance

9.2. International Bilateral, Multilateral and Regional Engagements

9.3. Participation in Large S&T Initiatives

9.4. Engagement with Indian Diaspora

9.5. Proactive STI Diplomacy Strategy

Priority Issues

The changing and challenging global STI landscape has created issues related to technology governance, standards, ownership, ethics, dual-use and market access. Formulating a dynamic, evidence-informed and proactive international S&T engagement strategy and associated facilitating mechanism are crucial to keep pace with the changing global scenario. There is a pressing need to play a more proactive role in global STI governance, including agenda and standard setting for frontier S&T areas.

India's international S&T engagements will

- i. recognise intertwining of **academic** and **post-academic**¹⁶ research. International STI engagements will emphasize on application-oriented research to provide economic, social, environmental solutions.
- ii. focus towards technology indigenization.
- iii. focus on emerging and need-based technology areas to develop and strengthen the technology base of the country.
- iv. be based on the concepts of “equal partnership” and “value-positive narrative” as appropriate. Wherever desirable, India will play an agenda-setting role.
- v. have a strong focus on application in the near term as a developing country, even as long-term perspectives continue to drive academic research.
- vi. focus on generating relevant outcomes for the country's developmental needs.

This chapter outlines strategies for strengthening India's STI engagement internationally.

9.1. Participation in Global STI Agenda Setting and Governance

9.1.1. India will take up a proactive **agenda-setting role in global S&T discourse, including, but not limited to, standards and regulations** - particularly, concerning emerging, disruptive, critical, futuristic and dual-use technologies and their application areas. A focus will remain on boosting technology competence and adaptation that will catalyze the achievement of national priorities. India will participate in major international projects and

¹⁶Research is classified into Academic Research (AR) and Post-Academic Research (PAR) which are intertwined. PAR embraces and motivates contextual AR. AR and PAR can be compared to NASA TRL scale. TRL1 corresponds to AR and the rest to PAR.

alliances, preferably as a founding member in the forthcoming ones, and support such partnerships financially, wherever appropriate. India's position and engagement with leading international agencies, including various UN bodies, Organization for Economic Co-operation and Development (OECD) committees, and World Bank groups etc., will be strengthened.

9.1.2. Priority areas will be identified for international engagements to contribute to UN-SDGs. International STI engagements will also be aligned with national SDG strategies.

9.1.3. Data aspects, in all its forms, will be considered carefully in all the international engagements, keeping in view the balance between various aspects including privacy, ethics, ownership, sharing research data, academic freedom and very importantly, national security. Given the range and volume of data that Indian population contributes, India will play a proactive role in the global discourses on (a) use of data as a tool for negotiations and (2) data governance and regulatory frameworks.

9.1.4. India will seek active participation in the global **technology control regime** and intensify the efforts for membership in strategic alliances.

9.2. International Bilateral, Multilateral and Regional Engagements

9.2.1. Taking various external factors into consideration, dedicated and customized engagement strategies will be adopted for bilateral, multilateral and regional/ neighbourhood S&T engagements. Existing engagements will be adapted accordingly.

9.2.2. Engagements will emphasize on being **sector/issue -focused, mission-oriented**, time-bound, and with identified deliverables. Role of industry and academic players will be identified, and their perspectives and requirements will be included at every stage of the engagement. Successful domestic sector-specific industry-academia cluster models will be emulated and scaled up in international engagements as well.

9.2.3. STI policy will be closely aligned with foreign policy priorities particularly in regional and neighbourhood S&T engagements. People-to-people connection with expert collaborations would be the core of such engagements.

9.2.4. Using the country's S&T strength as soft power to its fullest potential, India will strive to take leadership roles in multilateral and regional platforms, wherever desired and needed.

9.3. Engagement in Large S&T Initiatives

Large S&T Initiatives have multiple objectives, such as addressing some fundamental issues in science by participating in international collaborative research, developing cutting edge technologies, establishing scientific facilities of international standard in India, training of researchers, engineers and industry professionals, design and delivery of major precision

equipment for these and utilizing spin-off technologies emanating from them towards societal benefits.

9.3.1 To make India self-reliant in cutting edge technologies and setting-up world class scientific infrastructure, India will participate in the large S&T projects from the position of strength. Synergising the strengths of scientific capabilities and forging innovative paths in association with industry are essential for India to attain a leading position in technology and commerce.

