India's Quest for Technological Sovereignty

This editorial is based on "[The long march ahead to technological independence](#)" which was published in The Hindu on 10/09/2025. The article brings into picture the need for technological sovereignty in the digital age, stressing that India must reduce dependence on foreign software. It emphasizes building indigenous open-source solutions as an urgent and achievable path to true freedom.

For Prelims: [Digital Personal Data Protection (DPDP) Act, 2023](#), [Aatmanirbhar Bharat Abhiyan](#), [Bharat 6G Vision](#), [Intellectual Property Rights](#), [India Stack](#), [India Semiconductor Mission](#), [Indian Computer Emergency Response Team](#), [BHASHINI](#), [Sarvam AI](#).

For Mains: Technological Sovereignty and its Significance, Key Challenges Hindering India's Path to Technological Sovereignty.

True freedom in today's **digital age requires [technological sovereignty](#),** not just political autonomy. Modern warfare is waged through software and cyberspace, with a **handful of foreign companies controlling [critical infrastructure](#) like banks, railways, and power grids.** This dependence creates serious vulnerabilities, as demonstrated **when cloud services were recently cut off to an Indian company.** The solution lies in building **India's own foundational software through open-source development,** requiring our vast IT community to unite behind this mission. While the **path to hardware sovereignty** remains challenging, **achieving software independence through collective will and strategic planning** is both urgent and achievable before a crisis forces our hand.

What is Technological Sovereignty?

- **Technological sovereignty** refers to a nation's ability to develop, control, and govern the critical technologies it deems essential for its **security, economy, and strategic autonomy.**
- It is not about achieving complete technological self-sufficiency, which is impractical in today's interconnected world.
- Instead, it is **about avoiding one-sided and critical dependencies on foreign powers for key technologies.**
- While closely related to **digital sovereignty (which focuses on controlling data and digital infrastructure)**, technological sovereignty is a broader concept that also encompasses the physical hardware and the underlying intellectual property (IP) that drives these systems.

Why is Technological Sovereignty Critical for India?

- **National Security and Data Privacy: Technological sovereignty is a national security**

imperative, protecting against cyber warfare and surveillance.

- Relying on foreign hardware and software creates backdoors and vulnerabilities, enabling external actors to compromise critical infrastructure, from power grids to financial systems.
- The government's ban on over 119 Chinese apps citing national security concerns and the enactment of the Digital Personal Data Protection (DPDP) Act, 2023, reflect a proactive stance to localize data and reduce dependence on foreign tech giants, safeguarding citizen data and state secrets.

- **Economic Resilience and Aatmanirbhar Bharat:** Developing indigenous technologies is central to India's goal of economic self-reliance, fostering domestic innovation and job creation.
  - Aatmanirbhar Bharat Abhiyan aims to build a robust manufacturing ecosystem, reducing reliance on global supply chains that proved fragile during the pandemic.
  - For example, the PLI Schemes have witnessed exports surpassing ₹ 5.31 lakh crore (around US$ 61.76 billion), with significant contributions from sectors such as Large-Scale Electronics Manufacturing.
    - Also, India aims to exceed $20 billion in smartphone exports in FY25, driven by rising iPhone exports, a stark shift from being a net importer.

- **Geopolitical Leverage and Strategic Autonomy:** Technological self-reliance provides India with greater leverage in international relations, preventing it from being a pawn in geopolitical tech rivalries.
  - Dependence on a few global tech companies, predominantly from the US and China, can constrain foreign policy choices.
  - India's pursuit of the Bharat 6G Vision, aiming to secure 10% of global 6G-related Intellectual Property Rights (IPRs), is a strategic move to position itself as a net provider of technology, not just a consumer, enabling it to shape future global standards and partnerships on its own terms.

- **Infrastructure and Financial Inclusion:** Sovereign technology is vital for building and maintaining a resilient public digital infrastructure that is accessible and affordable to all citizens.
  - The India Stack, a suite of digital public goods, including Aadhaar, UPI, and DigiLocker, demonstrates this.
  - UPI achieved a milestone in August 2025, surpassing 20 billion monthly transactions, totaling ₹24.85 lakh crore, a testament to a homegrown technology enabling unprecedented financial inclusion and a digital economy.
  - This framework allows India to innovate from the ground up, tailored to local needs, rather than adapting to foreign models.

