APPSC GROUP-I MAINS — STUDY NOTES

INTEGRATION OF S&T AND INNOVATION

For Human Life

Paper V — Science & Technology | Day 1 (30 Mar 2026)

SECTION 1: SUMMARISED NOTES

1.1 Introduction

Science, Technology, and Innovation (STI) are the primary engines of modern civilisation. From the wheel to artificial intelligence, every leap in human progress has been driven by scientific inquiry and technological application. In the Indian context, S&T integration into human life is not merely an academic question — it is a policy imperative that determines healthcare access, agricultural productivity, communication, governance efficiency, and national security.

India's S&T journey reflects a deliberate policy evolution: from the Science Policy Resolution (1958) emphasising self-reliance, through the Technology Policy Statement (1983) focusing on indigenous capability, to STIP 2020 which envisions a decentralised, inclusive innovation ecosystem aligned with Atmanirbhar Bharat. This topic provides the foundational overview before detailed S&T topics in subsequent days.

1.2 S&T in Key Sectors of Human Life

1.2.1 Healthcare

S&T has revolutionised Indian healthcare: indigenous vaccine production (CoWIN platform delivered over 220 crore COVID doses), telemedicine (eSanjeevani — over 15 crore teleconsultations), diagnostics (RT-PCR, rapid antigen testing scaled during COVID), and pharmaceutical manufacturing (India produces 60% of world's vaccines, earning the 'Pharmacy of the World' title). Genomics, AI-driven diagnostics, and robotic surgery are emerging frontiers.

1.2.2 Agriculture

The Green Revolution (1960s-70s) transformed India from a food-deficit to food-surplus nation through high-yielding varieties, chemical fertilisers, and irrigation. Today, precision agriculture (drone-based spraying, soil sensors), biotechnology (Bt cotton), satellite-based crop monitoring (FASAL, Kisan), and

weather forecasting (Agromet advisories) are enhancing productivity. India's foodgrain production reached 3,577 lakh MT in FY2024-25.

1.2.3 Communication & Digital Revolution

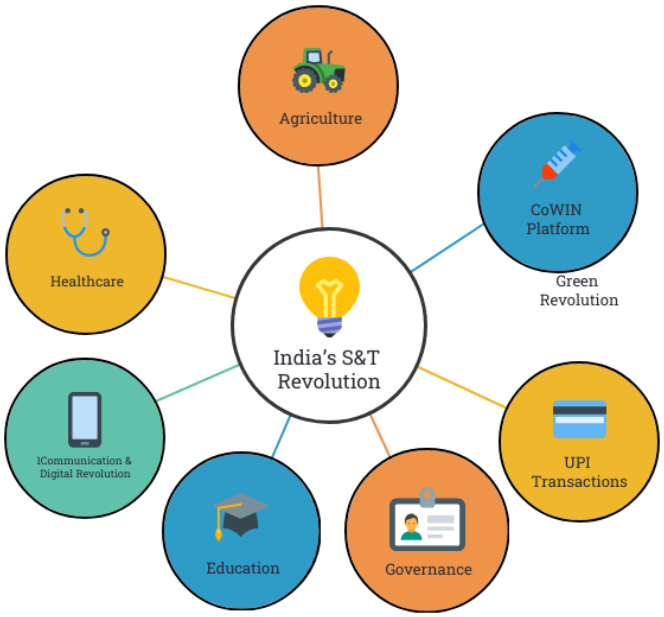
India's digital transformation is S&T-driven: UPI processed over 13,000 crore transactions in 2024-25; Aadhaar provides digital identity to 138+ crore people; DigiLocker, CoWIN, and UMANG demonstrate technology-enabled governance. India's telecom revolution (world's cheapest mobile data) connected over 120 crore subscribers, bridging the urban-rural information gap.