9.3.2 Major projects in key areas having larger societal impacts will be thoughtfully planned as medium and long-term **home-grown projects** in target-specific indigenous developmental areas like food and water security; health-care; clean and affordable energy, rural and urban amenities and communication and connectivity. This will be attained by leveraging the expert base of many research areas, who could engage in collaborative and cooperative work to achieve a well-defined goal.

9.3.3 A pragmatic approach will be followed in selecting and committing to international S&T projects-considering national scientific interests, technological capabilities, and availability of financial and manpower resources. For a seamless translation of laboratory science to production activities, enhancement of necessary capabilities in industry and handholding by the scientific community is recommended. Meticulous planning, close monitoring, accountability, mid-course corrections, a sound management structure and rigorous consultations involving competent leaders and industrial partners are proposed.

9.3.4 Beneficiary base of the large-scale S&T activities will be extended by strengthening **Inter-University Centres**, which have been playing major roles in drawing the academic community in the implementation of projects and utilization of facilities. A career and multifaceted skill- development plan for the scientists and engineers engaged in these projects will also be rolled out for effective utilization of their talents.

9.4. Engagement with Diaspora

As for the engagement with Indian diaspora is concerned, the policy direction is to create a fine balance between attracting the best talent back home and creating facilitating channels for the diaspora to contribute in national development from wherever they are. Appropriate institutional mechanisms and suitable opportunities will be created to engage with the Indian diaspora more effectively.

9.4.1. The untapped potential of a highly-skilled scientific diaspora will be leveraged. While the reverse brain drain (or brain gain) is encouraged by creating suitable opportunities for the returning Diaspora. The opportunities will not only be restricted to faculty positions, but also for pre-faculty and advisory roles. Challenges related to hiring in terms of transparency,

accessibility and accountability will be addressed to attract early and mid-career researchers back to the country.

9.4.2. Government has already initiated **specific fellowships and internships** to support active researchers/ scientists/engineers who want to return to India from abroad and contribute their work for the country. Such schemes and research opportunities in India will be expanded and widely promoted across different ministries to attract diaspora.

9.4.3. To promote brain circulation, appropriate **facilitating channels** will be created for the non-returning diaspora to contribute back to the country. Significant efforts will be made in identifying and communicating the facilitating channels to the diaspora. These facilitating channels will be widely popularized so that diaspora gets fully aware of the ambit of channels for contributing back to society in terms of economic support such as philanthropic funding, entrepreneurship support, and intellectual support.

9.4.4. An **engagement portal exclusively for Indian scientific diaspora will be created.** This portal will act as a one-stop focal point for the technical and scientific diaspora to engage with the Indian ecosystem.

9.4.5. Diaspora organizations and S&T Counsellors will be engaged in to create a **global academic and entrepreneurial network**. Such networks can create avenues for bringing together a distinguished group of Indian scientists and technocrats worldwide to participate in high-level consultations for key priority sectors and technological applications.

9.4.6. Policy instruments, programmes and schemes will be developed to **attract the best global talent/** skilled human resource, through Indian diaspora networks and connections. Additional focus will be given to establishing institutional mechanisms to retain the skilled human resource, and eventually, build and expand the domestic capacity.

9.5. Proactive STI Diplomacy Strategy

9.5.1. Post-COVID-19 situation provides India with both challenges and opportunities. It opens up new avenues for India's international S&T engagement and leadership. For the ease of connecting with international counterparts, appropriate formal and informal linkages will be developed. A proactive approach will be taken to strengthen existing partnerships and create new partnerships.

9.5.2. A **forward-looking international STI engagement framework** will be put in place supported by necessary institutional mechanisms and programmes, including components such as fellowships, joint research programmes, cross-incubation programmes and extended network of science and innovation counsellors.

9.5.3. Role of S&T in defining foreign policy priorities will be vitalized. Strong linkages with various divisions of the Ministry of External Affairs will be institutionalized. In addition to pursuing ‘S&T for diplomatic benefits’, Diplomacy for S&T development’ will be promoted.

9.5.4. Membership in S&T-focused strategic multinational groups, global consortia and technology regimes will be pursued proactively. Multilateral dialogues will be initiated with key partner countries on matters related to all aspects of technology and innovation, including issues around technology governance.

9.5.5. International Knowledge Centres play a crucial role in enabling access to critical human resources from across the globe. Such International Centres, preferably Virtual, will be established to promote global knowledge and talent exchange by creating avenues such as visiting fellowships, joint research schemes, training programmes, invited lectures etc.