- **Semiconductor Independence:** The global semiconductor shortage underscored India's critical vulnerability in hardware manufacturing, a foundational element of any digital economy.
  - India is heavily reliant on foreign-made chips, making it susceptible to supply chain shocks and price volatility.
  - The India Semiconductor Mission (ISM), with a budget of ₹76,000 crore, aims to establish a domestic ecosystem for chip design and fabrication, with major players like Vedanta-Foxconn and Micron Technology investing billions, laying the groundwork for a secure, self-sufficient electronics industry.

- **Cyber-Resilience and Digital Sovereignty:** True technological sovereignty is not just about building tech but also about securing it.
  - India's digital infrastructure is constantly under threat from sophisticated cyberattacks, and a lack of indigenous capability in cybersecurity can be catastrophic.
  - The Indian Computer Emergency Response Team (CERT-In) has recorded a massive increase in cyber threats, and the government's focus on building a robust cybersecurity framework and a skilled workforce is paramount.
    - A recent high-profile example is the WazirX crypto exchange hack (2025), where North Korean-linked Lazarus Group exploited smart contract flaws, revealing deep cybersecurity gaps in India's fintech backbone.

- **Cultural and Social Autonomy:** Technological sovereignty ensures that a nation's digital platforms and content reflect its unique cultural and social values.
  - Relying on foreign-owned social media and content platforms can lead to the erosion of local languages and cultural narratives and create an environment ripe for misinformation campaigns.
  - The government's initiatives to promote Indian-language content and platforms, coupled

with the new IT Rules, aim to hold platforms accountable.

- For instance, the promotion of platforms like BHASHINI, which supports real-time translation and content in Indian languages, is key to preventing the "digital colonisation" of India's linguistic diversity.

- **Space & Communications Sovereignty:** Sovereignty in space and communications is crucial for India's strategic independence and its growing digital economy.
  - Relying on foreign satellite systems for communication, navigation, and earth observation creates a critical vulnerability.
  - India's indigenous Navigation with Indian Constellation (NavIC) system, a regional alternative to GPS, is a prime example, providing secure and reliable positioning services for both civilian and defense applications.
  - Similarly, the Indian Space Research Organisation (ISRO) continues to launch its own communication satellites (GSAT series) to reduce reliance on foreign-leased transponders, safeguarding critical data and ensuring uninterrupted communication services for national broadcasters and military operations.

- **AI and Algorithmic Sovereignty:** AI and algorithmic sovereignty are a critical subset of technological sovereignty, focusing on a **nation's ability to control and govern the artificial intelligence systems that increasingly influence public and private life.**
  - Relying on foreign-developed black-box AI models risks a loss of control, potential for foreign influence, and the embedding of biases that don't reflect India's diverse social and cultural context.
  - In a significant step towards strengthening India's strategic autonomy in artificial intelligence (AI), **Bengaluru-based start-up Sarvam AI** has been chosen to develop the nation's first indigenous sovereign large language model (LLM).
    - This ensures that the AI can understand the nuances, cultural context, and linguistic diversity of India, making it a critical national infrastructure that serves the population without external dependencies.

What are the Key Challenges Hindering India's Path to Technological Sovereignty?

- **Dearth of Domestic Semiconductor Ecosystem**: India faces a significant challenge in building a complete domestic semiconductor ecosystem, from **design to fabrication.**
  - The **capital-intensive nature** and complex technical requirements of this industry have historically kept India out of the global value chain.

    - The country remains heavily reliant on imports for over **90% of its semiconductor needs**, making it vulnerable to geopolitical supply chain shocks.
    - Globally, the most advanced semiconductors are **made on sub-10 nanometer (nm) process nodes,** which are essential for high-performance computing, AI, and advanced smartphones. **India, by contrast, has no operational fabs for chips at or below 28nm.**

- **Acute Skills Gap and "Brain Drain":** While India produces a large number of STEM graduates, there's a significant skills mismatch and a persistent "brain drain" of top talent.
  - A large percentage of highly skilled professionals migrate abroad for better opportunities, higher salaries, and advanced research facilities.
  - Reports suggest a critical shortage of talent in cutting-edge fields like AI, cybersecurity, and chip design. According to the International Labour Organisation (ILO), India is likely to face a shortage of ~29 million skilled personnel by 2030.
    - This exodus of talent weakens domestic innovation capabilities and makes it difficult for India to build and scale its own deep-tech enterprises.

