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MINISTRY OF ELECTRONICS AND INFORMATION TECHNOLOGY

AI IMPACT SUMMIT
भारत 2026 INDIA

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WELFARE FOR ALL | HAPPINESS OF ALL

# AI for ALL

## Catalysing Jobs, Growth, and Opportunity

February 2026

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Prosus is a global technology company and the power behind the world's leading lifestyle ecommerce brands, across Europe, India, and Latin America, unlocking an AI-first world for our 2 billion customers. The Prosus technology ecosystem spans food delivery, payments, classifieds, travel, events, and mobility. Our integrated approach enhances user engagement and creates the foundation for unprecedented AI capabilities through proprietary data and cross-service intelligence.

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The team actively backs exceptional entrepreneurs who are using technology to improve people's everyday lives.

Prosus is one of India's largest FDI investors in the technology sector, reflecting our deep and sustained commitment to the nation's thriving economy.

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Our diverse, global teams bring deep industry and functional expertise and a range of perspectives that question the status quo and spark change. BCG delivers solutions through leading-edge management consulting, technology and design, and corporate and digital ventures. We work in a uniquely collaborative model across the firm and throughout all levels of the client organization, fueled by the goal of helping our clients thrive and enabling them to make the world a better place.

# Foreword

## Abhishek Singh

CEO, IndiaAI Mission
Director General, National Informatics Centre (NIC)
Additional Secretary, Ministry of Electronics and Information Technology (MeitY), Government of India

India stands at an important juncture in its technological evolution. Over the past decade, the country has demonstrated how digital public infrastructure can operate at population scale, delivering measurable outcomes across governance, finance and public service delivery. From expanded financial inclusion to large-scale public health initiatives, India's experience reinforces a fundamental lesson for the world: technology delivers value when it addresses real needs at scale. Integrating Artificial Intelligence (AI) is the next phase of this transformation.

AI is increasingly emerging as a foundational capability, shaping how economies generate value for its citizens. For a country of India's scale and diversity, the opportunity is substantial to ensure inclusion. AI must be leveraged across priority sectors — agriculture to enhance farmers' incomes, manufacturing to optimise and augment processes, healthcare to improve patient outcomes, education to strengthen teaching and learning, and financial services to expand access and efficiency. Accessibility, utility and impact must remain the guiding benchmarks.

Under the IndiaAI Mission, we are advancing this vision. Our aim is to position India as a global hub for responsible and inclusive AI by strengthening shared compute infrastructure, enabling access to high-quality AI-ready datasets, supporting the development of indigenous models and expanding the national talent base. Progress across these aspects reflects a clear shift from intent to execution.

A central principle guiding India's approach to AI adoption is that it must be sector-led and grounded in contextual realities. AI Adoption pathways should reflect the operational realities, safety considerations and economic priorities of individual sectors. Realising this potential, however, requires more than technological capability. It demands accessible compute resources, interoperable digital systems, reliable data flows, and governance frameworks that enable innovation while safeguarding trust—outcomes aligned with the IndiaAI Mission.

The India AI Impact Summit provides a platform for government, industry, startups and researchers to advance this agenda through collaboration and execution. This report, spanning critical sectors including Agriculture, Education, Healthcare, Manufacturing, and Financial Services, illustrates how AI can serve as a force multiplier across sectors that directly shape economic and social outcomes. I extend my appreciation to Prosus Group for convening the Amrit Manthan roundtables and to BCG for curating this report. I also thank the contributors, partners and institutions whose insights have guided this report. It is my hope that these perspectives support informed decision-making and catalyse meaningful action toward building an inclusive AI ecosystem across the globe.

# Foreword


## R. Chandrashekhar

Former Secretary, Electronics, IT and Telecom, Government of India
Former President, NASSCOM
Chairman, Centre for The Digital Future


AI is a defining technology of this century. It touches every sphere of human activity, including cognitive and creative functions. Its impact is deep and wide on growth, equity, and jobs. Yet the effects differ across geographies. Context matters.

For India, the opportunities are clear: vast digital capabilities, rising tech entrepreneurship, and pressing human development needs. But benefits won't come automatically. Strategy is essential.

This series of five Sectoral Round Tables brought together leading minds to craft an India-specific AI roadmap. The goal: maximize equitable growth and job creation. Unlike the western narrative of job-loss fears, India can chart a different path — but only with deliberate design.

Two levels must be addressed. First, point solutions for specific problems, best driven by entrepreneurs. Second, ecosystem-level foundations where government plays a critical role: standards, digital public infrastructure, regulatory frameworks, clear state-private roles, and balanced data policies. Data policies must protect rights yet unlock India's vast pool for safe, relevant AI.

AI can create jobs across healthcare, education, agriculture, manufacturing, and finance. It enables assisted access to services, bridges skill gaps, and generates high-skilled roles in data science, analytics, and model development. Crucially, it allows minimally skilled workers to perform higher-skill tasks with limited training.

India's digital track record shows that when goals and roles are clear, scale and speed follow. The challenge now is execution — turning insight into delivery and intent into measurable impact. This report aims to catalyze that phase, bringing stakeholders together to shape an AI-enabled future that delivers real value.

I thank Prosus for organizing these consultations, BCG for shaping the report, and MeitY for its strong support under the National AI Mission.

# Foreword


## Sehraj Singh

Managing Director
Prosus India


Can artificial intelligence be India's catalyst for achieving Viksit Bharat 2047?

As India stands at the threshold of this transformative decade, we find ourselves uniquely positioned to harness AI not merely as a technological advancement, but as a force multiplier for inclusive growth and human empowerment. This question has driven our comprehensive examination across five foundational sectors that will define India's development trajectory.

Today, artificial intelligence is reshaping economies worldwide, unlocking new possibilities in healthcare diagnostics, personalised education, precision agriculture, smart manufacturing, and inclusive financial services. Yet the true test lies not in AI's potential, but in our ability to translate breakthrough technologies into tangible outcomes for India's 1.4 billion people - particularly those in our villages, our MSMEs, and our frontline institutions.

At Prosus, our decade-long partnership with India's digital economy has taught us a fundamental truth: technology succeeds when it augments human capability rather than replacing it. Through our collaboration with the Ministry of Electronics and Information Technology and insights from the Amrit Manthan roundtables, a clear principle has emerged - AI must work alongside our farmers, teachers, healthcare workers, and entrepreneurs, strengthening rather than displacing the human expertise that drives India's growth.

This white paper report represents a paradigm shift from experimentation to systematic deployment. Our analysis reveals that India's greatest constraint is not access to AI models or talent, but execution at scale. Too many promising pilots fail to deliver repeatable, system-wide impact. We must move from vendor-led demonstrations to outcome-linked implementations that leverage India's Digital Public Infrastructure - from DIKSHA in education to ABDM in healthcare - as the backbone for AI integration.

India possesses extraordinary advantages: our young, digitally native population; our world-class entrepreneurial ecosystem; our proven ability to build inclusive digital infrastructure; and most importantly, our human capital that remains the cornerstone of any technological transformation. These strengths, combined with our multilingual diversity and innovation spirit, position India not just as an AI adopter, but as a global leader in human-centric AI deployment.

The path forward demands sustained collaboration across government, industry, regulators, investors, researchers, and civil society. We must establish governance frameworks that balance innovation with trust, create sector-specific regulatory pathways that enable responsible experimentation, and invest in workforce development that ensures no one is left behind in this AI-powered future.

This white paper offers more than analysis - it provides a blueprint for action, grounded in Indian realities and aligned with our national aspirations. From AI-powered crop diagnostics that can transform smallholder farming to intelligent tutoring systems that can deliver personalised learning at unprecedented scale, the recommendations within these pages chart a course toward measurable developmental impact.

The moment for deliberation has passed; the time for execution has arrived. Together, we have the opportunity to make artificial intelligence not just a technological milestone, but India's greatest enabler of inclusive prosperity and our strongest foundation for Viksit Bharat 2047.

# Foreword

## Vipin V

Managing Director & Partner
Boston Consulting Group

Artificial Intelligence is now at a turning point in India's development. The focus has shifted from exploring possibilities to asking how AI can be used widely to create lasting economic and social benefits. Recent roundtable discussions before the India AI Summit show that the ecosystem is maturing. There is a shared belief in AI's potential and a clear understanding that real impact will depend on how well it is put into practice.

One clear takeaway from these discussions, also highlighted in BCG's latest AI Radar, is that technology is ready. Many organizations have started AI pilot projects, but only a few have turned these into real, repeatable results. Progress is now held back by issues like scattered data, unclear responsibilities, old ways of working, and systems that are not built to grow. Without focused effort, AI could stay stuck in trial phases instead of becoming a key part of how organizations work.

In the next few years, India's progress with AI will depend more on building strong systems than on individual breakthroughs. Reports covering agriculture, education, healthcare, manufacturing, and financial services all highlight the same need: AI should help rethink core processes and decision-making, not just be added on top of old problems. To make this happen, the ecosystem must work together. The government should set direction and manage shared digital infrastructure. Industry and startups need to turn this foundation into real solutions, while academia when everyone's role is clear and they support each other, AI can truly boost human abilities, improve services, and help expand opportunity for everyone.

According to BCG, the main challenge now is making AI a core part of organizations. AI should be seen as a strategic asset that is directly tied to results, costs, and long-term success. This means organizations need to set clear priorities, measure impact carefully, and be ready to change processes, incentives, and governance - not just add new tools. Those who take this complete approach will benefit more over time.

The report has five sections that follow the path from context to action. It places India in the global AI scene, looks at India's unique opportunities and needs, reviews how AI is used in different sectors, and ends with broad insights and future priorities to guide the next steps.

This report urges everyone to take collective ownership. It turns the insights from the India AI Summit into a clear plan that now needs action, moving from small trials to large-scale solutions and from potential to lasting results. India has the chance not just to use AI well at home, but also to lead by example for the global South.

# Methodology

This report has been developed through a structured, consultative process combining primary stakeholder engagement with rigorous secondary research. A series of closed-door, sector-specific roundtables were convened across agriculture, education, healthcare, manufacturing, and financial services. These discussions brought together senior policymakers, industry leaders, startup founders, domain practitioners, academics, and sector veterans with deep operating experience. The roundtables aimed to move beyond technology abstraction and surface execution-level insights by identifying binding constraints, validating priority AI use cases, and assessing real-world feasibility under Indian operating conditions.

Prosus curated and facilitated these discussions, leveraging its ecosystem relationships across technology, industry, and entrepreneurship to ensure diverse and practitioner-led participation. Insights emerging from the roundtables were synthesised and triangulated with secondary research, including sector studies and public data. Boston Consulting Group (BCG), in collaboration with Prosus, led the analytical synthesis and drafting of the report, integrating practitioner perspectives with evidence-based analysis. The resulting output is this report that reflects both on-the-ground realities and global best practices, with a clear focus on scalable, outcome-oriented AI adoption in India.