9.5.6. The number of **S&T Counsellors** will be increased and rationality behind having an S&T counsellor in a specific country will be reviewed periodically. The role of S&T Counsellors will be revitalised and redefined given evolving technologies, nature of national demands and changing global dynamics. S&T Counsellors will be empowered to create opportunities for greater participation of the Indian scientific community, both in India and abroad.

Chapter 10: STI Governance

10.1. Institutional Architecture

10.2 Research and Innovation Governance

10.3. Strengthening STI Interconnectedness

Priority Issues

Science, Technology and Innovation (STI) governance mechanisms need to be made more efficient both administratively and financially. Dynamic monitoring, evaluation and incentivization framework need to be strengthened. In addition, it is imperative to address issues related to rationalising data and regulatory frameworks. There is also the challenge of weak interconnectedness across the ecosystem.

Background

A strong STI ecosystem can prosper only when premised upon an efficient governance mechanism with functional autonomy, transparency and adaptability to changes. Currently, our STI ecosystem is faced with the challenges related to institutional architecture, issues of research and innovation governance and weak interlinkages. To address these impediments from a perspective of efficient governance, there is a pressing need to chart a path of institutional synergy at the local and global levels. This Chapter outlines strategies for implementing modern and scientific governance to ensure India's preparedness for meeting the current challenges and future directions.

10.1. Institutional Architecture

A decentralized institutional mechanism balancing top-down and bottom-up approaches, focussing on administrative and financial management, research governance, data and regulatory frameworks and system interconnectedness, will be formulated for a robust STI Governance. The governance mechanism will focus on ensuring the autonomy of function for stakeholders complemented with accountability. Best practices in governance mechanisms will be mapped for cross-learning among relevant stakeholders.

10.1.1 To provide renewed focus and stimulation to the STI ecosystem, an appropriate, governance mechanism with centralised coordination with de-centralised functionality will be set up

10.1.2. An inter-sectoral, inter-ministerial national level STI Governance mechanism will be set up at the highest level, for building synergy and improving coordination among various ministries/departments/organizations to strengthen national STI ecosystem

10.1.3 An interlinked, Centre-State, inter-State governance mechanism will be created at the highest level for better coordination between the Centre and the States and to enhance overall participation of the States in research and innovation.

10.2 Research and Innovation Governance

10.2.1. A robust Research and Innovation (R&I) governance framework will be set up and adequately linked with the proposed '*National Research Foundation*' (NRF)¹⁷ to facilitate, stimulate and coordinate R&D activities across the sectors. This will be guided by the overall STI governance mechanism set up at the highest level.

10.2.2 Lateral recruitment (minimum 25%) of professionals and subject matter experts will be mandated in all scientific ministries for a finite duration with comparable roles, responsibilities and empowerment to a regular official.

10.2.3. Institutional interventions will be made to address issues related to individual researchers and research groups in terms of creating a **conducive working environment**. A particular focus will be given to academic mental health issues including peer pressure, mentor-mentee relationship and work-life balance.

10.2.4. A suitable metric will be developed to evaluate and recognize the outcome and impact of research activities with respect to its direct relevance to Indian needs, while continuing to maintain international comparability. This metric must reflect the meaningful impact of science on society, solving local problems and resource optimization among others.

10.2.5. Standardized **Research and Innovation Excellence Frameworks (RIEF)**, based on international benchmarks, will be formulated to ensure cohesive and transparent evaluation of all kinds of research and innovation. The framework will set cross-country benchmarking tools that will be positioned to assess the performance of STI in key priority areas, using a set of indicators such as sectoral R&D progress, patents, and other knowledge products.

10.2.6. Capacity development efforts for R&I will be strengthened through the establishment of a **Capacity Building Authority**. This will help in planning, designing, implementing and monitoring of capacity building programmes at the national and state levels.

10.2.7. The STI Policy Institute and other think tanks, will perform regular **technology assessment, foresight and advisory** activities.

10.2.8. To ensure transparency, accessibility and accountability within the STI ecosystem, a comprehensive **administrative and financial management** will be put in place within the broader R&I governance framework. It will further assist in streamlining programmes and

¹⁷Refer to National Research Foundation: NEP 2020, Chapter 17

schemes to avoid duplication of efforts and resources among various ministries and departments. It will further aid in strengthening the translational research chain and its management by providing necessary support mechanisms through the life cycle from inception of an idea to product development and commercialization.

10.2.9. To promote STI across the ecosystem, an **STI enabling environment** will be created to stipulate funding opportunities, ownership, product certification, market access, and public procurement. The enabling ecosystem will be facilitated by (i) enhanced fund availability through various sources including from public and private sectors, (ii) joint ownership of patents in consortia-led R&D, (iii) financial support for patent filing costs, (iv) monitoring of risks and antitrust activities, (v) market creation by easing public procurement norms (review L1 criteria) and supply chains, particularly for startups and MSMEs, (vi) updating product certification standards and accredited testing facilities for emerging innovations, and (vii) fast-track accelerators and incubators.

10.2.10. The national IP regime will be strengthened and issues related to IP ownership, licensing, sharing, commercialization (patent box regime), transfer modalities and IP related regulatory frameworks will be streamlined. Patent filing and management processes will be made simpler and less time-consuming. There will be focus on raising mass awareness related to IP along with sensitizing young researchers and scientists about processes for patent filing, maintenance and commercialization. There will be close cross-linking between the instruments and priorities of the national IPR policy and STI policy.

10.2.11. In consultation with relevant stakeholders, a robust **data governance** mechanism and associated guidelines will be formulated for scientific data, including research data, to ensure appropriate data classification, ownership, storage, interoperability, retention, ethics and privacy.

10.2.12. A renewed and **coherent regulatory framework** will be devised which facilitates synergy among the already operating national and state regulatory agencies to cut across their functional silos. It will ensure harmonized, enabling and transparent regulatory frameworks for speedy translation of innovations from institutions for commercialization in a competitive market place. **Sector-specific regulatory frameworks and guidelines will be strengthened and streamlined** to promote effective execution of research and innovation in key sectoral priority areas.

10.2.13. The R&I framework will also play a pivotal role in **Standard setting** for STI related activities. It will guide the collaborative creation and strengthening of minimum acceptable standard guidelines across industries and sectors for certification and validation.

10.2.14. A component of anticipatory governance will be built into the overall R&I governance framework to prepare the country for unforeseen crises and emergencies. Establishment of a central focal point for appropriate forecasting, planning and execution, will be explored. Additionally, robust surveillance and early warning systems for emerging

threats such as infectious diseases will be strengthened through technologies such as digital health, artificial intelligence, mobile labs and so on.

10.2.15. To strengthen security in sectors such as health, food, agriculture and environment etc, scientific, technical and regulatory expertise will be sought to promote open innovation and equitable access across the ecosystem. In the health sector, an enabling environment for large scale and low cost manufacturing of essential products such as drugs, vaccines and medicines will be promoted, including innovative licensing approaches where necessary.

10.3 Strengthening STI Interconnectedness

10.3.1 A strong **STI collaboration framework** to strengthen existing channels and create new ones for enhanced interconnectedness among stakeholders at the domestic and global levels will be created. This framework will outline **institutional mechanisms** to promote effective and outcome-driven collaborations and generate a common pool of resources. It will lead to inter-sectoral, interdisciplinary, and inter-institutional collaboration for sectoral innovations.

10.3.2. The collaboration framework will focus on promoting **inter-ministerial and inter-departmental linkages** across sectors to pursue collaborative projects in alignment with the national priorities. **Inter-institutional linkages** among academic and research institutes will also be facilitated to enhance multidisciplinary and transdisciplinary research. This will be based on careful pre-collaboration analysis of strengths and weaknesses of respective ministries/departments/institutions and identification of gaps and opportunities that can be addressed through collaborative efforts. Provisions for social scientific responsibility and patent pooling will be specified.

10.3.3. A **multi-stakeholder collaborative model** including government, industry and academia will be developed based on successful models such as Virtual Integrated Platforms, City-based and domain-based clusters, Government-Owned Contractor-Operated (GOCO) etc. This will aid in defining research objectives and aligning priorities with pre-decided time frames and responsibilities. In addition, **strong interlinkage among various facilitating agencies** within the innovation landscape will be encouraged.

10.3.4. Industry-Academia linkages will be further strengthened through the development of trust-building pathways to pursue collaborative research and translate academic research to market through institutional support and adequate incentives. Innovative partnership models will be established to promote partnerships between academia, start-ups and MSME to speed up the process of commercialization at local levels.

10.3.5. End-user community linkages will be developed and strengthened to ensure last-mile delivery of S&T-led innovations. Strong interconnection with civil society organizations, NGOs, charitable organizations, regional and local bodies will be promoted.

Pathways will be created to enable public-private-civil society consortia in key priority areas such as connecting farmers and scientists for ensuring access to technology and innovation, which would enhance agricultural production and increase farmers' income.