- **Low R&D Investment:** India's expenditure on Research & Development (R&D) remains low, a major obstacle to indigenous technological development.
  - The country's Gross Expenditure on R&D has hovered between 0.6% and 0.7% of its GDP for years, which is significantly lower than major global innovators like South Korea, Israel, and the U.S.
  - A major factor is the low private sector contribution, which accounts for only about 36% of

the total R&D expenditure, a stark contrast to developed economies where the private sector often contributes over 70%.
- This lack of funding stifles innovation and limits the creation of new intellectual property.
- **Lack of Patient Capital for Deep Tech:** India's startup ecosystem, while vibrant, is heavily skewed towards consumer-facing and e-commerce ventures that promise quicker returns.
  - There is a noticeable lack of patient, long-term capital for deep-tech startups that require significant investment and a longer gestation period for R&D.
  - A recent report stated that the number of investors participating in funding rounds for India's deeptech startups dropped by over 60% in 2023 compared to 2022.
  - This reluctance from investors, who often have a 5-7 year exit horizon, makes it challenging for startups working on foundational technologies like quantum computing, advanced materials, and robotics to secure the funding needed to scale and succeed.
- **Fragmented Regulatory and Governance Framework:** India's regulatory landscape for the technology sector is often fragmented, with multiple ministries and departments responsible for different aspects of tech, leading to bureaucratic bottlenecks and a lack of unified vision.
  - For instance, a deep tech startup may need to navigate separate policies and approvals from the Ministry of Electronics and Information Technology (MeitY), the Department of Science & Technology (DST), and the Department of Biotechnology (DBT).
  - This bureaucratic inertia and risk-averse culture can delay project approvals and commercialization.
- **Inefficient Government Procurement:** Despite a strong push for "Make in India," government procurement processes remain a significant barrier for local tech startups.
  - The system is often slow and favors large, established foreign vendors who can meet stringent eligibility criteria, such as prior experience and turnover.
  - While initiatives like the **GeM Startup Runway** have introduced exemptions for startups, they face challenges in getting a foot in the door for large-scale, strategic projects.
    - The **absence of a "trial-run" model or a dedicated fund for procuring cutting-edge solutions** from startups limits the public sector's ability to act as a first anchor customer, a role critical for helping nascent tech firms prove their capabilities and scale their products.
- **Weak Intellectual Property (IPR) Enforcement:** A weak IPR enforcement regime undermines the very incentive to innovate. Although India has a comprehensive legal framework for intellectual property, **its enforcement is often slow and ineffective.**
  - The judiciary is overburdened, and the litigation process can be prohibitively expensive for small innovators and startups.
  - According to the US Chamber of Commerce's latest **International IP Index** report India has been ranked **42nd out of 55 countries,** highlighting concerns over patent enforcement and trademark protection.
    - This environment of weak IPR protection **dissuades both domestic and foreign companies from investing heavily in R&D within India,** as they are not confident in their ability to protect their intellectual assets from infringement.

How Can India Strategically Advance Towards Achieving Technological Sovereignty?

- **Catalyzing a Sovereign Deep Tech Ecosystem: India must shift its focus from a service-centric IT model to a product-first, deep tech-driven economy.**
  - This requires fostering a robust ecosystem for startups working on foundational technologies like AI, quantum computing, and advanced materials.
  - Measures should include creating specialized deep tech funds with patient capital, establishing public-private partnership (PPP) "Innovation Hubs" that co-locate academic researchers and industry experts, and offering tax incentives and grants for companies that invest in high-risk, long-gestation R&D.
  - The goal is to build indigenous intellectual property (IP) from the ground up, reducing reliance on licensed foreign technology.
- **Sovereign Technology Testbeds & Regulatory Sandboxes:** Dedicated sovereign testbeds for frontier-tech (chips, AI, space, quantum) must be created to simulate real-world deployment and accelerate translation from lab-to-market.

