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Role of Science, Technology and Innovation (STI) for Viksit Bharat@2047: Opportunities and Challenges

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ABSTRACT
Science, technology and innovation (STI) are central to India's ambition to become a developed nation by 2047, the centenary of Independence. This paper reviews the contribution of research, emerging technologies and entrepreneurship to that vision, using secondary information from government publications and other authoritative sources. India's gross expenditure on research and development (GERD) reached ₹2.45 lakh crore in 2023–24, equivalent to 0.84% of GDP, while India ranked 38th in the Global Innovation Index 2025 (Department of Science and Technology [DST], 2026; World Intellectual Property Organization [WIPO], 2025). The paper considers opportunities in artificial intelligence, biotechnology, quantum technology, space, semiconductors and green technology. It also identifies persistent barriers, including limited R&D intensity, uneven research infrastructure, weak links between academia and industry, and difficulties in translating research into products and public benefits. It recommends sustained public and private investment, stronger research-industry partnerships, improved skills and infrastructure, and inclusive, ethical and environmentally responsible innovation.

Keywords: Science, technology and innovation, Viksit Bharat@2047, research and development, artificial intelligence, biotechnology, startups, sustainable development.

Introduction

Science, technology and innovation are important drivers of productivity, public services and social development. For India, the ambition of becoming a developed nation by 2047 depends not only on generating scientific knowledge but also on translating it into useful technologies, services and employment. India has developed capabilities in information technology, pharmaceuticals, space science, biotechnology and digital public infrastructure. Artificial intelligence, quantum technologies, robotics, semiconductors and clean energy offer further opportunities, provided that innovation is supported by appropriate skills, infrastructure, regulation and access (DST, 2025; WIPO, 2025).

The Viksit Bharat Buildathon 2025 was presented as a student-centred innovation initiative around themes including Aatmanirbhar Bharat, Swadeshi, Vocal for Local and Samriddh Bharat. Such initiatives can help introduce problem-solving and locally relevant innovation to young people. Claims about participation numbers should be supported by the relevant official announcement before publication.

2. Objectives

1.To examine the role of STI in achieving Viksit Bharat@2047.
2.To identify major technological opportunities for India.
3.To discuss key challenges in India's innovation ecosystem.
4.To suggest strategies for strengthening STI-led and inclusive development.

3. Methodology

This paper is a narrative review based on secondary sources, including publications and webpages from the Department of Science and Technology, the Press Information Bureau, the Department for Promotion of Industry and Internal Trade, the Indian Space Research Organisation, the Ministry of New and Renewable Energy, the India Brand Equity Foundation and the World Intellectual Property Organization. Official statistics are cited with their reporting year. The paper does not present original field data or a systematic review protocol; consequently, its findings should be interpreted as a policy-oriented synthesis of selected sources.

4. STI and India's Development

India's gross expenditure on research and development (GERD) rose from ₹1,32,567 crore in 2019–20 to ₹2,44,768 crore in 2023–24. However, GERD represented 0.84% of GDP in 2023–24, showing that

the scale of spending has grown while R&D intensity remains a significant policy concern (DST, 2026). India ranked 38th in the Global Innovation Index 2025, reflecting areas of innovation strength alongside continuing gaps in infrastructure and R&D investment (WIPO, 2025).

Indicator	Status
GERD, 2019–20	₹1,32,567 crore
GERD, 2023–24	₹2,44,768 crore
GERD as % of GDP, 2023–24	0.84%
Global Innovation Index rank, 2025	38th
DPIIT-recognised startups, 31 March 2026	>2.23 lakh (31 March 2026)

These indicators suggest that India's innovation ecosystem is expanding, but spending totals and rankings alone do not establish the quality, accessibility or social impact of research. Outcomes also depend on research capacity, private-sector participation, skills, technology transfer and the extent to which innovations address local needs.

5. Major STI Opportunities

Artificial Intelligence

Artificial intelligence can support healthcare screening, precision agriculture, education, manufacturing, public administration and disaster management. Benefits will depend on reliable data, local-language access, transparency, privacy protection and safeguards against bias. Adoption should be accompanied by evaluation of accuracy, affordability and effects on workers rather than measured only by the number of tools deployed.

Biotechnology

Biotechnology has applications in vaccines, diagnostics, genomics, agricultural improvement, biofertilisers, industrial bioprocessing and environmental management. The India Brand Equity Foundation reported that India's biotechnology industry was valued at about US$130 billion in FY2024 and projected further growth; such projections should be identified as estimates, not achieved outcomes (India Brand Equity Foundation [IBEF], 2025). Strengthening research translation, quality assurance, biosafety, skilled personnel and affordable access will be important to ensure that biotechnology benefits public health, agriculture and industry.

Quantum Technology

The National Quantum Mission, approved by the Union Cabinet on 19 April 2023 with an outlay of ₹6,003.65 crore for 2023–24 to 2030–31,

supports research and development in quantum computing, communication, sensing and related materials (DST, n.d.-a). Its longer-term contribution will depend on sustained research, trained personnel, domestic component development, industry participation and realistic pathways from laboratory research to applications.

Space Technology

Space science and satellite systems contribute to communication, navigation, weather forecasting, agriculture, disaster management and scientific research. Chandrayaan-3 demonstrated a successful soft landing on the Moon, while Aditya-L1 is India's solar-observation mission (Indian Space Research Organisation [ISRO], n.d.). The policy opportunity is to connect space-derived data and services more effectively with public agencies, researchers, farmers and commercial users, while maintaining reliable data access and mission sustainability.

Semiconductors

Domestic semiconductor design, fabrication, assembly, testing and packaging can strengthen supply-chain resilience and create high-value employment. The Semicon India Programme has a total outlay of ₹76,000 crore. In December 2025, the government reported approval of ten semiconductor units with proposed investment of about ₹1.60 lakh crore (Press Information Bureau [PIB], 2025). These are approved projects and investment commitments, not evidence that all facilities are already operational. Skills, water and power availability, supply chains and long-term commercial viability will influence their success.

The semiconductor opportunity should therefore be assessed through transparent milestones, workforce development, technology capability, production outcomes and integration with domestic electronics manufacturing.

Green Technology

Renewable energy, green hydrogen, electric mobility, energy storage, waste treatment and circular-economy technologies are central to a lower-carbon development pathway. India announced a plan to invite bids for 50 GW of renewable energy capacity annually over five years, in support of the national objective of 500 GW of installed non-fossil electricity capacity by 2030 (PIB, 2023). Capacity targets are policy goals rather than completed outcomes; implementation also requires grid upgrades, storage, finance, responsible mineral sourcing and attention to local environmental impacts.

6. Role of Startups and Innovation

Startups can turn scientific knowledge into products, services and jobs, particularly in agritech, health technology, biotechnology, space and clean energy. DPIIT-recognised startup numbers have grown substantially; the government reported more than 2.23 lakh recognised startups as of 31 March 2026 (PIB, 2026a). Recognition counts are not the same as the number of active, profitable or research-intensive firms, so evaluation should also consider survival, employment quality, investment, patents and societal impact.

Education and skills development are essential to inclusive innovation. The National Education Policy 2020 emphasises multidisciplinary learning and the development of scientific temper and skills. STEM education, coding, digital literacy, vocational learning and opportunities for hands-on research can help prepare students for technology-driven work. These programmes should also support critical thinking, ethics and access for students in rural and under-resourced institutions.

Further support is needed for deep-tech startups, university and college incubation centres, technology-transfer offices, shared research facilities, proof-of-concept grants and industry-sponsored research. Public support should be tied to transparent evaluation and clear public-benefit objectives.

7. Major Challenges

India's STI ecosystem continues to face several connected challenges:

•R&D expenditure remains modest as a share of GDP (DST, 2026).
•Research infrastructure and access to advanced equipment are uneven across institutions and regions.
•University–industry collaboration and pathways for technology transfer need strengthening.
•Research findings are not always translated into affordable products, services or public policy.
•There is a continuing need for highly skilled researchers, technicians and research managers.
•Regional and institutional inequalities can limit participation in research and innovation.
•Intellectual-property support, licensing expertise and incentives for collaboration need improvement.
•Emerging technologies raise concerns about privacy, bias, safety, cybersecurity, biosafety and environmental impacts.

8. Strategies for Viksit Bharat

The following measures could strengthen India's STI ecosystem:

1.Increase sustained public and private investment in R&D, with transparent assessment of outcomes.
2.Strengthen the Anusandhan National Research Foundation's role in supporting research across institutions and disciplines.
3.Build long-term partnerships among universities, colleges, public laboratories and industry.
4.Develop accessible technology-transfer, incubation and proof-of-concept facilities.
5.Support deep-tech and manufacturing startups while evaluating their long-term viability and public value.
6.Improve research infrastructure, technical staffing and shared facilities, including in regional colleges and universities.
7.Encourage interdisciplinary, mission-oriented and reproducible research.
8.Develop advanced and continuing skills in AI, biotechnology, quantum science, semiconductor technology and clean energy.
9.Support locally appropriate innovation in rural development, agriculture, public health and environmental management.
10.Build ethics, privacy, safety, accessibility and environmental sustainability into technology design and deployment.

9. STI Framework for Viksit Bharat

A practical development pathway can be represented as:

Scientific research → Knowledge → Technology → Innovation → Entrepreneurship → Manufacturing and services → Employment → Inclusive and sustainable development → Viksit Bharat@2047

This pathway is not automatic. It requires funding, skilled people, institutional capacity, public trust, supportive regulation and feedback from communities and users. Research success should be assessed not only through publications or patents but also through reliability, adoption, affordability and measurable social or environmental benefit.

10. Conclusion

Science, technology and innovation are essential to the vision of Viksit Bharat@2047. India's GERD reached ₹2.45 lakh crore in 2023–24, equivalent to 0.84% of GDP, and the country ranked 38th in the Global Innovation Index 2025 (DST, 2026; WIPO, 2025). These indicators show both progress and the need to strengthen the depth and reach of the innovation system. Opportunities in AI, biotechnology, quantum technology, space, semiconductors and

green technology are substantial, but outcomes will depend on sustained investment, strong research institutions, effective industry collaboration, skilled personnel and responsible governance.

A developed India will require more than scientific advances alone. It will require converting knowledge into useful, safe and affordable solutions, with benefits reaching rural as well as urban communities. Coordinated action by government, educational institutions, research organisations, industry and startups can help make STI a driver of productive, inclusive and sustainable development.

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