10.3.6. Channels will be created for strategic government departments to partner with industry and academia to engage in R&D activities in critical areas. Flexible knowledge and talent exchange models will be developed to facilitate **hassle-free collaborations in strategic areas**.

Chapter 11: STI Policy Governance

11.1. Institutional Mechanism for STI Policy Governance

11.2. Formulating Implementation Strategy and Roadmaps

11.3. Monitoring and Evaluation of STI Policies and Programs

11.4. Policy and Programme Interlinkages

Priority Issues

The success of any policy depends on how it is implemented and governed. There is a critical need to build a robust STI policy governance system with respect to evidence gathering through data and policy research, evidence-based policymaking, policy to programme translation and interconnection, implementation, monitoring, review/assessment, and feedback. Setting up an institutional mechanism for STI policy research in different sectors and thereby strengthening the evidence-supported science advice mechanism is one of the priorities.

Background

STI Policy governance defines and guides the planning, implementation, monitoring and evaluation of STI policies and programmes. The 5th STI Policy aims to develop and nurture an effective, transparent, responsible, accountable and self-reliant STI ecosystem. Through consistent evaluation of the performance of various institutions, policies and programmes, ensuring the equitable representation of diverse groups and adequate feedback mechanism; the policy governance will strengthen STI policies and processes. Agile policy governance in place will respond to emerging challenges, at the sub-national and national level. This Chapter outlines institutional mechanisms for STI Policy Governance, implementing strategy and roadmap, monitoring and evaluation of the policy and program and their interlinkages.

11.1. Institutional Mechanism

An **STI Policy Institute**, with a strong national and international connect, will be established with a mandate to serve all aspects of STI policy governance. This STI Policy Institute will be positioned within and governed by the apex-level STI governance institutional architecture¹⁸ and function as a dedicated knowledge support unit to institutionalised governance mechanisms.

The STI Policy Institute will also provide the knowledge support for other national/sectoral and sub-national STI planning, coordination, evaluation and capacity building. The Institution will work closely with existing policy institutions and think tanks, as a hub to connect, promote and support national and international institutions, in order to strengthen the

¹⁸ Refer to STI Governance Institutional Architecture in Chapter 11 Section 11.1

national STI policy ecosystem. The STI Policy Institution will help to ensure concordance, harmonisation and linkages of and with STI policies and other national policies and programmes.

11.1.1 Interoperable STI metadata architecture

One of the primary responsibilities of the STI Policy Institute is to build and maintain a robust interoperable STI metadata architecture. The metadata includes:

- **Inputs** such as R&D expenditure, funding pattern, sectoral resource mapping, FTEs etc.
- **Processes** such as industry-academic interlinkages, the career trajectory of researchers, gender balance in STEM, international linkages etc.
- **Output** such as scientific papers, scholarly proceedings, patents, inventions, skilled human resources etc.
- **Outcome** such as technologies, innovations, startups, socio-economic outcomes etc.

11.1.2. Strengthening STI Policy Research

The STI Policy Institute will conduct and promote nationally and internationally relevant STI policy research, to identify policy gaps and provide evidence for effective policymaking. It will also work towards expanding policy research in different sectoral and thematic areas.

11.1.3. Strengthening Science Advice Mechanism

Data generates information; policy insights are built upon the information which forms the evidence base. Science advice mechanism, at sub-national, national and international levels, will be strengthened by systematically linking the evidence base with the apex-level advisory and governance mechanisms.

11.1.4. Capacity Development Programmes

The STI Policy Institute will also play a critical role in developing long-term capacity in STI policy through training and fellowship programmes. The institute will work closely with the stakeholders including academia, industries, autonomous and independent think tanks and research and policy institutions in identifying gap areas and will develop tailored capacity development programmes to build both institutional capacity as well as critical mass of policy professionals.

11.2. Formulating Implementation Strategy and Roadmaps

Evidence-driven and decentralized approach will be followed in translating policy objectives into actions through well-structured implementation strategies. The strategy will include identification of priority areas, implementing agencies, stakeholders and planning the process

of implementation. Stakeholders are key in formulating implementation strategies and roadmaps for programme design. The proposed STI Policy Institute will work with, and provide necessary knowledge support to all the stakeholders and implementing agencies in developing feasible implementation roadmaps.

11.3. Monitoring and Evaluation of STI Policies and Programmes

Mechanisms will be put in place for continuous monitoring and timely evaluation of policy and programme implementation. These activities are critical ensuring the policy objectives are getting translated in the expected direction. Stakeholder feedback and adaptation mechanisms will be incorporated to fine-tune the policy/programme implementation strategies. Appropriate exit strategies will also be developed to remove policy instruments whenever necessary, based on the dynamic evaluation.