- Regulatory sandboxes allow innovation without rigid compliance, reducing delays in experimentation.
- Such sovereign environments nurture indigenous startups and insulate validation from foreign reliance.
- **Technology Sovereignty Zones (TSZs):** Dedicated clusters of sovereign technology development-*Technology Sovereignty Zones*-should be established to incubate frontier innovations.
    - These hubs would integrate startups, academia, defence labs, and industries under state-backed infrastructure and procurement pipelines.
    - By **aligning industrial policy with sovereignty objectives,** TSZs reduce reliance on imports while fostering innovation-led exports. Regional hubs also democratise technology growth, reducing overconcentration in metros and promoting balanced development.
- **Strategic Stockpiling & Resource Diplomacy:** Securing critical minerals such as **lithium, cobalt, nickel, and rare earths is indispensable for India's high-tech sovereignty.**
    - India must explore domestic reserves while simultaneously pursuing long-term international contracts through strategic partnerships.
    - Proactive stockpiling creates buffers against global supply shocks, ensuring uninterrupted access for industries like **EVs, defence electronics, and semiconductors.**
    - Resource diplomacy with **Africa, Latin America, and Central Asia** can anchor resilient supply chains independent of Chinese monopolies.
- **Sovereign Cloud & Federated Edge Infrastructure:** India needs to build a sovereign digital backbone through a multi-layered national cloud, **supplemented by federated edge nodes across strategic sectors.**
    - Such an **architecture decentralises data flows, enhances cyber resilience, and reduces exposure to foreign-controlled platforms**. Sensitive domains like defence, governance, healthcare, and finance demand sovereign-grade cloud and edge integration.
    - A federated model ensures efficiency while allowing distributed sovereignty, aligning with India's scale and diversity.
        - It also **future-proofs India against hostile cyber or geopolitical scenarios**.
- **Institutionalised Dual-Use Technology Pathways:** India must formalise frameworks for seamless transfer of innovations **between civilian and defence domains, optimising R&D outcomes.**
    - For example, defence-grade cybersecurity tools can enhance civilian financial systems, while biotech research can feed into national biosecurity.
    - **Structured pathways prevent silos and enable faster diffusion of technology.** Dual-use innovation also strengthens national security by broadening industrial applications of strategic technologies.
    - This approach multiplies the returns on public R&D spending while boosting indigenous capacity.
- **Diaspora Technology Bridges:** India's global diaspora, embedded in leading tech ecosystems, is an untapped strategic asset for sovereignty.
    - Structured initiatives such as **sovereign venture funds, short-term research residencies, and innovation exchange programs** can **convert brain drain into brain circulation.**
    - Leveraging their global networks also strengthens India's position in technology diplomacy.
        - **These bridges foster not just knowledge inflow but also capital, mentorship, and collaborative patents**. A coordinated diaspora strategy transforms global Indian talent into a sovereignty multiplier.
- **Sovereign Cybersecurity Architecture:** India must construct a layered, indigenous cyber defence stack encompassing sovereign cryptographic protocols, AI-enabled threat detection, and critical infrastructure protection.
    - **Domestic security operations centres (SOCs), sovereign digital forensics, and rapid incident response systems** must be institutionalised.
    - Investing in homegrown cybersecurity startups and research labs ensures resilience against external dependencies.
        - Cyber defence thus evolves into a national security imperative central to India's technological sovereignty.

Conclusion:

Technological sovereignty rests on **Talent, Tools, and Trust—**the three pillars securing India's digital and strategic autonomy. Cultivating world-class talent drives indigenous innovation, while developing sovereign tools and infrastructure ensures self-reliance in critical technologies. Establishing **trust in secure systems protects data, critical services, and public confidence from external threats.** Combined with strategic resource management and diaspora collaboration, these pillars transform India from a technology consumer to a global innovator.

> **Drishti Mains Question:**
>
> Discuss the strategic importance of technological sovereignty for India in the 21st century. How does it intersect with national security, economic resilience, and geopolitical autonomy?

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Prelims

Q. With the present state of development, Artificial Intelligence can effectively do which of the following? (2020)

1. Bring down electricity consumption in industrial units
2. Create meaningful short stories and songs
3. Disease diagnosis
4. Text-to-Speech Conversion
5. Wireless transmission of electrical energy

Select the correct answer using the code given below:

(A) 1, 2, 3 and 5 only
(B) 1, 3 and 4 only
(C) 2, 4 and 5 only
(D) 1, 2, 3, 4 and 5

Ans: (B)

Q. With reference to "Blockchain Technology", consider the following statements: (2020)

1. It is a public ledger that everyone can inspect, but which no single user controls.
2. The structure and design of blockchain is such that all the data in it are about cryptocurrency only.
3. Applications that depend on basic features of blockchain can be developed without anybody's permission.

Which of the statements given above is/are correct?

(A) 1 only
(B) 1 and 2 only
(C) 2 only
(D) 1 and 3 only

Ans: (D)

Mains:

Q. COVID-19 pandemic has caused unprecedented devastation worldwide. However, technological advancements are being availed readily to win over the crisis. Give an account of how technology was

sought to aid management of the pandemic. (2020)

PDF Refernece URL: