

India's emergence as a hub of Knowledge and Technology

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India's participation in cutting-edge fields like quantum computing, artificial intelligence, space exploration, and renewable energy reflects its determination to position itself as a global leader. By continuing to invest in R&D, building strategic global partnerships, and nurturing homegrown talent, India is carving out a formidable role on the global stage as a hub of innovation and knowledge.

India's economic evolution has been profoundly shaped by the integration of technology, which has become a fundamental engine of its progress. Across multiple sectors, technological advancements have driven efficiency, innovation, and productivity, helping to propel India's rise as a significant player on the global economic stage. As the largest democracy in the world, with a population of 1.3 billion, India is targeting a Gross Domestic Product (GDP) of 5 trillion USD by 2025¹.

Over the decades, India's journey in science and technology (S&T) has witnessed several transformative milestones. India has consistently pursued technological self-reliance from the Green

and White Revolutions, which bolstered food and milk production, to advances in atomic energy, space, and pharmaceutical sectors. The nation's resolve was exemplified in its response to being denied access to a supercomputer, sparking the development of indigenous solutions for various applications like meteorology and computational fluid dynamics. Similarly, the solar and wind energy sectors witnessed robust growth during the 1990s and 2000s, adding new dimensions to India's technological landscape.

Although India has traditionally excelled in generating knowledge, the global shift toward innovation has inspired the nation to focus on translational research. This strategic pivot bridges

World GDP Ranking 2024



Figure 1: Largest economies in the world by GDP (nominal) in 2024 (Courtesy: International Monetary Fund)

the gap between theoretical advancements and practical applications, ensuring that technological progress benefits all segments of society. Ranked fifth globally by nominal GDP and third by purchasing power parity, India's economy demonstrates resilience, balancing traditional industries with modern, technology-driven sectors². Initiatives such as Digital India, Startup India, and UPI-driven digital payments exemplify the country's commitment to technological innovation, fostering

an inclusive future for all³.

Technology as a National Priority

- **Landscape of Science and Technology in India**

The progress in science and technology has not only improved the quality of life but also laid the groundwork for new opportunities. The Prime Minister has consistently highlighted the nation's scientific capabilities as critical tools for tackling