11.4. Policy and Programme Interlinkages

Both intra as well as international linkages are required for formulation, implementation and evaluation of the policies and programmes. At the international front, this will help in adapting global best practices, standards and in improving the international comparability of Indian STI data and strengthening India's position in global rankings and benchmarks. At the national level, it requires both, inter-ministerial and inter-departmental (horizontal) linkages as well as inter-state (vertical) linkages for effective implementation of policies and programs.

11.4.1. Inter-Sectoral Linkages

The existing policies will be interlinked across the sectors by creating systematic synergy between scientific and socio-economic ministries and departments. By doing so, shared ownership, equal responsibility and complementarities will be created among various ministries, departments, funding bodies and implementing agencies. Such interlinkages will be institutionalized for long-term benefits.

11.4.2 State and Sub-national Linkages

Inter-State Science, Technology and Innovation Council (IS-STIC)¹⁹ will be responsible for aligning national and international STI developments and missions with that of the states. It will encourage states to provide knowledge support for STI, create a robust STI policy and advisory mechanism, and facilitate monitoring and evaluation at the state level.

¹⁹Refer to Chapter 11 Section 11.1.2

Regular interaction between the Centre and the States for STI policy planning will be held. Such collective and collaborative interactions will help in identifying common problems, priorities and to formulate and implement policies to address them.

A platform for State S&T administrators will be created for cross learning, and to disseminate and share good policy practices which can address similar and common problems. Such a mechanism will be further strengthened to enhance State-level policy implementation and monitoring processes.

IV. Implementation Framework

The implementation strategy will be devised through a robust institutional mechanism. The implementing agencies will be guided by this mechanism in the tasks of landscape analysis, institutional mapping, identifying stakeholders and resources. Coordinated actions across a range of actors with proactive leadership and a culture of collaboration across the STI landscape will be fostered. While identifying and engaging with the stakeholders for STI policy planning and coordination, indiscriminate representation of experts from science and social science domains will be ensured.

Once the roadmap for the implementation is developed, the implementing agencies will focus on capacity building. The STI Policy Institute will provide knowledge support to different STI departments and agencies, at the centre and the state levels in the training of STI workforce for implementation and monitoring. The policy and programme milestones will be set up at the beginning of the implementation by the implementing agency with the guidance of the STI Policy Institute. From the beginning of the implementation and throughout the process, systemic communication to generate and share the information and feedback on the process of implementation will be ensured.

V. Monitoring, Evaluation and Feedback Framework

Digital platforms will be created for monitoring, impact assessment, accounting and other analyses of STI initiatives. A feedback mechanism will be established between policymakers and relevant stakeholders after the implementation process begins. Baseline and mid-term reviews will be conducted and a transparent reporting mechanism for implementing agencies will be created to ensure regular updating of the policy progress.

Methods such as social assessments through household surveys, focused group discussions, process tracing, participatory mapping of STI planning and implementation can be used to monitor and evaluate the policy implementation. Quantitative measurements/indicators-specific to the policy and/or programme- will be used alongside qualitative measurements to assess policy impact. Metrics will be created or a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis will be conducted to map policy implementation programs, aligned with bench-marked aspirational outcomes.

VI. Vision

The Science, Technology and Innovation Policy will be guided by the following broad vision;

- i) *To achieve technological self-reliance and position India among the top three scientific superpowers in the decade to come.*
- ii) *To attract, nurture, strengthen and retain critical human capital through a 'people centric' science, technology and innovation (STI) ecosystem.*

- iii) *To double the number of full-time equivalent (FTE) researchers, Gross Domestic Expenditure on R&D (GERD) and private sector contribution to the GERD every 5 years.*
- iv) *To build individual and institutional excellence in STI with the aspiration to achieve the highest level of global recognitions and awards in the coming decade.*
- v) *To capture the aspirations of a new, future-ready India, by ensuring active participation, shared responsibility and equitable ownership of all stakeholders; transforming the national STI landscape maintaining the delicate balance between fortifying India's indigenous capacity and nurturing meaningful global interconnectedness.*

To capture the aspirations of a new, future-ready India, by ensuring active participation, shared responsibility and equitable ownership of all stakeholders; transforming the national STI landscape maintaining the delicate balance between fortifying India's indigenous capacity and nurturing meaningful global interconnectedness.