# Introduction

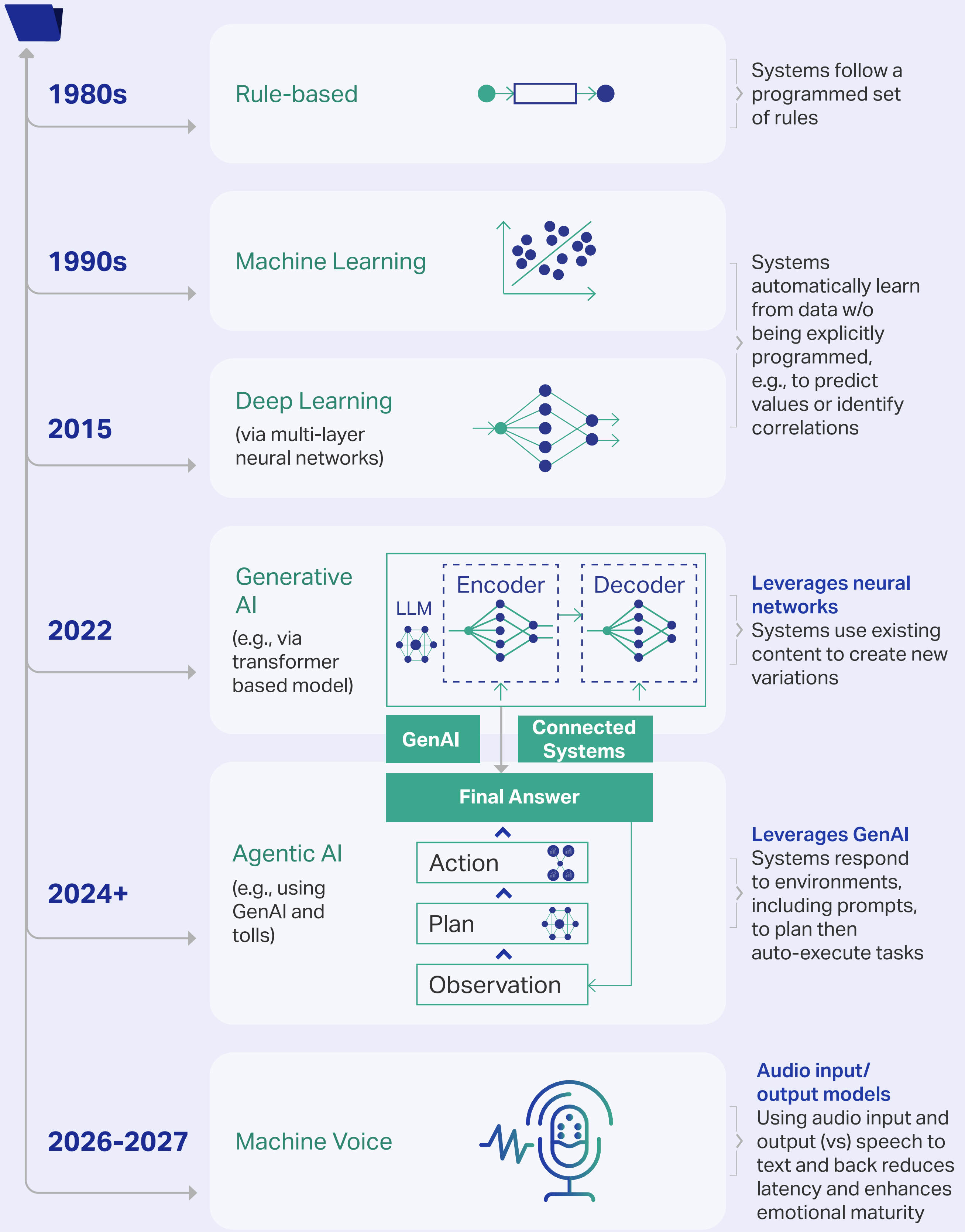
India's development narrative is about to enter a pivotal stage. India is predicted to contribute almost 20% of the incremental global economic growth over the next 15 years, making it the primary force behind global expansion. The national goal of Viksit Bharat 2047, which aims to transform India into a developed economy through consistent productivity growth, inclusion, and institutional strengthening, serves as the foundation for this trajectory. Improving the quality, effectiveness, and resilience of fundamental economic and social systems will be necessary to realize this vision, going beyond scale alone.

This next stage of development will be largely made possible by artificial intelligence. With roughly 16 percent of the world's AI talent residing there, one of the biggest and fastest-growing AI user bases, and a rapidly developing reputation as a global center for applied AI use cases rather than just model development, India comes into the AI era with unique advantages. India is increasingly ranked as one of the top AI-ready economies in international evaluations, including those conducted by the IMF. With the establishment of the IndiaAI Mission and the hosting of the AI Impact Summit 2026, India is positioned to deploy AI extensively across real-world systems in addition to producing AI talent.

Even though AI has experienced rapid generational shifts, its economic impact has not yet fully materialized on a global scale. Machine learning, deep learning, and most recently, generative AI driven by transformer-based models, replaced what started out as inflexible, rule-based systems in the 1980s. A completely new paradigm is emerging today with agentic AI: systems that can sense their surroundings, make plans on their own, and carry out tasks through networked systems without continual human guidance. AI is now an active participant in workflows rather than just a passive tool.

## The AI landscape is rapidly evolving, with Agentic AI as the latest frontier & Machine Voice will be the next

### Year when tech starts becoming mainstream

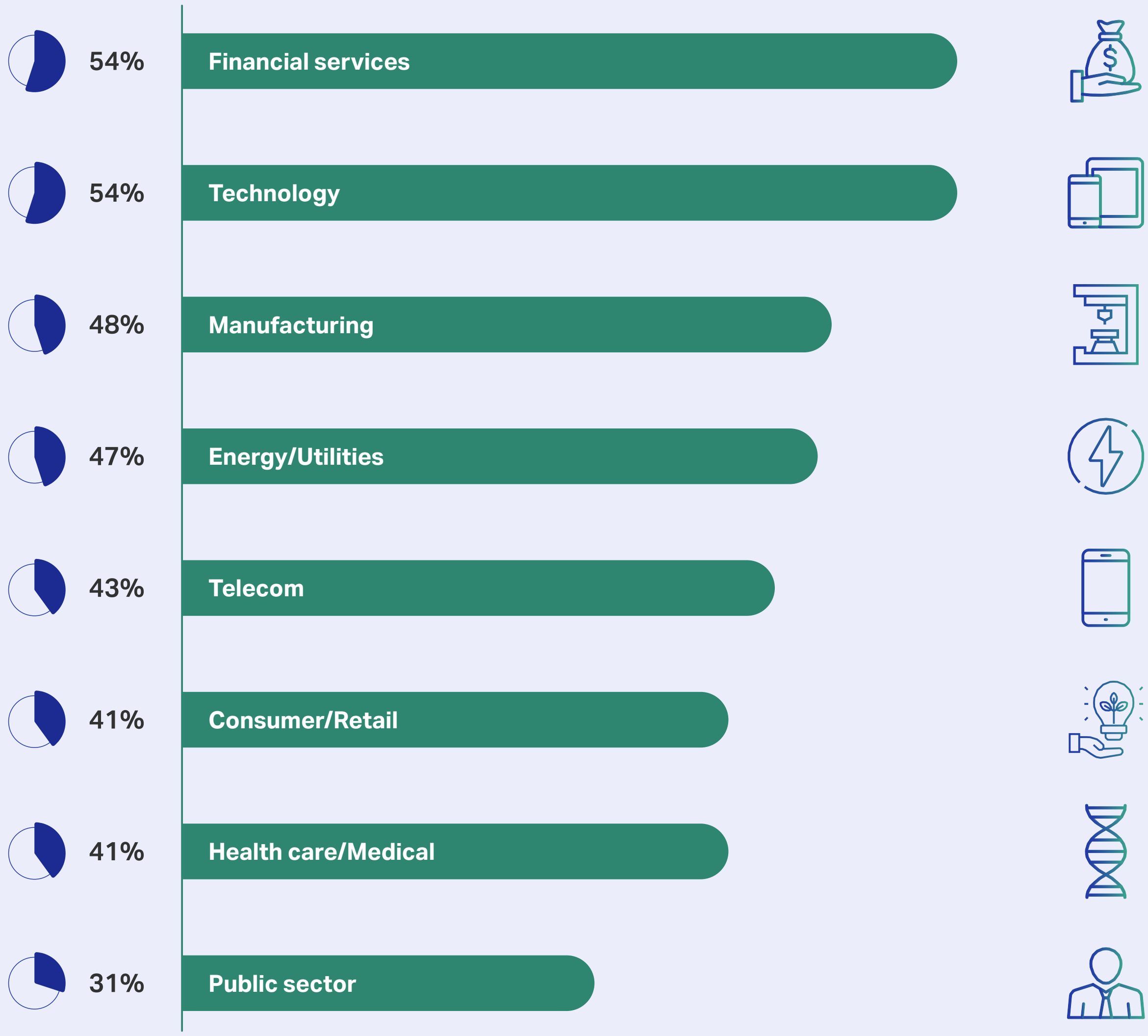


Most organisations remain stuck in what is commonly described as “PoC hell”, characterised by fragmented pilots, limited integration into core workflows, and weak translation into measurable outcomes. Evidence from global research, including BCG’s AI Radar, shows that AI-driven value creation is highly uneven across sectors and geographies.

A small set of leaders, particularly in financial services, manufacturing, and parts of healthcare, are pulling ahead, while many others struggle to scale adoption beyond experimentation. The implication is clear: AI advantage is not determined by access to technology, but by the ability to execute at scale.

## Financial services and tech are leading the pack on workflow redesign

### Share of respondents who report their company is doing workflow redesign (Reshape) among industries



Adoption trends by sector support this finding. While sectors like agriculture, education, and public health continue to be under-integrated with AI despite its enormous potential, industries like financial services and advanced manufacturing have made faster progress in integrating AI into decision-making, risk assessment, quality control, and operations. Disparities in data readiness, institutional capacity, workforce readiness, and problem definition clarity are reflected in this uneven adoption. If AI is to significantly support India's growth and inclusion goals, these gaps must be filled.

This report series responds to that challenge. It represents the outcome of a structured set of sector-specific roundtables across agriculture, education, healthcare, manufacturing, and financial services, involving policymakers, industry leaders, practitioners, startups, researchers, and civil society representatives. The discussions focused deliberately on execution: identifying binding structural constraints, validating high-impact AI use cases, and assessing what must change across policy, institutions, data, and skills for AI to scale responsibly in the Indian context. These insights are in line with current government programs and digital public infrastructure, and they have been combined with secondary research.

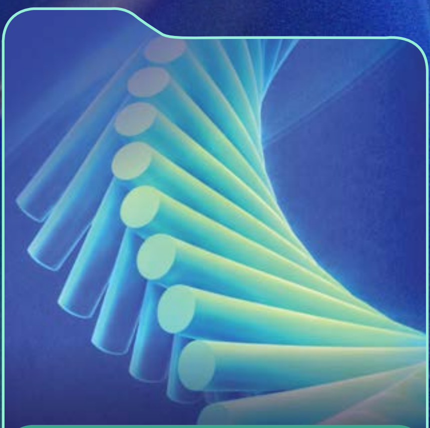
Across the five sectors examined, a common pattern emerges. India has achieved scale, but outcomes remain uneven. Fragmented data, workforce constraints, limited feedback loops, and institutionally weak decision-support systems continue to constrain productivity and service quality. AI introduces fundamentally new capabilities to address these challenges. Doctors in resource-constrained settings can access AI-assisted diagnostics and triage; farmers can receive hyperlocal, vernacular advisory; teachers can personalise instruction in large or single-teacher classrooms; MSMEs can access credit through cash-flow-based underwriting rather than collateral. These are not incremental improvements; they expand the operational feasibility frontier at scale.

However, discipline is necessary to realize this potential. Research consistently demonstrates that 70-20-10 principle: roughly 10% of effort goes toward algorithms, 20% goes toward data and technology infrastructure, and 70% goes toward people, processes, governance, and cultural change, which is the key to successful AI adoption. Therefore, institutional preparedness, workflow redesign, accountability, and human capacity building are more important for AI success than model sophistication. India has a rare chance to learn this lesson early on and focus its AI strategy on systemic change rather than just technology implementation.

Accordingly, each sector is structured into five integrated sections. The first sets out the sector context and structural challenges. The second identifies priority opportunity areas and the architectural principles required for AI to work at scale. The third details practical, high-impact AI use cases grounded in real deployments. The fourth examines employment and workforce implications, including new role archetypes created by AI adoption. The final section outlines the system-level shifts and action agenda required to move from pilots to scale.

Taken together, this report series seeks to move the conversation from AI potential to AI execution, positioning artificial intelligence as a foundational capability for inclusive growth, improved service delivery, and sustained national competitiveness in India’s journey toward Viksit Bharat 2047.