1.2.4 Education

Technology has democratised education: SWAYAM (MOOCs), DIKSHA (school education platform), National Digital Library, and virtual labs have expanded access. NEP 2020 emphasises coding, computational thinking, and interdisciplinary STEM education. AI-powered personalised learning and AR/VR classrooms are emerging.

1.2.5 Governance

E-governance platforms have transformed citizen-government interaction: Aadhaar-based Direct Benefit Transfer (DBT) saved over ₹2.73 lakh crore by eliminating duplicates and ghosts; GST Network digitised indirect taxation; GeM (Government e-Marketplace) enabled transparent public procurement; and PM Gati Shakti's geospatial platform coordinates 16+ ministries for infrastructure planning.



1.3 India's Innovation Ecosystem

India's Global Innovation Index (GII) rank improved to 38th in 2025 (from 66th in 2019). The ecosystem includes: Atal Innovation Mission (AIM) with 10,000+ Atal Tinkering Labs in schools and 73 Atal Incubation Centres; Start-Up India (recognised over 1.25 lakh start-ups, with 100+ unicorns); CSIR, DRDO, ISRO, ICAR, ICMR as institutional pillars; and the private sector contributing ~41% of national R&D spending.

However, India's R&D expenditure at 0.64% of GDP remains far below global benchmarks (China 2.4%, Israel 4.9%, South Korea 4.8%). The Economic Survey 2025-26 highlighted the need to increase private R&D investment significantly. Business sector's R&D share at 41% compares poorly with China's 77%.

1.4 Frugal Innovation — India's Unique Strength

India has demonstrated a distinctive capacity for 'frugal innovation' — achieving more with less. Iconic examples include: Mangalyaan (Mars Orbiter Mission, 2014 — at $74 million, cheaper than a Hollywood film about space); Jaipur Foot (affordable prosthetics used in 30+ countries); Tata Nano (attempt at world's cheapest car); Aravind Eye Care (assembly-line cataract surgery model); and affordable generic pharmaceuticals that serve global health needs.

1.5 Challenges in S&T Integration

- **Low R&D Spending:** At 0.64% of GDP, India's R&D spending is grossly inadequate for a $3.5+ trillion economy. The target of reaching 2% requires a four-fold increase.
- **Brain Drain:** India produces 15 lakh engineers and thousands of PhDs annually, but a significant proportion migrate to the US, UK, and other countries for better research opportunities and compensation.
- **Lab-to-Market Gap:** Research output (publications, patents) has grown, but translation into commercial products and services remains weak. University-industry linkage is underdeveloped.
- **Digital Divide:** Despite digital progress, rural-urban and gender gaps in digital access persist. Only about 43% of rural households have internet access compared to 76% in urban areas.
- **IPR Regime:** India's patent filing and enforcement remain weaker than global peers. Balancing IPR protection with affordable access (especially in pharmaceuticals) is a continuing challenge.

1.6 S&T Policy Evolution

Year	Policy	Key Focus
1958	Science Policy Resolution	Foster scientific research; self-reliance; build institutional base (CSIR, DRDO, AEC)
1983	Technology Policy Statement	Indigenous technology development; technology self-reliance; commercialisation
2003	S&T Policy	Investment in R&D; national innovation system; S&T for development
2013	STI Policy	Top 5 global scientific powers; S&T-led innovation; private sector in R&D
2020 (Draft)	STIP 2020	Decentralised, bottom-up; Atmanirbhar Bharat; ease of doing research; open science

1.7 AP's S&T Landscape

AP has positioned itself as a technology-friendly state: Visakhapatnam is emerging as a major tech hub with Google's $15 billion AI data centre (largest single FDI in India); Tirupati hosts the Indian Institute of Science Education and Research (IISER); AP Innovation Society promotes start-ups and incubators; and the state's IT policy offers incentives for tech parks and R&D centres. The Fintech Valley Vizag initiative and AP's drone policy for agriculture are notable innovations.

SECTION 2: KEY DIMENSIONS TO COVER

These are the important sub-topics and angles an examiner can frame questions from.

1. **S&T Policy Evolution:** Timeline from SPR 1958 → TPS 1983 → STP 2003 → STIP 2013 → STIP 2020. Know key focus of each.
2. **S&T in Everyday Life:** Healthcare (vaccines, telemedicine), agriculture (precision farming, biotech), communication (UPI, Aadhaar), education (SWAYAM, digital labs), governance (DBT, GST Network).
3. **Innovation Metrics:** GII rank, R&D spending (% GDP), patent filings, start-up ecosystem, unicorn count.
4. **Frugal Innovation:** Mangalyaan, Jaipur Foot, generic pharma. Why India excels at low-cost innovation.
5. **Institutional Framework:** DST, CSIR, DRDO, ISRO, ICAR, ICMR, DBT — mandate, key labs, achievements.
6. **Digital Revolution:** India Stack (Aadhaar + UPI + DigiLocker), JAM Trinity, Digital India, 5G rollout.
7. **Challenges:** Low R&D, brain drain, lab-to-market gap, digital divide, IPR issues.
8. **Ethical Dimensions:** AI ethics, data privacy (Digital Personal Data Protection Act 2023), algorithmic bias, gene editing regulations.
9. **AP-Specific:** Google data centre Vizag, Fintech Valley, AP Innovation Society, drone agriculture, iHUBs.
10. **Global Comparisons:** India vs China (R&D spending), India vs Israel (innovation ecosystem), India vs South Korea (chaebol-led R&D).

SECTION 3: PRELIMS MUST-REMEMBER FACTS

Crisp factual points for MCQ-based Prelims. Memorize these.

1. Science Policy Resolution 1958 — India's first S&T policy. Focus: foster scientific research, self-reliance.
2. Technology Policy Statement 1983 — Focus on indigenous technology and self-reliance.
3. STIP 2013 — Aimed to position India among top 5 global scientific powers. Decade of Innovation (2010-20).
4. STIP 2020 (Draft) — Decentralised, bottom-up, inclusive. Four-track consultation. Aligned with Atmanirbhar Bharat.
5. India's R&D spending: 0.64% of GDP. China: 2.4%. Israel: 4.9%. South Korea: 4.8%. US: 3.5%.
6. Global Innovation Index 2025: India ranked 38th (up from 66th in 2019).
7. Article 51A(h): Fundamental Duty to develop scientific temper, humanism, and spirit of inquiry and reform.
8. Key institutions: DST (Department of Science & Technology), CSIR (38 labs), DRDO (52 labs), ISRO, ICAR (113 institutes), ICMR, DBT.
9. Atal Innovation Mission (2016): 10,000+ Atal Tinkering Labs; 73 Atal Incubation Centres.
10. Start-Up India (2016): 1.25 lakh+ recognised start-ups; 100+ unicorns.
11. UPI transactions 2024-25: 13,000+ crore. Aadhaar coverage: 138+ crore.
12. Mangalyaan (MOM, 2014): India's Mars mission at $74 million. Made India 4th nation to reach Mars.
13. CoWIN platform: Managed 220+ crore COVID vaccine doses. Open-source, replicated globally.
14. India: 'Pharmacy of the World' — produces 60% of world's vaccines, 20% of global generic medicines.
15. DBT savings: Over ₹2.73 lakh crore saved by eliminating duplicates through Aadhaar-linked transfers.
16. Foodgrain production FY2024-25: 3,577.3 lakh MT (record). Green Revolution: began 1960s with Norman Borlaug's HYVs.
17. AP: Google's $15 billion AI data centre in Vizag — largest single FDI in India.
18. Digital Personal Data Protection Act 2023: India's first comprehensive data privacy law.
19. 5G: Launched in India October 2022. Coverage: all district headquarters by 2024.

20. SWAYAM: MOOCs platform. DIKSHA: School education. National Digital Library: 7 crore+ resources.

SECTION 4: MAINS MUST-WRITE POINTS

Structured points for descriptive answers.

1. **S&T as Equaliser:** Technology has the power to bridge historical inequalities — UPI gave 50+ crore people access to digital payments; Aadhaar-DBT ensured benefits reach the last mile; telemedicine connected rural patients to specialist doctors. The integration of S&T into everyday life is not a luxury but a necessity for inclusive development.
2. **Policy Evolution Reflects National Priorities:** From Nehru's vision of scientific temper (1958 SPR) to Modi's Atmanirbhar Bharat (STIP 2020), India's S&T policies mirror its developmental stage. The shift from 'institution-building' (1950s-80s) to 'innovation ecosystem' (2010s onwards) reflects a maturing economy that needs not just scientists but entrepreneurs, not just labs but start-ups.
3. **Frugal Innovation as Competitive Advantage:** India's ability to innovate under resource constraints — Mangalyaan at $74 million, CoWIN as a global model, generic pharma saving millions of lives worldwide — is a distinctive national strength. This 'more from less' approach is relevant for developing countries globally and positions India as a leader in accessible innovation.
4. **The R&D Deficit is a Strategic Vulnerability:** At 0.64% of GDP, India's R&D spending is one-quarter of China's and one-seventh of Israel's. This limits India's ability to develop cutting-edge technologies (AI, quantum computing, semiconductors) indigenously, creating strategic dependencies. The Economic Survey's call for increased private R&D investment is urgent.
5. **Digital India — A Case Study in S&T Integration:** India Stack (Aadhaar + UPI + DigiLocker) is a globally unique example of how S&T can transform governance. DBT saved ₹2.73 lakh crore; UPI became the world's leading real-time payment system; and CoWIN managed the world's largest vaccination drive. This demonstrates that government as 'platform' (technology-enabled governance) can deliver public goods at scale.
6. **Brain Drain to Brain Gain:** India's diaspora scientists (Sundar Pichai, Satya Nadella, Venki Ramakrishnan) demonstrate Indian talent. Policy must focus on 'brain circulation' rather than preventing emigration — creating world-class research institutions, competitive compensation, and a vibrant innovation ecosystem that attracts talent back.
7. **Ethical Frontiers:** As AI, gene editing (CRISPR), and big data become central to human life, ethical frameworks become critical. India's Digital Personal Data Protection Act (2023) is a step, but comprehensive AI regulation, algorithmic accountability, and equitable access to emerging technologies need attention.

8. **AP's Technology Opportunity:** Google's $15 billion AI data centre in Vizag could transform AP's technology landscape. Combined with Fintech Valley, AP Innovation Society, and drone-based agriculture, AP has the ingredients for an S&T-driven growth model. However, this requires human capital development (skilling), infrastructure (power, connectivity), and institutional support.

SECTION 5: VALUE ADDITION

Use these to enhance your Mains answers.

Constitutional Linkage

- Article 51A(h): Fundamental Duty to develop scientific temper, humanism, and spirit of inquiry and reform.
- Article 51A(j): Duty to strive towards excellence in all spheres of individual and collective activity.
- Entry 63-66 of Union List: Institutions of scientific/technical importance; coordination of scientific research.
- Article 21: Right to Life — access to healthcare, clean environment, and digital services increasingly read into this.

SDG Linkage

- SDG 9: Industry, Innovation and Infrastructure — Resilient infrastructure, inclusive industrialisation, innovation.
- SDG 3: Good Health and Well-Being — S&T in healthcare (vaccines, diagnostics, telemedicine).
- SDG 4: Quality Education — Technology-enabled education (SWAYAM, digital labs).
- SDG 17: Partnerships for Goals — Technology transfer, international S&T cooperation.

Scheme & Policy Framework

- Atal Innovation Mission (2016): Tinkering Labs + Incubation Centres + Grand Challenges.
- Start-Up India (2016): Tax exemptions, Fund of Funds, simplified compliance for start-ups.
- Digital India (2015): Nine pillars including broadband, e-governance, IT jobs.
- Make in India (2014): 25 sectors; FDI liberalisation; manufacturing push.
- National Education Policy 2020: STEM emphasis, coding from Class VI, multidisciplinary approach.
- PM-STIAC: Prime Minister's Science, Technology and Innovation Advisory Council. Nine missions including AI, quantum, deep ocean.

Key Institutions

- DST: Nodal department for S&T policy. Manages INSPIRE, SERB, nano-mission.
- CSIR: 38 national laboratories. Focus: industrial R&D. Notable: NAL, NCL, CDRI.

- DRDO: 52 labs. Defence R&D. Achievements: Agni, Prithvi, Tejas, INS Arihant technology.
- ISRO: Space programme. Chandrayaan, Mangalyaan, Gaganyaan. Commercial arm: NSIL.
- ICAR: 113 institutes. Agricultural R&D. Green Revolution to nano-fertilisers.
- ICMR: 26 institutes. Health R&D. COVID response, genomic surveillance.

Comparative Perspective

- India vs Israel: Israel's 'Start-Up Nation' model: mandatory military service builds tech skills; 4.9% R&D/GDP; deep VC ecosystem. Lesson: concentrated investment in niche areas yields disproportionate returns.
- India vs China: China's R&D at 2.4% GDP; 77% from business sector. China has national champions in AI, 5G, EVs. India's strength is software/services; weakness is hardware/manufacturing.
- India vs South Korea: Chaebol-led R&D (Samsung, LG, Hyundai spend 4-5% revenue on R&D). India lacks comparable corporate R&D commitment.

SECTION 6: QUICK REVISION BOX

Last-minute glance before the exam.

▶ SPR 1958 → TPS 1983 → STP 2003 → STIP 2013	▶ STIP 2020 = Bottom-up, Decentralised, Inclusive
▶ R&D = 0.64% GDP; GII rank = 38th (2025)	▶ Art. 51A(h) = Scientific temper duty
▶ DST, CSIR (38 labs), DRDO (52 labs), ISRO	▶ AIM = 10,000+ Tinkering Labs
▶ Start-Up India: 1.25L+ start-ups, 100+ unicorns	▶ UPI = 13,000+ Cr transactions/year
▶ Mangalyaan = $74M, 4th nation to Mars	▶ India = Pharmacy of World (60% vaccines)
▶ DBT savings = ₹2.73 lakh crore	▶ CoWIN = 220+ Cr COVID doses managed
▶ Green Revolution = HYV + Fertiliser + Irrigation	▶ Digital India = 9 pillars, 2015
▶ AP: Google $15B Vizag data centre	▶ Frugal Innovation = More from Less
▶ China R&D = 2.4%; Israel = 4.9%	▶ DPDP Act 2023 = Data privacy law
▶ PM-STIAC = 9 missions (AI, Quantum, Ocean)	▶ SDG 9 = Industry, Innovation, Infra

SECTION 7: RECOMMENDED SOURCES

Refer to these for deeper understanding.

Source	What to Read	Why
Ravi Agrahari — S&T for Civil Services	Ch. 1–3: S&T Policy, Innovation, Institutions	*Exam-oriented coverage with data points*
Science Reporter (Monthly)	Current S&T developments, policy updates	*Latest achievements, missions, awards*

Source	What to Read	Why
DST Annual Report (latest)	Policy implementation, scheme status	*Official data on R&D spending, institutions*
Economic Survey 2025-26	Chapter on Innovation & R&D	*Latest GII rank, R&D data, policy direction*
India Year Book (latest)	S&T chapter	*Updated institutional data, scheme outcomes*
NITI Aayog — India Innovation Index	State-wise innovation rankings	*AP's innovation ranking and comparative data*