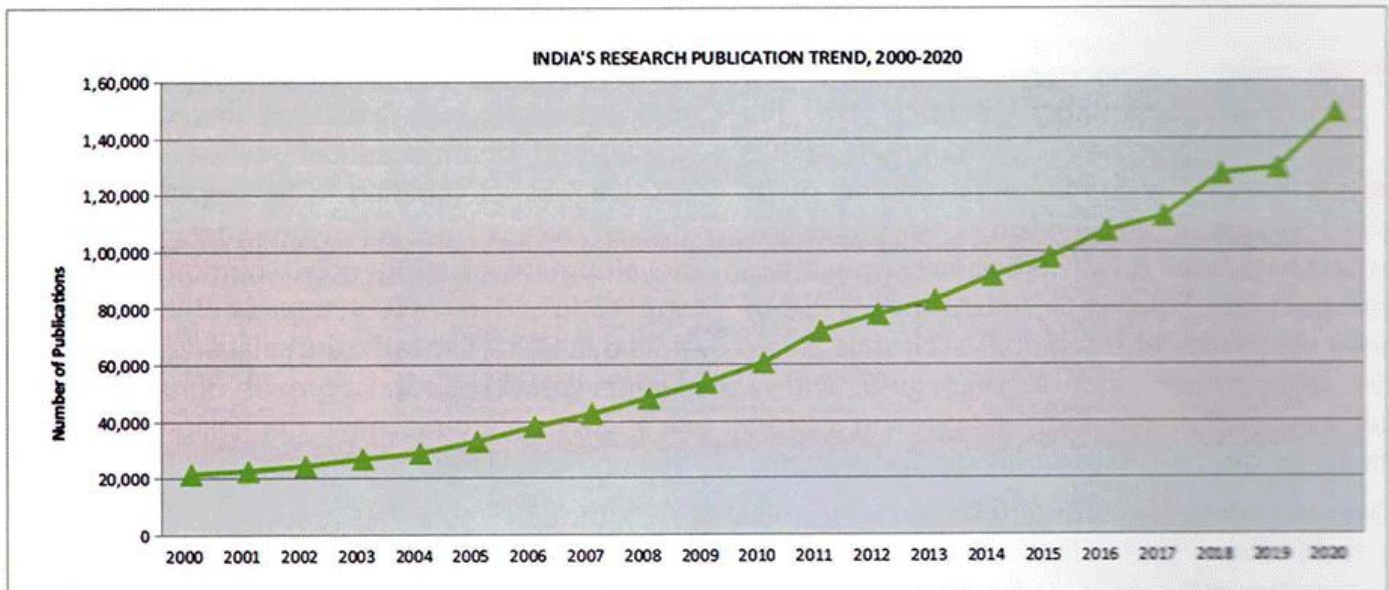


Figure 2: India's Research Publication Trend (Courtesy: NSF database, Science and Engineering Indicators, 2022)

major challenges like climate change, clean energy, and healthcare. The effective transition of innovations from research labs to the broader market is essential for achieving these objectives.

India's commitment to S&T is reflected in its increasing investment in research and development (R&D). Gross Expenditure on R&D (GERD) has doubled in the last decade, reaching Rs 1,27,380.96 crores in 2020-21⁴. While much of this funding is government-driven, the private sector also plays a growing role, contributing 36.4 per cent to the GERD in 2020-21, particularly in sectors like pharmaceuticals, IT, and textiles. The Indian research ecosystem has seen a surge in output, with the number of scientific publications growing 2.5 times from 2010 to 2020, positioning India as a global leader in fields such as computer science, engineering, and health sciences.

Innovation Ecosystem

• Global Innovation Index

India's steady rise in the Global Innovation Index (GII) showcases the nation's strong focus on fostering innovation. Ranking 39th in 2024, up from 81st in 2015, India has become a dominant force in Central and Southern Asia's innovation landscape⁵. With over 100 unicorns and initiatives such as Startup India, Atal Innovation Mission (AIM), and *Atmanirbhar Bharat Abhiyaan*, India has successfully harnessed the power of technology to fuel global progress. The rise in the GI is a testament to these initiatives, which have transformed India into a global hub of research and innovation.

• Atal Innovation Mission

Atal Innovation Mission (AIM), established by the Government of India, has emerged as a central pillar in nurturing innovation and entrepreneurship across the country. AIM's initiatives, such as Atal Tinkering Labs (ATLs) and Atal Incubation Centres (AICs), empower students and startups by providing hands-on technological experience and funding support.

AIM has funded 10,000 schools to date for ATLs. AIM also supports Atal Incubation Centres (AICs) to catalyse startups, with 72 AICs and 14 Atal Community Innovation Challenges (ACICs) established. The Atal New India Challenge (ANIC) program invites innovators to address national issues with creative solutions.⁶



This mission is integral to building a vibrant startup ecosystem that has already produced over 100 unicorns, aligning India's innovation landscape with global standards.

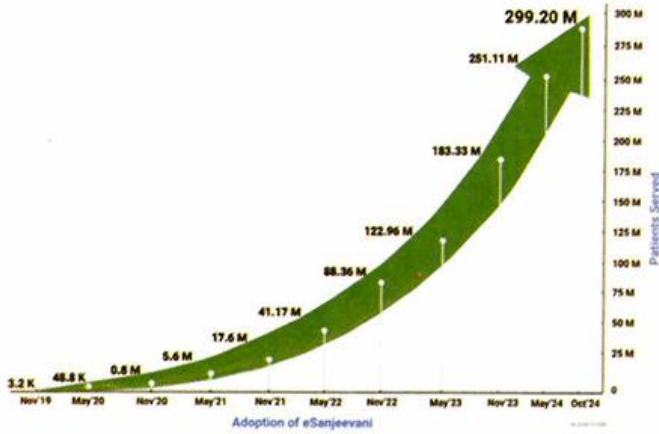
Economic Impact of Technology

• Transformation across Key Sectors

Technology's influence spans various sectors of the Indian economy, driving significant improvements in agriculture, healthcare, manufacturing, and mobility. In agriculture, advancements such as precision farming, AI-powered crop monitoring, and the use of drones have drastically improved productivity⁷. The healthcare sector has similarly benefitted from digital interventions, with telemedicine and AI-driven diagnostics transforming the way healthcare services are delivered, particularly in rural areas⁸.

The manufacturing sector, especially through the adoption of Industry 4.0 technologies, has achieved remarkable gains in efficiency. Initiatives like 'Make in India' and advancements





in 3D printing and smart factory setups have attracted significant investments, positioning India as a global manufacturing hub⁹.

The digital economy is also experiencing rapid growth, with the integration of 5G technology, artificial intelligence (AI), and the Internet of Things (IoT) creating new opportunities for smart cities, telemedicine, and automation¹⁰. These developments are set to revolutionise the connectivity landscape, driving innovation in fields ranging from transportation to finance.

• Shift Toward Translational Research

India's transition from fundamental to translational research has been instrumental in converting scientific discoveries into real-world applications. Through programs like the National Initiative for Development and Harnessing Innovations (NIDHI) and the Biotechnology Industry Research Assistance Council (BIRAC), India has encouraged collaboration between academia and industry. This collaborative approach has led to significant breakthroughs in biotechnology, space technology, and renewable energy, positioning India as a global leader in technology commercialisation.

Social Impact of Technology

• Digital India and Social Inclusion

Launched in 2015, the Digital India mission has transformed how citizens access public services, promoting inclusivity and transparency. By focusing on universal access to digital infrastructure and services, this initiative has democratised access to education, healthcare, and financial services. Programs such as *Aadhaar*, Common Service Centres (CSCs), and DigiLocker

have empowered millions of Indians, especially in rural areas, by simplifying access to government services¹¹.

India's success in promoting digital literacy, enhancing cybersecurity, and creating accessible platforms for participatory governance has set a global example for digital inclusion. With more than 15 billion UPI transactions handled in a single month (September 2024)¹², the initiative demonstrates how technology can break down barriers and empower citizens.

• Health and Family Welfare

Technology's integration into the healthcare sector has revolutionised medical service delivery, particularly through telemedicine and AI-driven diagnostics. India's *eSanjeevani* telemedicine platform, operational in thousands of government centres, has made healthcare more accessible to remote populations¹³. Meanwhile, initiatives like the *Ayushman Bharat* Digital Health Mission have strengthened collaboration between government and private entities, enhancing overall healthcare infrastructure.

During the Covid-19 pandemic, India demonstrated its healthcare innovation capabilities by developing the indigenous vaccine, 'Covaxin'¹⁴. The swift deployment of vaccines and subsequent vaccination campaigns were critical in safeguarding the health of millions, while initiatives like 'Vaccine Maitri' showcased India's commitment to global solidarity¹⁵.

• Education and Empowerment

The National Education Policy (NEP) 2020 has laid the foundation for a comprehensive overhaul of India's education system. By emphasising multidisciplinary learning and digital infrastructure, NEP 2020 aims to equip students with 21st-century skills while fostering a robust research-oriented higher education system. As the shift to online learning accelerated during the Covid-19 pandemic, the rise of EdTech platforms has transformed access to education, particularly in underserved regions.

The growth of online learning and digital pedagogy is empowering individuals across all socioeconomic backgrounds, enabling them to upskill and participate in the global knowledge economy.

Strategic Impact of Technology

Defence and Space Sectors

India's focus on self-reliance in defence technology has led to notable achievements, including indigenous missile systems, aircraft carriers, and anti-satellite technologies. Programs like the Integrated Guided Missile Development Programme (IGMDP) and *INS Vikrant* showcase India's growing defence capabilities, bolstered by innovations in radar, sonar, and electronic warfare technologies.

In the space sector, ISRO's advancements have been game-changers. From the reliable PSLV launcher to the *Chandrayaan-3* lunar mission, India's space program continues to demonstrate technological prowess. Recent initiatives like *Gaganyaan*, India's human spaceflight mission, and the privatisation of space exploration promise to propel India into a new era of space innovation.

Emerging Technologies

India's strategic investments in emerging technologies are vital for maintaining its global competitive edge. Initiatives like the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) are fostering innovation in fields like AI, robotics, and quantum computing. The National Quantum Mission (NQM) and the National Supercomputing Mission (NSM) further underscore India's ambition to become a leader in high-performance computing and next-generation technologies. The NSM enhances research and development capabilities, exemplified by the *PARAM Shivay* supercomputer, one of India's fastest, with over 120,000 compute cores and 833 TeraFlops of peak compute power¹⁶.

Quantum Computing represents the next frontier in computational power. Unlike classical computers, which process information in binary, quantum computers leverage the principles

of quantum mechanics to perform complex calculations at unprecedented speeds. This technology has the potential to revolutionise fields such as cryptography, materials science, and drug discovery.

In ocean sciences, the Deep Ocean Mission, with its focus on seabed exploration and energy resource development, highlights India's growing emphasis on sustainability and resource management. The mission demonstrates India's scientific capabilities with manned submersibles that can reach depths of 6,000 meters¹⁷. Equipped for deep-sea mining, it also addresses climate change, biodiversity conservation, and sustainable bio-resource utilisation.

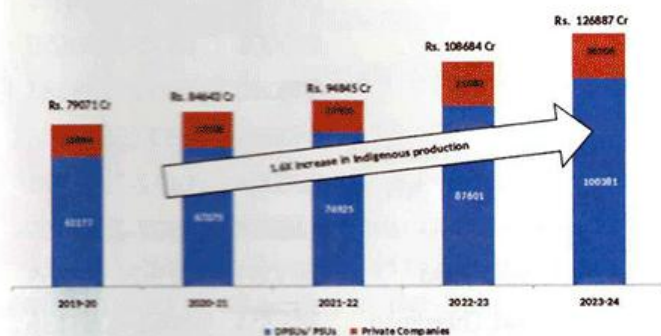
Viksit Bharat: A Vision for a Developed Nation

India's vision of '*Viksit Bharat*' embodies the aspiration to become a developed nation, where science, technology, and innovation drive economic growth, social equity, and environmental sustainability. This vision rests on the belief that India can leverage its rich scientific heritage and technological capabilities to build a self-reliant and prosperous nation.

Achieving this vision requires substantial investment in future scientific technologies and creating an enabling ecosystem for innovation. Fostering a scientific temperament across society, promoting research and development (R&D), and encouraging entrepreneurship, particularly in the tech sector, are essential steps. The '*Atmanirbhar Bharat*' initiative emphasises self-reliance by promoting domestic manufacturing, reducing imports, and advancing indigenous technologies, particularly in fields like AI, quantum computing, and biotechnology, where India aims to become a global leader.

Building a future-ready workforce is crucial, necessitating a strong focus on education and skill development in STEM (Science, Technology, Engineering, and Mathematics). By equipping the younger generation with essential knowledge, India can ensure its citizens are prepared for future challenges.

Additionally, ensuring technology is accessible to all citizens is critical for social equity, with initiatives like Digital India aiming to bridge the digital divide and extend the benefits of technology to every segment of society.



Conclusion

As India stands at the crossroads of an era defined by rapid technological advancement and innovation, the nation's vision for science and technology is not merely about economic growth but about building a resilient, self-reliant, and inclusive future. The roadmap ahead embraces both emerging and critical technologies, with science and technology serving as a driving force that cuts across all sectors, from agriculture and healthcare to defence, space, and education.

The focus on bridging the gap between research and real-world applications through translational research ensures that technological advancements are accessible to all, enabling a future where the benefits of innovation are widely shared. Moreover, India's participation in cutting-edge fields like quantum computing, artificial intelligence, space exploration, and renewable energy reflects its determination to position itself as a global leader. By continuing to invest in R&D, building strategic global partnerships, and nurturing homegrown talent, India is carving out a formidable role on the global stage as a hub of innovation and knowledge.

The future holds boundless possibilities as India leverages science and technology to tackle some of the world's most pressing challenges—climate change, sustainable development, and digital equity. This bold vision will enable India not only to strengthen its economy but also to lead in

shaping global progress. As the country moves forward, science and technology will remain at the heart of its mission to build a sustainable, inclusive, and technologically empowered society, ensuring prosperity and global leadership for generations to come. □

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