# Table of Contents



**Amrit Udyog**

AI in Indian Manufacturing




**Amrit Niti**

AI in Indian Financial Services



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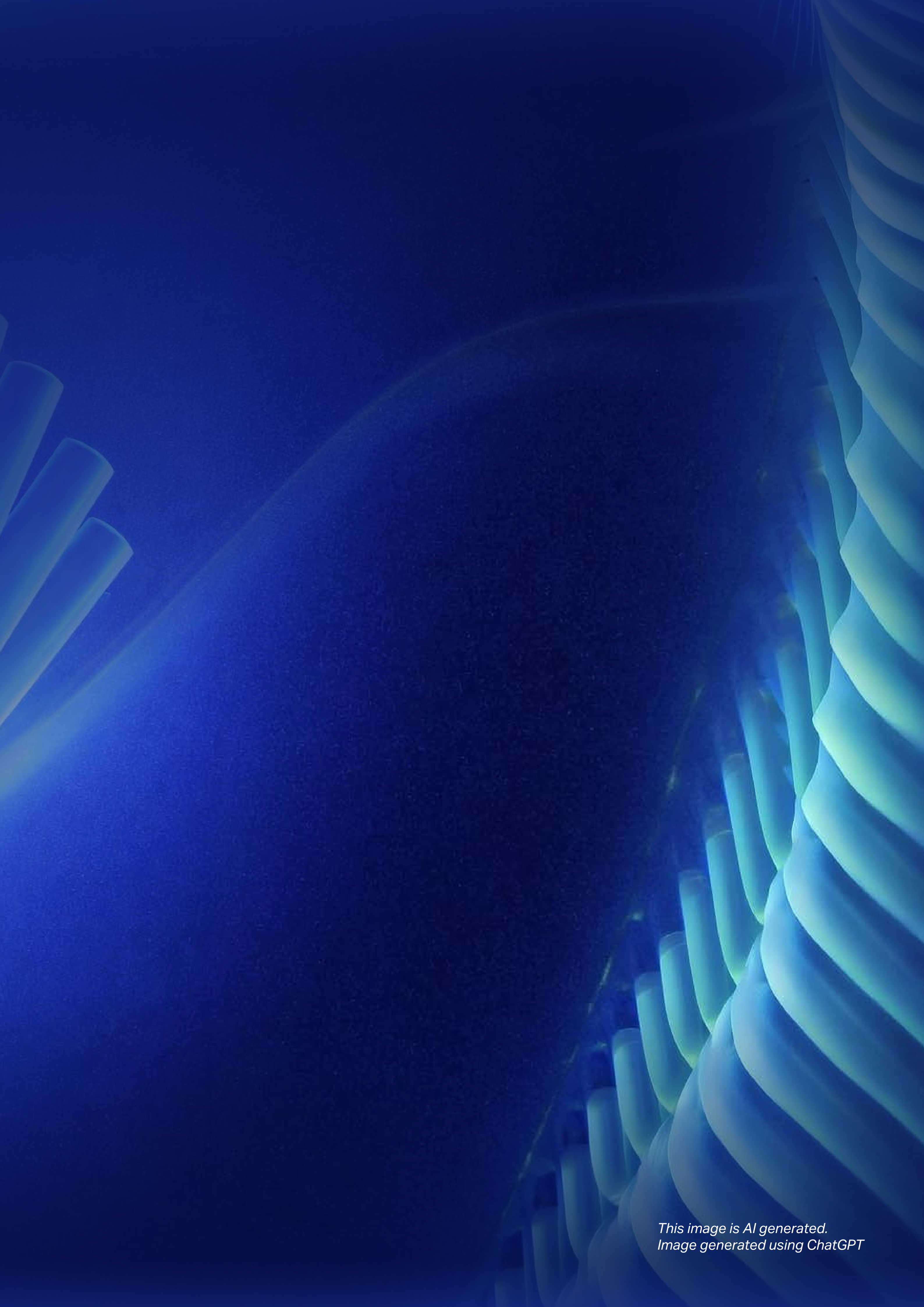
# Amrit Arogya

## AI in Indian Healthcare



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# Executive Summary

India's health system is undergoing major changes. Over the past 2 decades, the country has seen improvements in life expectancy, maternal and child health, disease control, and the rollout of large-scale programs. Digital public infrastructure has made care delivery more effective, supporting platforms like e-Sanjeevani and laying the groundwork for the Ayushman Bharat Digital Mission. These advances show that India can manage large-scale medical care systems.

However, structural gaps remain. Access to prompt care remains uneven, largely due to the unequal distribution of doctors and specialists, with the most serious shortages occurring outside major urban areas. Diagnostic capacity inside regions beyond metropolitan areas is limited, causing delays and inconsistent quality of care. Despite advancements in public coverage, out-of-pocket expenses remain high, driven not only by service prices but also by repeat testing, fragmented care experiences, travel costs, and lost wages. At the same time, the disease burden has moved towards chronic and lifestyle conditions that require ongoing, coordinated care instead of occasional treatments.

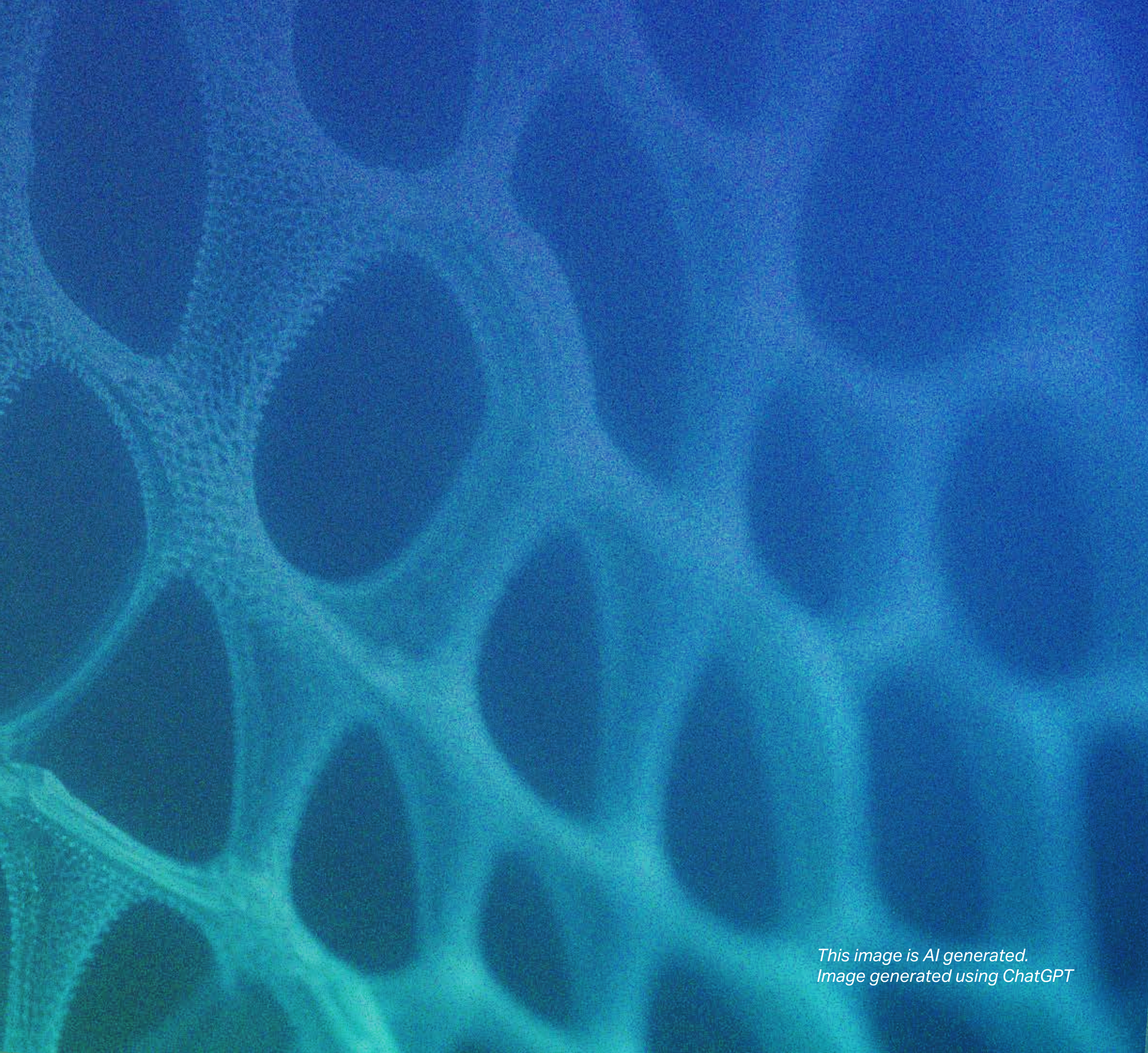
These challenges are further compounded by fragmented data systems and limited capacity to generate actionable insights. Much of the health data is still kept separate by public programs, private providers, and facilities, and a lot of it is still on paper or not organised. Frontline staff and clinicians face heavy workloads and extensive paperwork, with uneven support for decision-making, making it hard to maintain consistent quality across the system.

Artificial Intelligence now offers fundamentally new levers to address these constraints. Used as a force multiplier rather than a replacement for clinicians or infrastructure, AI can help India leapfrog structural limitations. The report identifies how AI can reinforce the health system across four critical dimensions:

- **Maximising workforce productivity or access at scale** via AI-driven triage, assisted telemedicine, documentation assistance, multilingual voice tools, and decision tools for frontline staff to ensure that scarce clinical skills are deployed on those most at risk.
- **Improving accuracy, consistency, and quality of care** through the standardisation of diagnostic tools and documentation of process implementation, reducing variability driven by location, workload, and individual experience.
- **Reducing avoidable financial burden on households and the system** by cutting repeat tests, improving care-pathway efficiency, lowering travel and wage-loss costs, and curbing fraud and leakage in insurance and public programs.
- **Generation of actionable intelligence for the administrators,** through the translation of fragmented data sets into district-level risk signals, early warning systems, and operational dashboards to accomplish precise planning.

AI adoption also creates complementary employment opportunities across healthcare technology operations, care coordination, analytics, and governance, supporting, rather than displacing, human roles.

Realising this potential may require system-level shifts. Policymakers could consider a unified, risk-tiered AI-in-health regulatory framework anchored in patient safety and human oversight; strengthened data governance aligned with the DPDP Act; accelerated ABDM adoption; shared national utilities for benchmarking, anonymisation, and assurance; and sustained skilling of clinical and non-clinical cadres.AI in healthcare is thereby placed not as a strategic goal, but as a practical, near-term enabler that can extend access, improve quality, reduce financial stress, and strengthen governance at population scale, while remaining firmly anchored in ethics, safety, and accountability.



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# India’s Healthcare Paradigm

*Progress, Structural Gaps, and a Moment of Opportunity*

India's healthcare system has made steady and undeniable progress over the past two decades. Life expectancy has risen, infant and maternal outcomes have improved, institutional deliveries are now the norm, and national programs ranging from tuberculosis to immunisation have scaled to populations unmatched anywhere in the world.

The country has also built one of the world's most advanced digital public infrastructures, enabling growth of telemedicine, digitised health facilities, and more than 400 million digital consultations through platforms such as e-Sanjeevani.

Yet, some structural challenges remain driven by systemic reasons: geography, resource distribution, population size, and the rising burden of chronic disease.

## Significant progress made...

Life expectancy improved from 35 years in 1950 to 60 years in 1990 to 72 years in 2023

Average Indian lives 12 years more than a few decades ago

Infant mortality rate improved 30% (2014–2021)

Out of pocket health expenses fell from 64% in 2014 to 39% in 2022

Institutional deliveries surged from 39% in 2006 to ~90% in 2021

400 mn+ patients served by eSanjeevani

## ...but large headroom remains

### Health adjusted Life Expectancy Expectancy (HALE)[1]

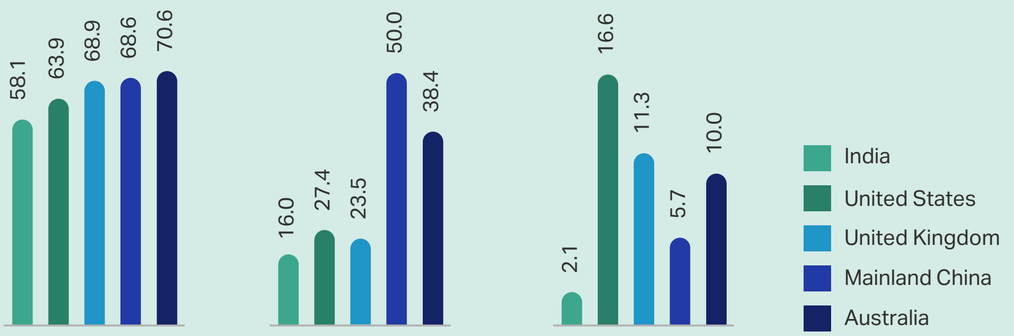
*At birth, in years*

### Hospital Bed – Patient Ratio

*Beds per 10,000 Population*

### Public Health Expenditure

*Share in current GDP*




**1:811** Doctor-to-patient ratio (per 1,000 patients)[1] limiting access to timely and quality healthcare

**60%** Deaths caused by NCDs, owing to lack of proper nutrition, care and diagnostics

**33%** Doctors serve 2/3rd of population in rural areas, highlighting high degree of regional disparity[1]

**63** Universal Health Coverage (UHC) service index; as the developed world is over 80 *(United States: 86, Australia: 87, United Kingdom: 88)*

1. HALE estimates years lived in good health (adjusted for illness/disability), while life expectancy counts total years lived regardless of health.

**Source:** National Health profile, 2022; World Bank database; WHO, UHC Service Coverage Report, 2021; Ministry of Statistics and Programme Implementation (MoSPI), Ministry of Food Processing Industries (MoFPI); Agricultural Statistics at Glance, Ministry of Agriculture and Farmers' Welfare 2022; District Level Risk and Vulnerability of Indian Agriculture to Future Climate Change, NICRA-ICAR 2021; India Agriculture Research Institute

# The Core Healthcare Challenges that Need to be Addressed

Despite clear progress, India's health system continues to face structural gaps that affect access, quality, and affordability of care, especially beyond major cities. Prior approaches like capacity expansion, digital point solutions, and disease-specific vertical programs have delivered meaningful improvement, and there is opportunity to build on these foundations to accelerate progress at India's scale. The pace of population growth, rising chronic disease burden, and persistent district-level inequities continue to strain community health systems that were not designed for continuous, risk-based care. These challenges are systemic, reflecting the sheer scale, diversity, and complexity of India's health landscape.

## Limited Access to Timely Care across Geographies

- India's overall doctor-to-population ratio is close to ~1:811 (MoHFW) (vs ~1:400 in China), but national averages mask sharp inter-state and district-level disparities, ranging from near sub-Saharan benchmarks in some geographies to much higher clinician density in major metros.
- **More than two-thirds of citizens** live in Tier-2 towns and beyond but are **served by roughly one-third of the nation's doctors**; within many states, specialists also cluster in a few urban/private hubs, compounding the access gap for peripheral districts.
- Primary Health Centres face heavy patient loads and unfilled vacancies, while **Community Health Centres see shortfalls approaching ~80%** in key specialists such as surgeons, physicians, paediatricians, and obstetricians/ gynaecologists as noted in the Health Dynamics of India 2022-23 report.
- These patterns translate into longer travel times, delayed consultations, and uneven access to specialist care in many districts.

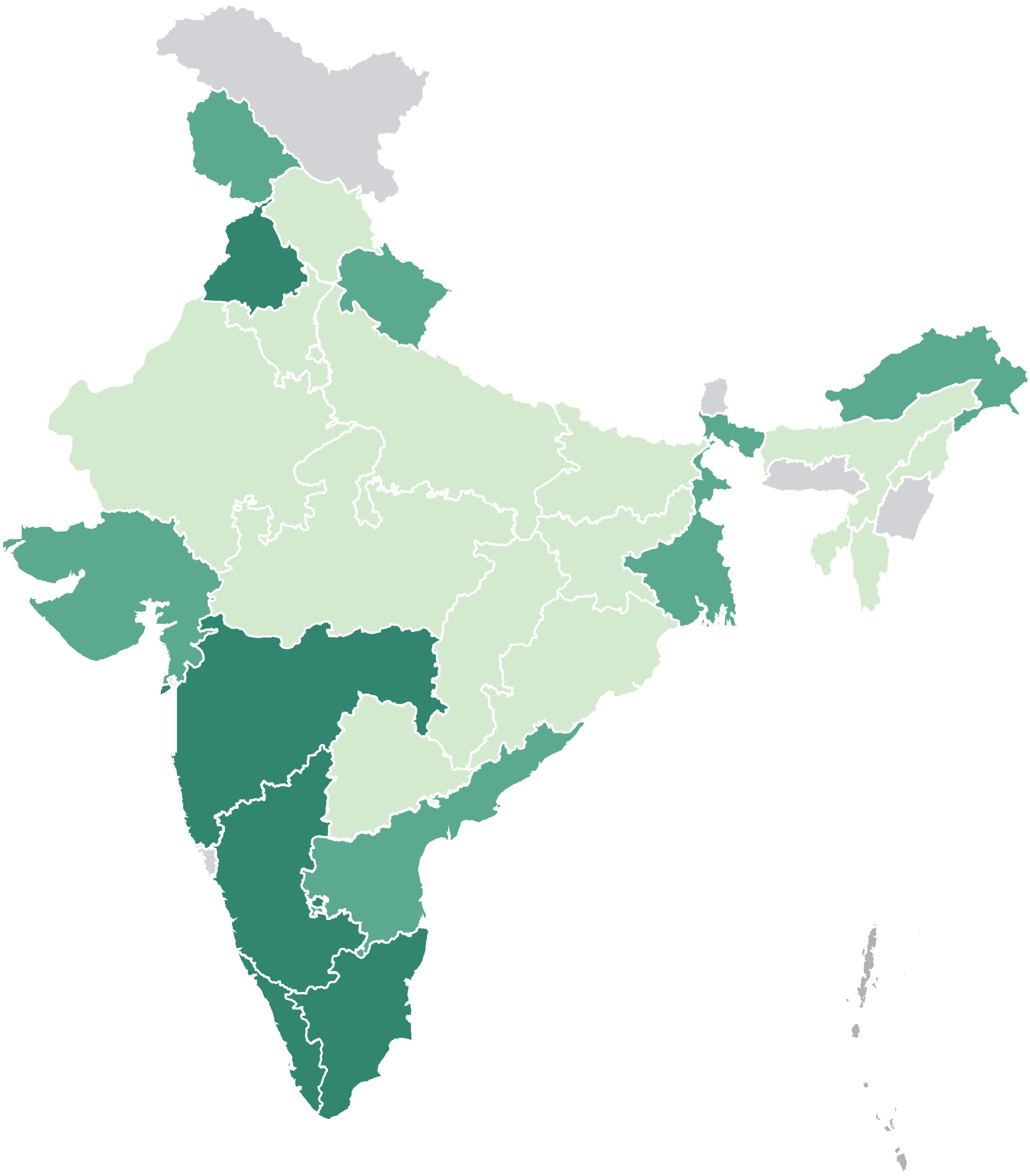
## Uneven Diagnostic Capacity and Quality of Care

- **India has only ~1.5–2 MRI units per million people,** (IUAC - IMRI), compared with 10–30 per million in many developed countries.
- Access to advanced imaging, pathology, and other diagnostics is more limited outside major urban centers, and turnaround times can be longer in high-volume environments.

## Out-of-Pocket Expenditure (OOPE) and Journey Inefficiencies

- Cross-country comparisons in the underlying analysis continue to show India at the higher end of **OOPE as a % of total health expenditure (~40% down from 64% in 2014 - MoHFW- PIB)** relative to several peers.
- Repeated testing is often driven by non-portable records, limited trust in external results, variation in diagnostic pathways, and payer/administrative requirements; combined with travel for follow-ups and wage loss, these non-clinical frictions materially increase out-of-pocket burden even when the nominal service price is low.

# Exhibit 1 - MBBS Doctor to population ratio for Indian states
*(# of doctors per 1000 people)*




**Source:** National Health Profile 2024

## Rising Burden of Chronic and Lifestyle-related Diseases

- **Non-communicable diseases account for roughly two-thirds (~60%) of deaths in 2019 as per WHO's statistics,** reflecting the growing importance of long-term risk management, continuous monitoring, and lifestyle support.

## Fragmented Data and Limited Actionable Intelligence

- India's healthcare data landscape is **highly fragmented across public programs, large private hospitals, diagnostic chains, and smaller providers.** Significant volumes of clinical, diagnostic, and outcomes data sit in proprietary private or public systems and are not shared externally, limiting system-wide visibility of disease burden, care pathways, and outcomes.
- A **large proportion of primary and secondary care facilities continue to operate partially or fully on paper**, resulting in delayed, incomplete, or inaccurate data flows. In many settings, the most complete longitudinal record is carried by the patient (paper reports, prescriptions, discharge summaries), which constrains continuity of care and keeps valuable data outside routine analytics and AI training pipelines.
- **A significant share of clinically useful information also sits in unstructured artifacts** (scanned PDFs, handwritten notes, text prescriptions/discharge summaries), limiting interoperability and making India-relevant dataset creation difficult without extraction and structuring.
- **Health data is captured in heterogeneous formats, metrics, and terminologies across providers and states.** Quantitative data often lacks common standards, while qualitative clinical notes and contextual information remain largely unstructured, making aggregation, interoperability, and analytics difficult even where digitisation exists.
- **National programs and facilities generate large volumes of data,** yet district and block teams often lack real-time, local risk signals to guide "who needs what next".
- Aggregated **data flows "upwards" for reporting but does not always return as local risk maps or targeted insights** constraining the ability of planners and program managers to precisely allocate resources, anticipate demand, and act early.

## Workforce Workload and Variability in Support

- **Clinicians and Frontline staff must balance clinical care with substantial administrative overheads.** This includes administrative paperwork and program reporting (for compliance/management) as well as clinical record-keeping (for continuity and quality of care), which together reduce time available for patient counselling.
- Protocol adherence can be challenging under workload and resource constraints.
- The result is a system where effort is high, but support tools are uneven, and standardization of practice is hard to sustain at scale.

# Healthcare Reimagined with AI

Indian healthcare needs levers that can amplify human capacity, ensure consistent quality, and enable data-driven decision-making across every tier of the system. AI now provides fundamentally new levers that were not available over the past decades, enabling us to crack these entrenched problems differently. AI and emerging technologies are useful, not as substitutes for clinicians or infrastructure, but as force multipliers that elevate the performance of the existing system.

As these systems are redesigned, we must also anticipate exponential advances in AI. The tools available today represent the floor, not the ceiling, of the possible. Solutions introduced now should be architected for continuous-learning models and evolving medico-legal norms, ensuring improvements in accuracy, automation, and personalization can be integrated safely. Designing for this trajectory allows India to leapfrog structural constraints rather than encode technologies that quickly become outdated.

## In this context, AI can reinforce the health system across four critical dimensions

### Unlocking healthcare workforce productivity to enhance healthcare access at scale

### Improving Accuracy, Consistency and Quality of Healthcare

### Reducing avoidable financial burden on families and the public exchequer

### Providing actionable intelligence to health administrators and policymakers

## Unlocking healthcare workforce productivity to enhance healthcare access at scale

With a doctor-to-population ratio of roughly 1:811, and specialist shortages across many districts, AI can help provide certain services without the physical presence of a clinician or specialist. Also, India has nearly 3 million frontline health workers, and a significant portion of their time is lost to manual paperwork, travel, and fragmented systems. This time can also be reduced using AI.

- Embedding structured triage models that reduce outpatient load, prioritise high-risk cases, and create more predictable patient flows in high-volume settings.
- Auto-summarizing patient histories to cut clinician documentation time.
- Capturing symptom histories through multilingual voice inputs, reducing literacy barriers.
- Ensuring care continuity even in digitally deprived geographies by enabling AI-assisted, human-supported models of access (e.g., assisted telemedicine at community service centers).
- Automated documentation and reporting to cut administrative workload.
- Optimised routing and scheduling to reduce travel time and increase daily coverage.
- Allowing AI-assisted teleconsultation support, enabling MLHPs to confidently manage more cases locally before escalating.
- Mobile-first guidance and referral navigation that directs patients to the appropriate facility or specialist, using doctor/facility registries under Health DPI, and progressively supports appointment scheduling (from suggested options to confirmed bookings as system integration matures).

## Multiple exemplars are working towards solving the capacity problem today

- AI-assisted TB triage using cough audio and symptoms (e.g., “Cough Against TB”), when deployed in the hands of frontline health workers, expands clinician capacity by assigning patients into low, medium, and high-risk swim lanes at first contact:
  - Risk-based swim lanes at the point of contact: assigns each patient to low/medium/high presumptive TB risk based on cough signature plus symptom profile, with clear routing per lane.
  - Clinician time protected for severe/high-risk cases: high-risk patients are prioritized for clinician review and fast-tracked for diagnostics, preventing clinician bandwidth from being consumed by low-yield visits.
  - Optimises diagnostics utilisation: medium-risk patients are routed to confirmatory testing (e.g., sputum, CXR) pathways without immediate clinician consultation, reducing unnecessary clinician touchpoints while maintaining safety.
  - Decongests primary facilities by resolving low-risk demand: low-risk patients are directed to non-clinician managed pathways (counselling, symptomatic care, monitoring, and re-screen triggers), reducing footfall and repeat visits while keeping escalation thresholds explicit.
- AI-based automation and triage of presumptive TB based on chest X-rays (computer-aided detection to flag likely TB and prioritise reads). E.g., DeepCXR

(ICMR + Institute for Plasma Research), qXR (Qure.ai).

- AI-enabled digital pathology enables remote review – especially helpful in focus districts with acute specialist shortage.
- AI-assisted triage for kidney disease for frontline workers (under development with IISc) to identify high-risk cases early and guide escalation/ referral pathways.
- Case in point: Tata MD SuperGP model for connecting specialists doctors to PHCs/District hospitals through telemedicine technology and with enhanced productivity by automating pre and post consultation activities using AI.

## Improving Accuracy, Consistency and Quality of Healthcare

In India, the quality of healthcare can vary depending on the experience of the clinician/ pathologist, availability of tools and volume of patients. AI-based decision support, and diagnostics co-pilots can provide standardised, repeatable, and evidence-aligned recommendations. The Democratization of clinical knowledge and expertise that AI enables, could be leveraged to provide transformative uplift of clinical outcomes.

- Using ambient listening and multilingual speech-to-text tools to automatically generate accurate, structured clinical notes, enhancing continuity of care.
- Standardising case-sheet/health record preparation using voice-based interfaces with vernacular capabilities.
- Improving diagnostic reliability through AI tools that surface critical findings quickly.
- Offering real-time clinical nudges for protocol compliance, such as maternal or NCD guidelines.
- Creating consistent documentation architecture across facilities, enabling meaningful longitudinal records and reducing re-diagnosis of patient histories.

### Solutions enhancing consistency and quality of care

- Ambient scribe tools (e.g., Notable/ Artisight; Indian equivalents in care hospitals) could potentially reduce clinicians' documentation load by 70–80%.
- Aarogya Aarohan (IISc/TANUH) enables point-of-care, mobile phone-based oral cancer screening to flag suspicious lesions and support early referral in primary & community settings.
- Thermalytix detects early breast abnormalities using thermal imaging, especially useful for younger women where mammography is less effective.
- AFMS's (+ RPC, AIIMS, and EHealth AI – MoHFW), AI-enabled diabetic retinopathy screening tool detects retinal changes early from fundus images, enabling timely referral and treatment to prevent avoidable vision loss.

## NCDs account for ~60% of deaths in India. These conditions require daily monitoring, timely escalation, and personalised engagement, which AI is uniquely suited to support.

- Use AI to detect early risk patterns in nutrition, maternal, and NCD datasets.
- Use of "digital vaccines" - AI applications that promote healthier behavior.
- Integrate preventive analytics into district-health planning cycles.
- Wearable-linked AI can detect risk patterns early.
- Chat-based and voice-based coaching helps sustain adherence.
- Virtual care models allow follow-up without travel or lost wages.

**Examples include**

- BeatO + ML glucose pattern detection alerts users in real time; widely used in India.
- One Drop/Omada Health (US) demonstrated sustained weight-loss and HbA1c improvements via AI-guided coaching - models that can be replicated by Indian digital therapeutic players.
- Propeller Health uses inhaler + AQI data to predict asthma/COPD flare-ups ideal for India's pollution profile.
- Care Planogram - AI for prescribing pro-active long term (24 months) and short term (90 day) treatment plans for certain NCDs (Tata MD).

## Reducing Avoidable Costs for Citizens and the System

### AI can potentially help reduce unnecessary financial burden by:

- Reducing repeat tests through digitised, portable, and standardized health records.
- Boosting OT/ICU throughput with AI-driven scheduling, avoiding costly capacity expansion.
- Lowering travel and wage-loss costs via remote follow-ups and virtual care pathways.
- Curbing Insurance fraud and leakage through AI-enabled claims anomaly detection.
- Streamlining claims, authorisations, and discharge workflows to cut delays and inefficiencies.

**Examples include**

- AI-driven scheduling (Qventus/LeanTaaS models) increases OT/ICU throughput without new beds.
- AI-based claims verification in insurers reduces manual review time dramatically; NHA sandbox indicates significant fraud-detection potential.

**Examples include**

- "Personal Health Assistant" prototypes built on ABDM rails for vernacular guidance, pre-visit summaries, and secure data access.
- AI-based chronic care engines for certain NCDs (e.g., oncology, diabetes) can be used to drive remote monitoring and adherence.

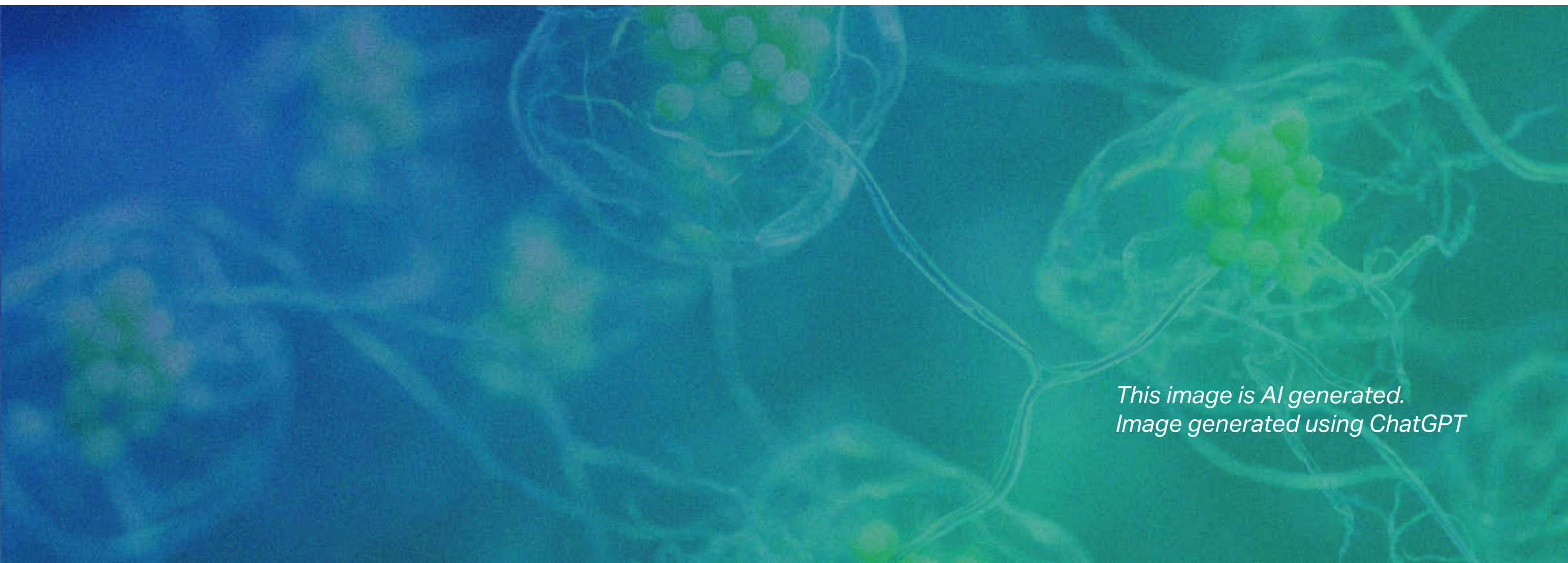
## Generating Actionable Intelligence for Health Administrators

Although India collects extensive health data across programs, district teams often lack timely, actionable insights that can guide resource allocation, risk targeting, and operational planning. Addressing this requires solutions that transform raw program data into tools frontline teams can actually use, including:

- Converting program datasets into district-level insights that let block teams pinpoint local disease or service-delivery hotspots, such as TB, malnutrition, or maternal risk clusters.
- Generating early-warning signals for outbreaks, service gaps, or population-level risks.
- Providing household-level vulnerability flags for ASHAs and ANMs, helping them prioritize home visits.
- Synthesizing fragmented datasets (e.g., nutrition, maternal/child health, TB, immunization) into unified dashboards that improve planning, staffing, and resource allocation.

**Examples include**

- Nikshay risk models: ML models combining TB program + geo data to map high-risk villages for targeted screening.
- State-level digital disease surveillance platforms (e.g., UP's UDSP) integrating data for predictive analytics.
- Data analytics based early flagging for SAM (Severe Acute Malnutrition) and MAM (Moderate Acute Malnutrition) children, enabling Anganwadi workers to deliver targeted counselling and timely interventions.



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# Job Creation through AI Adoption in Healthcare

**AI adoption in healthcare creates employment across three broad and complementary pathways**

### AI in Healthcare Technology and Infrastructure Roles

These are predominantly non-medical/non-clinical roles that support the deployment, operation, and upkeep of AI-enabled healthcare systems across hospitals, laboratories, and digital care platforms. They ensure that AI tools function reliably, safely, and at scale, especially in resource-constrained settings.

**Examples:** Professionals managing AI-enabled documentation, triage, and scheduling systems, Technicians operating and maintaining AI-assisted diagnostic equipment (imaging, screening, monitoring), Telemedicine and tele-diagnostics platform operators supporting remote consultations, System administrators ensuring uptime, integration, and data flow across facilities.

### Care Delivery, Advisory, and Knowledge Roles

This pathway represents roles where AI directly supports care provision and decision-making. AI reduces administrative load and expands reach, while human roles focus on judgment, interaction, and continuity of care.

**Examples:** Clinical workflow coordinators and AI-enabled care managers supporting doctors and nurses, Diagnostic technicians, image reviewers, and tele-radiology/tele-pathology coordinators, AI-assisted health facilitators supporting ASHAs, ANMs, CHOs, and nurses, Assisted-telemedicine operators working from PHCs, CHCs, and panchayat-level centres, Population health analysts, preventive care coordinators, and follow-up counsellors for NCDs, TB, and maternal health.

### Governance, Administrative and Capacity planning Roles

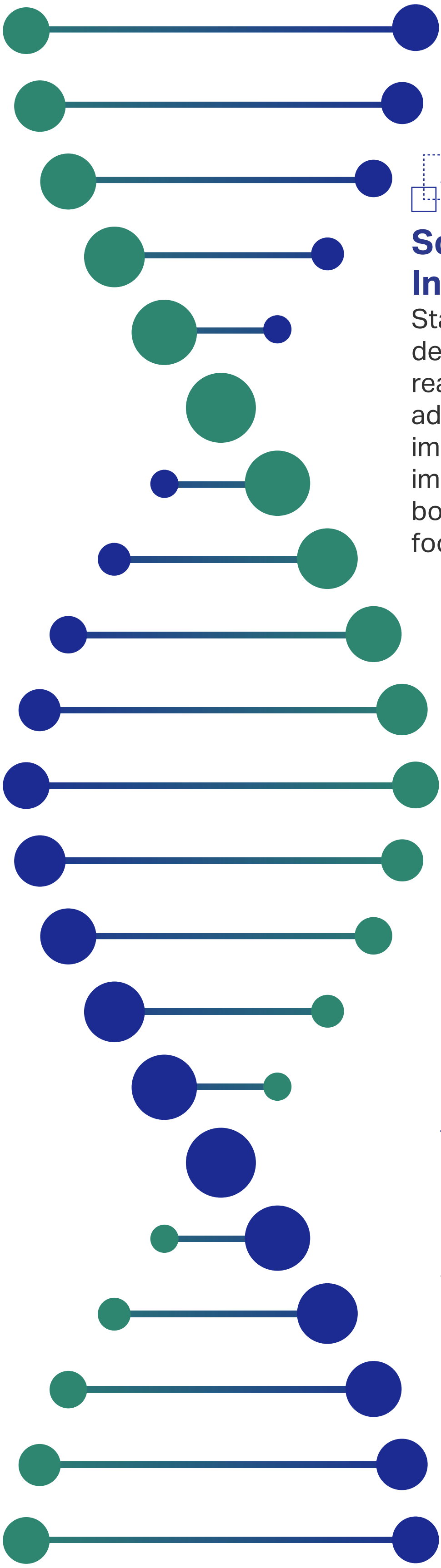
They focus on coordination, oversight, training, and ensuring alignment with public health goals and regulatory standards.

**Examples:** Health data analysts and program monitoring staff at district and state levels, Planning officers using AI insights for resource allocation and service design, Digital safety, ethics, and compliance specialists overseeing responsible AI use, Quality assurance teams monitoring accuracy, bias, and performance of AI tools, Trainers and skilling professionals building AI readiness among clinicians and frontline workers, Implementation coordinators managing rollout across facilities and programs.

AI creates jobs in healthcare when it is used to support health workers, extend specialist capacity, and strengthen community-level care. This job growth is strongest when adoption is paired with skilling, clear clinical guardrails, and institutional support for new roles. When done well, AI can help healthcare move from an overstretched, paperwork-heavy system to a people-centric, prevention-oriented system while also creating new categories of employment.

# System-Level Shifts Required to Unlock AI's Potential in Healthcare

# Key design principles aligned in the Amrit Arogya Roundtable



## Focus on Outcome and Cost Efficiency

Target reduction in out-of-pocket expenditure (OOPE) as a key measurable outcome, in addition to enhancing the delivery and reach of healthcare services

## Scalability-First Innovation

Start with innovations that can be deployed broadly and sustained in real operating conditions (coverage, adoption, unit economics, implementability) and with highest impact/value delivery. Ensure time bound PoCs/Pilots (6 months) and focus on speed of scaling

## Iterative Improvement Approach

Embrace a philosophy of "improvement now, perfection later." Focus on achieving tangible progress in the short term, with a clear roadmap for gradual refinement rather than waiting for perfect technological solutions from the outset

## Indian - Context-Aware Evaluation

Assess all innovations and implementations within the practical realities of Indian field conditions, recognizing infrastructural limitations and regional diversity. Success should be measured relative to improvement against these ground-level constraints, not idealized standards

## Ethical and Safe Innovation

Anchor all AI adoption in the "Do No Harm" principle that guides clinical practice, by requiring risk-based safeguards, clinician oversight and accountability, auditability, and post-deployment monitoring

# Government and National Policymakers

## ✦ Enabling innovation in Healthcare AI via Unified National Regulatory Architecture

A National AI-in-Health Regulatory Framework could be considered, with clear norms:

- Risk-tiered AI regulatory pathways with differential evaluation depth (low-risk e.g., back-end processing ➞ fast track; high-risk e.g., diagnostics ➞ rigorous evaluation).
- Clinical AI could be started with "human-in-the-loop" requirements-explicit human review and override capability but can be continuously evaluated and progressively certified for specific workflows for higher autonomy under defined guardrails.
- Explore Including patient-data protection, explainability, and auditability, purpose limitation, audit logging, and consent-driven data access facilities with a federated-by-default approach where clinical data stays with source custodians and is exchanged only through secure, consented interfaces.
- AI certification agencies and a national Health AI TrustMark (India's CE/FDA-equivalent) could be explored.

## ✦ Innovation Enablement and Sandbox ecosystem:

Existing sandbox mechanisms (e.g., MeitY Sandbox, MedTech Mitra) provide a strong foundation. There is opportunity to build on these to further streamline startup pathways through four measures:

- National/regional sandboxes could be standardized and scaled.
- Consider instituting a clear, time-bound review window for clinical validation and ethics clearance.
- Use a transparent benchmarking mechanism (e.g., IIT Kanpur–NHA model) to test competing AI solutions on common datasets.
- After successful pilots, an open procurement route for government adoption could be explored, considering any solution that meets the benchmark regardless of public vs private provider, avoiding monopolies by allowing subsequent solutions that meet or exceed the standard, and exploring a shift to service procurement models (pay-for-performance/uptime/SLA) rather than one-time solution procurement.

## ✦ Strengthen Data availability and Digital Health Infrastructure

- Data availability is a significant blocker in the development of several India-specific AI use cases such as Clinical Decision Support Systems (CDSS). A significant amount of digital health data exists today, but in siloes, non-interoperable, and severely under-utilised. While structured datasets can often be anonymized using established techniques, the binding constraint in healthcare is increasingly unstructured clinical content (notes, documents, scanned artifacts, and multimodal records). A shared national capability for unstructured de-identification, with standard QA and risk scoring will enable safe, scalable secondary use

- The DPDP Act provides a strong foundation for privacy compliance. Operational guidance could further support ministries in implementation. Three measures could be considered:
  - National standards in accordance with the DPDP Act & Rules for digital health data collection, storage, anonymization, and access could be notified.
  - Government datasets could be made progressively discoverable and shareable for research and AI development under controlled, privacy-preserving conditions.
  - Clear rules on ownership, use, and permissible sharing of anonymized data for public-health and AI use cases could be established.
- Turbo-charge ABDM adoption by addressing root-challenges:
  - Leverage DPDP framework to nudge the ecosystem to share data with ABDM, with the patient as the Data Principal (controller of consent and access), and providers/platforms acting as Data Fiduciaries/custodians and enable purpose-bound, consent-driven sharing.
  - Enable federated access; data can stay at source with controlled access.
  - Enable AI-assisted structuring of unstructured health records to accelerate ABDM adoption: deploy OCR/speech-to-text + clinical NLP pipelines to convert paper, PDFs, and free text into standards-aligned structured artifacts (e.g., ABDM/FHIR-compatible) with human verification for critical fields.
  - Create interoperability mechanisms so large program datasets (e.g., PM-JAY scale claims/admissions) can "talk to" facility clinical records: ABHA-linked consented exchange, common data models, standardized terminologies/metadata, and APIs that allow longitudinal stitching without forcing central data pooling.
  - Provide an OSS HMIS/HIMS as a public utility to digitize the long tail of small hospitals and clinics and accelerate ABDM integration: explore building on existing government-backed stacks (e.g., NIC's open-source eHospital and lightweight clinic-grade HMIS such as C-DAC's e-Sushrut@Clinic) and pair this with an empanelled SI ecosystem, deployment playbooks, training, and ongoing support to ensure adoption beyond software availability.
  - playbooks, training, and ongoing support to ensure adoption beyond software availability.

## ✦ AI enabled health-extension workforce via PPP model

- AI-enabled Health Access Points across gram panchayats could be explored, leveraging existing assisted models (ASHAs, CHOs, CSC operators).
- An institutional support mechanism (e.g., CSC SPV model) could be developed to train and coordinate these workers.
- Deploy voice-driven and offline-friendly AI tools for low-literacy, multilingual populations.
- Allow nominal service fees to sustain participation.

## ✦ Dedicated Health SPV for AI ecosystem stewardship

- A Health SPV (potentially under the NHA) could be considered to provide stewardship to the AI ecosystem.
- Anchor multistakeholder participation (government, providers, payers, industry) to drive adoption and accountability.
- Steward interoperability and trust layers, including certification, standards, APIs, and shared platform services.
- Operate common enablers such as registry services, QA frameworks, analytics, and grievance/redress mechanisms to sustain the ecosystem at scale.

# Public and Private Healthcare providers

## ✦ Operationalise AI Across Care Pathways

- Embed AI use-cases in day-to-day operations (e.g., AI-enabled triage, pre-visit summarization, ambient documentation, and discharge automation across PHCs, CHCs, and hospitals).
- Operationalize virtual-first chronic care pathways for green-listed set of ailments - supported by AI risk scoring, automated follow-ups, and remote monitoring.
- Integrate AI copilots into high-variation workflows like OT checklists, emergency care, ANC risk scoring, and TB screening.

## ✦ Institutionalise Continuous Evaluation and Drift Management

- For AI use cases implemented, mandate algorithm drift audits, bias checks, incident/adverse event reporting.
- Use a transparent benchmarking mechanism (e.g., IIT Kanpur–NHA model) to test competing AI solutions on common datasets, and scale it into a National Health AI Testbed Network.
- Publish standardised evaluation summaries (performance, cohort coverage, and limitations) for procurement and oversight.

# Medical Professional Bodies and Medical Colleges

## ✦ Modernized Medical Education for the AI Era

- Embed AI literacy, digital documentation, algorithmic bias, and safety modules in Medical, Nursing and allied programs.
- Provide short-course certifications on EHR use, privacy, and AI safety.
- Extend digital-capacity programs (e.g., Mission Karmayogi) to health cadres
- Train clinicians and mid-level providers on AI failure modes and hallucinations, Risk-tiered interpretation, Decision boundaries, Documentation and consent standards etc.)

### ✦ Create New Clinician-Adjacent Cadres

- Certify AI-assisted diagnosticians, Digital health coordinators, Remote monitoring specialists, Population analytics officers, position these cadres as avenues for employment growth and expanded rural service capacity.

### ✦ Enable AI in Diagnostics and Tele-Expertise

- Standardize telepathology (digital microscopy + AI) and teleradiology.
- Build state-level Digital Diagnostics Hubs to support remote interpretation.

### ✦ Define Clear Clinical Guardrails for AI Use

- Establish specialty-wise AI practice standards (OB-GYN triage, cardiology scoring, oncology follow-up, emergency care etc.)
- Codify when AI support is appropriate vs when mandatory human escalation is required.
- Publish medico-legal guidance clarifying clinician vs AI accountability.

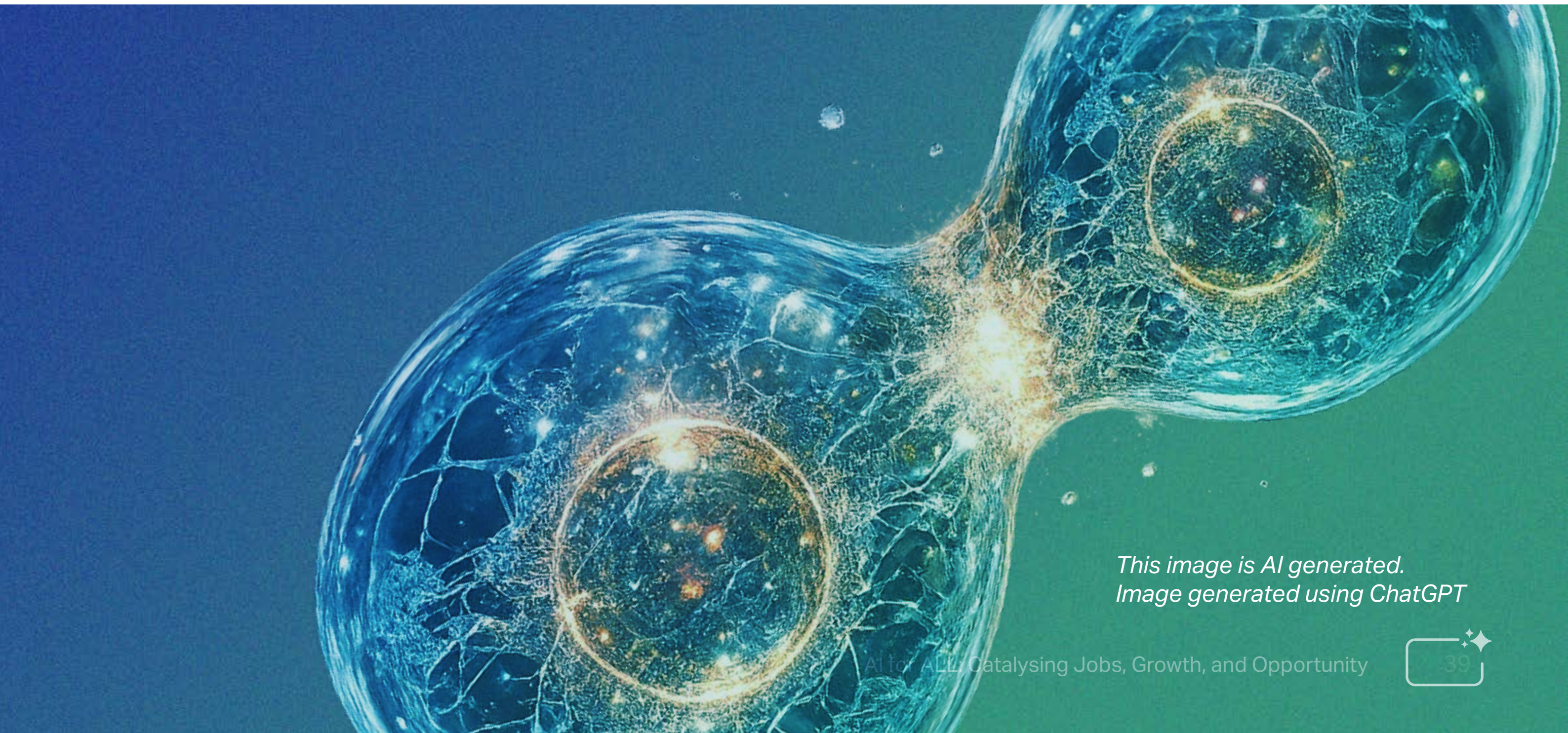
## Startups, Industry and Research Ecosystem

### ✦ Develop India-Optimized AI Solutions

- Design offline-first, low-bandwidth, multilingual AI tools suitable for PHCs, CHCs, vans, and rural settings.
- Build models tailored to Indian epidemiology (malnutrition, TB, maternal health, NCD onset patterns).

### ✦ Strengthen Transparency, Safety and Real-World Validation

- Report calibration metrics, drift, uncertainty scores, sensitivity/specificity, and population stratification.
- Contribute to ICMR evaluation frameworks and benchmarking challenges.



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# Moving from Insight to Execution – Action Agenda

India has successfully addressed similar execution challenges in other sectors - UIDAI, UPI, and GSTN etc. These initiatives succeeded through a common operating philosophy: small, empowered groups driving execution; government defining the core digital rails and rules of engagement; a competitive ecosystem delivering services on top; and an implementation model that adjusted as adoption, technology, and market conditions evolved.

This report therefore does not aim merely to collate recommendations. It is intended to define an execution model for advancing AI in healthcare. That model rests on three pillars: small action groups as execution mechanisms, government setting the paradigm while the ecosystem delivers, and a self-adjusting implementation approach.

## Action Groups as Delivery Mechanisms

The first pillar of this agenda is therefore the creation of a small number of empowered action groups with clear mandates and time-bound outputs.

These action groups must act as delivery mechanisms, not deliberative committees. Their purpose is to move defined priorities part of the way from recommendation to execution, not to reopen first-principles debate. Related problem areas should be clustered under thematic action groups, supported by one overarching strategy group.

The overarching group must maintain alignment across action groups, ensure coherence with national initiatives such as ABDM and DPDP, and surface trade-offs early. Each action group should focus on moving a defined set of priorities from concept to adoption. Individual bodies could take lead in formation of the action groups with guidance from other groups.

| *Activity Area* | *Potential Actions to Consider (non-exhaustive)* | *Key Stakeholders that could be included in the group.* |
|---|---|---|
| **Strategy, Prioritization, Coordination & Integration across thematic groups & Program Governance** | ✦ Consider publishing a 12–18-month AI for Health portfolio with sequencing, dependencies, and resourcing assumptions<br>✦ Focus on outcomes and cost-effectiveness, setting impact measurement metrics<br>✦ A clear and consistent definition of private sector role across all groups can strengthen alignment<br>✦ Governance could include decision rights, escalation paths, cadence, and reporting KPIs<br>✦ Traceability mechanisms that map Challenges to Recommendations to Actions can improve accountability<br>✦ Aligning the program with the principle of "Think Big, Start Small, Scale Fast" may accelerate progress | **Lead**<br>MoHFW<br><br>**Others**<br>NHA, State Health Depts, NHM/SPMUs, program divisions (TB/NCD/MCH), MeitY, ICMR, private sector healthcare services providers (hospitals, clinics, diagnostic labs, startups, etc.) |

| *Activity Area* | *Potential Actions to Consider (non-exhaustive)* | *Key Stakeholders to be included in the group* |
|---|---|---|
| **Regulatory, Innovation and Adoption Enablers** | ✦ Consider embedding the "Do No Harm" principle into regulatory and adoption enablers through risk-tiered acceptance criteria, mandatory clinical oversight, audit logs and traceability, and post-deployment surveillance and incident reporting<br>✦ Targeting perfection through incremental improvement can help prioritize innovation over excessive regulation<br>✦ A national AI-in-health sandbox could enable time-bound, supervised testing with defined guardrails, data access controls, evaluation protocols, and clear entry-exit criteria for scale-up<br>✦ Minimum competency requirements for clinical users of AI solutions may include training/ certification expectations for defined risk tiers and workflows<br>✦ Enabling mechanisms such as fast-track device approval pathways (where relevant) and AI algorithm acceptance criteria could clarify what requires prior approval vs what can be monitored post-deployment<br>✦ Progression pathways from pilot to wider rollout can include oversight and assurance expectations<br>✦ Identifying and aligning the stakeholders needed to operationalize these enablers across central/ state systems can facilitate implementation | **Lead**<br>MoHFW<br>**Others**<br>NHA; clinical councils, private sector healthcare services providers (hospitals, clinics, diagnostic labs, startups, etc.) |
| **Health AI Assurance, TrustMark and Benchmarking** | ✦ Consider defining a Health AI TrustMark with risk-tiered categories and tiered evidence thresholds aligned to risk level<br>✦ A standard evidence dossier could specify: intended use and workflow, data provenance, external validation across geographies/cohorts, performance metrics, bias and safety testing, human oversight and escalation design, cybersecurity and audit logging<br>✦ Scaling benchmarking into a National Health AI Testbed Network (building on IITK-type platforms) could include: standardized evaluation protocols, out-of-set validation, reproducibility checks, bias/safety testing, and publishable benchmark summaries/ leaderboards where appropriate<br>✦ Post-deployment obligations may include: drift monitoring, incident/adverse event reporting, periodic re-validation and re-certification cadence, and withdrawal triggers<br>✦ Linking procurement eligibility and scale-up pathways to TrustMark certification (or defined interim certification) and benchmark performance thresholds can ensure quality standards | **Lead**<br>MoHFW + NHA<br>**Others**<br>ICMR; MeitY; BIS; IIT Kanpur and partner institutions (testbed network); AIIMS/medical colleges; NABH/NABL (accreditation/quality ecosystem); State Health Departments |

| *Activity Area* | *Scope/Issue Covered (non-exhaustive)* | *Key Stakeholders to be included in the group* |
|---|---|---|
| **SPV Structure, Linkages & Ecosystem Operating Model** | ✦ Consider defining the SPV's mandate and operating model, including governance, funding, and accountability<br>✦ Examining the suitability of NHA as an autonomous, attached office of MoHFW to perform all the above functions directly versus a new SPV as a corporate entity backed by MoHFW without Government investment (on the lines of ONDC backed by MOC or CSC SPV backed by Meity) which complements NHA and works in close coordination with it could clarify the optimal structure<br>✦ A recommended ownership/equity structure for the SPV may include involvement of state governments and public and private sector entities<br>✦ The linkage model between SPV, registries, and service providers could specify interfaces, responsibilities, onboarding, and compliance requirements<br>✦ Coordination mechanisms across central and state execution can help reduce fragmentation and duplication<br>✦ Adopting the Fusion Architecture reference pack as the required integration baseline for SPV–registry–provider onboarding and compliance may streamline implementation | **Lead**<br>MoHFW<br><br>**Others**<br>NHA; MeitY; NITI Aayog; State Health Departments; leading public hospitals; public health + clinical experts, private sector healthcare services providers (hospitals, clinics, diagnostic labs, startups, etc.) |
| **Shared Tools and Enablement Services (under SPV)** | ✦ Consider standing up a shared services catalogue required to execute the recommendations, including provisioning of utilities such as anonymization tooling and Indian-language NLP tools for the medical sector including conversion of local language audio conversation into preliminary case-sheet<br>✦ Encouraging public & private sector health-utility providers such as CDAC, NIC and others to host the apps on the DPI/SPV with/without source code, free/paid access, with a commitment by the contributing entity to maintain and upgrade the tool periodically could expand available resources<br>✦ Publishing and maintaining a Fusion Architecture reference pack including required standards/APIs, reference integration patterns (registries ↔ facility systems ↔ AI services), and shared reference components (e.g., anonymisation service, audit/logging layer, common SDKs) can accelerate compliant adoption<br>✦ Access, usage, service levels and governance for these tools could be defined to ensure consistent adoption<br>✦ A rollout plan for shared tools and enablement services across priority institutions/states may facilitate coordinated implementation | **Lead**<br>SPV<br><br>**Others**<br>NHA/ABDM tech teams; NIC/state IT, NIC; C-DAC; state health IT agencies, SI/implementation partners; ABDM ecosystem solution providers, private sector healthcare services providers (hospitals, clinics, diagnostic labs, startups, etc.) |

| *Activity Area* | *Scope/Issue Covered (non-exhaustive)* | *Key Stakeholders to be included in the group* |
|---|---|---|
| **Health Data Governance & Data Management Framework** | ✦ Consider issuing a national data governance framework covering standards, metadata, quality, provenance, and auditability<br>✦ Data access and sharing rules could define consent, purpose limitation, access controls, and compliance expectations<br>✦ Measures for state government led mandates may include (a) progressive adoption of digitalization of health records starting with larger institutions (b) storage of health records in local secure facilities and (c) enabling effective control of access (such as OTP-based consent) by data principal/patient as required under DPDP Act<br>✦ De-identification/anonymization requirements and reference workflows (including audit logs) could be specified to ensure privacy protection<br>✦ A tiered data access model for research, innovation, and clinical deployment (with guardrails) can balance innovation with data protection | **Lead**<br>NHA/ABDM<br>**Others**<br>MoHFW; MeitY (DPDP), private sector healthcare services providers (hospitals, clinics, diagnostic labs, startups, etc.) |
| **Clinical Capacity Building & Skilling** | ✦ Consider designing cadre-wise training and certification pathways for physicians, health professionals, front-line workers, and non-medical workers on adoption, safeguards, oversight, and escalation<br>✦ Quantitative capacity enhancement (assisted access) models could explicitly target employment creation while maintaining quality and accountability: institutionalizing hyper-local, AI-assisted frontend workers on an entrepreneurial model on the lines of CSCs of MeitY may create new opportunities<br>✦ Training governance (standards, certification approach if needed, delivery partners) and adoption tracking can ensure consistent quality and monitor progress | **Lead**<br>NMC<br>**Others**<br>NIHFW, ICMR, Nursing and allied health councils, private sector healthcare services providers (hospitals, clinics, diagnostic labs, startups, etc.) |
| **Public Procurement, Contracting** | ✦ Consider publishing a clear post-POC procurement roadmap for central/ state agencies<br>✦ A decision tree of procurement routes could help move from successful POCs to scale (open tender/rate contract/framework-empanelment/outcome-based contracting), including when Swiss Challenge is appropriate (e.g., unsolicited/unique solution needing market test)<br>✦ Providing a Swiss Challenge process template (challenge window, disclosure package, evaluation criteria, governance and transparency safeguards, timelines) can enable states to execute consistently | **Lead**<br>MoHFW procurement<br>**Others**<br>NHM procurement; public hospitals, private sector healthcare services providers (hospitals, clinics, diagnostic labs, startups, etc.) |

## Government Sets the Paradigm, the Ecosystem Delivers

India's most successful digital transformations have worked when government clearly defined the paradigm, and the ecosystem competed to deliver within it.

In India's digital transformations, government has often played a central role in defining and operating core digital public infrastructure, setting standards and safeguards, and establishing clear rules of engagement. Clarity on what constitutes core DPI and registries, what is left to competitive provisioning, and how safety, liability, data use, interoperability, certification, and auditability are handled can strengthen ecosystem confidence. Explicit articulation of boundaries can also help avoid unintended expansion into full-stack service provision.

Within this paradigm, service delivery and innovation should remain competitive and non-monopolistic. Public and private providers, startups, and academic institutions should provision AI-enabled services on top of government-owned digital rails through open, API-based interfaces. Medical bodies should define clinical guardrails and appropriate-use standards. Industry should focus on building solutions that are interoperable, validated, and usable in Indian field conditions.

Data governance is central to this paradigm. The DPDP framework should be used as an enabler, not merely a compliance requirement. Anonymized and privacy-preserving data should be made available for AI development and public health use at scale.

## A Self-Adjusting Implementation Model

The third pillar recognises that healthcare systems evolve under uncertainty. Adoption should be phased and value led. States could have the flexibility to determine sequencing based on institutional categorization, system readiness, institutional capacity, and local priorities. Early adopters, whether states, hospital systems, or specific programs, will generate learnings that inform standards, regulatory refinements, and investment decisions. Solutions that demonstrate value should be scaled. Those that do not should be revised or discontinued.

Uneven adoption across regions and institutions should be expected. It reflects differences in starting conditions, not policy failure. Where market mechanisms alone do not ensure equitable outcomes, targeted public support or subsidies may be required for specific services or populations. Workforce productivity gains through tools such as voice-based documentation, agentic assistants, and decision support should be treated as early adoption anchors, given their immediate value to clinicians and administrators.

The underlying paradigm and building blocks, however, should remain stable even as technologies improve and economic conditions change. What adjusts is the pace and composition of implementation, not the system's core logic. Safeguards such as human-in-the-loop oversight should be viewed as transitional mechanisms that evolve as confidence, evidence, and technology maturity increase.

# Amrit Krishi

## AI in Indian Agriculture

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# Executive Summary

Over the past several decades, India's agricultural system has undergone a massive transformation. Moving past the history of chronic food scarcity, the country has risen to become one of the world's largest agri-food producers. Today, it generates over 332 million tonnes of food grains and employs nearly 46% of the national workforce. This shift was driven by government investments and the Green Revolution, which supported the expansion of irrigation, varietal improvement, and increased mechanisation. These advancements led to the high production levels we see today, serving as the backbone for India's national food security and rural livelihoods.

However, several structural constraints now prevent India's agricultural system from sustaining improvements in productivity, enhancing farmer incomes, and building environmental resilience. Yield gaps are significant across major key crops. For example, India's wheat yields lag considerably behind global standards. More than 86% of farmers are smallholders, cultivating an average of fewer than two hectares. This makes it difficult for individual farmers to adopt and invest in new technologies, thereby increasing dependence on shared models and collective services. Meanwhile, pressure on natural resources is intensifying - agriculture accounts for almost 90% of freshwater withdrawals, over half of farmland remains rainfed, and soil health is deteriorating due to widespread nutrient imbalances and micronutrient deficiencies. These developments increase cultivation costs and erode long-term productivity.

Market inefficiencies further depress farm incomes. Post-harvest losses of 15-20% translate into billions of dollars of foregone value annually. In contrast to more structured value chains like dairy, where 80-85% of the final consumer price is captured by farmers, in agriculture, it is only around 30–40%. Farmers are reduced to price takers due to fragmented market access, inconsistent grading, limited aggregation, and poor price discovery. Rising temperatures, fluctuating rainfall patterns, and an increase in the frequency of extreme wet/dry events will all contribute to increased yield and income volatility.

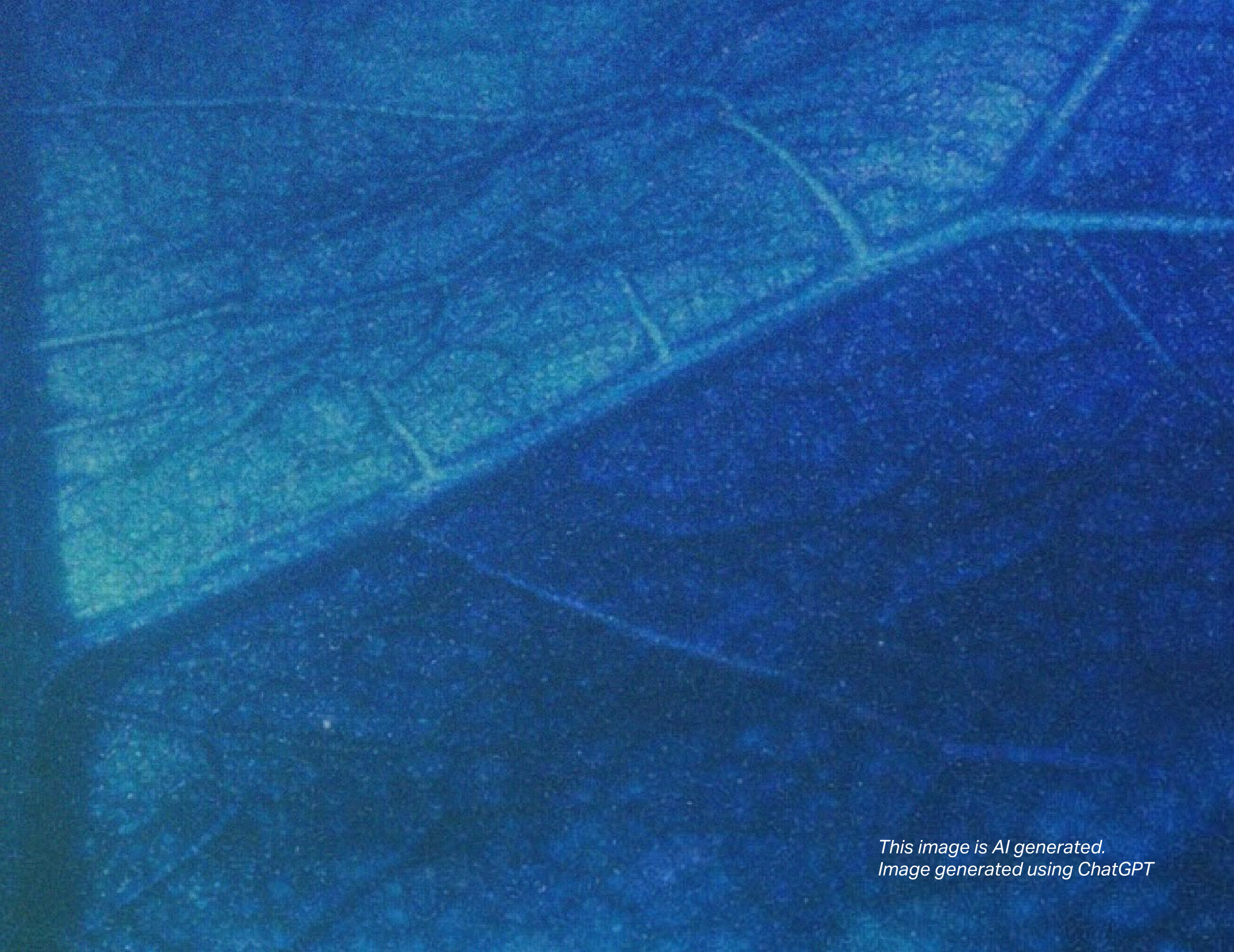
India's agricultural model is thus at a critical juncture. The paradigm of producing output, which has successfully expanded the overall volume of food produced, must now transition to a system that emphasises precision, resource efficiency, climate resilience, and market linkages. Artificial intelligence, when combined with digital public infrastructure and advances in biological and mechanical innovation, offers a strategic opportunity to enable this transition at scale, provided solutions are affordable, locally operable, and verifiable under smallholder conditions.

The report identifies ten opportunity areas spanning input optimisation, demand-aligned crop planning, scale efficiencies for smallholders, cultivator identification, data integration, last-mile advisory, market access, climate resilience, crop protection, and risk management. Across these dimensions, AI can serve as a force multiplier by improving decision quality, reducing waste, and strengthening institutional linkages.

Six application domains stand out. AI-enabled crop planning and demand forecasting can align production with evolving consumption, nutrition, and trade patterns, reducing cycles of surplus and shortage. Precision agriculture tools can optimise water, fertiliser, and chemical use at the plot level, lowering costs while restoring soil and groundwater health. Predictive diagnostics across crops and livestock can enable early intervention, reducing losses and pesticide overuse. AI-driven grading, market intelligence, and digital linkages can improve transparency and farmer value realisation. In finance and insurance, AI can improve cultivator identification, credit assessment, and risk coverage, accelerating payouts and expanding formal inclusion. Finally, generative AI can radically scale agricultural extension by translating research into personalised, multilingual guidance delivered on demand.

Increasing AI and technology penetration in agriculture will open up many meaningful employment opportunities. Emerging roles include drone and precision-machinery operators, AI-enabled farm advisory consultants, quality-assaying and grading professionals, and rural micro-entrepreneurs delivering machine-as-a-service and data-led extension.

To realise this potential, we must look beyond discrete pilot projects. The government's role lies in stewarding digital public infrastructure, data governance, standards, and certification. Delivering services on these shared rails will be the primary focus of markets, agribusinesses, startups, and farmer institutions. When used effectively, AI can help Indian agriculture move away from input-intensive growth toward precision, resilience, and higher farmer incomes. This will improve food security, restore the base of natural resources, and create new, large-scale rural employment opportunities.



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# India's Agricultural Transformation

*Strong Gains, Rising Pressures*

India's agricultural system has undergone a structural shift over the past several decades. What began as a national priority to secure basic food supplies has matured into one of the world's largest and most diverse agri-food ecosystems. The sector today employs **~46% of the national workforce and produces 332 mn tonnes of food grains** (MoA&FW 2024) reflecting the cumulative impact of sustained public investment, scientific innovation and coordinated national missions The Green Revolution, followed by other scientific advances, enabled India to move from chronic food deficits to consistent surpluses and global competitiveness. Robust research institutions, significant varietal improvement, expansion of irrigation and rising mechanization have anchored this shift. These achievements transformed India from being dependent on imports for food security to **today being a net exporter of food.**

However, the system now faces constraints that limit future growth. Productivity gaps are substantial: India's **wheat yields are 3.52 tons/ha,** considerably lower than China (5.8 tons/ha) and Egypt (7 tons/ha). More than **86% of farmers cultivate less than 2 hectares,** with an **average holding of 0.7 hectares,** making individual investment in modern technologies harder and increasing the need for shared-service and aggregation models. Water stress is intensifying, with **51% of net sown area still dependent on rainfall and agriculture accounting for almost 90% of India's freshwater withdrawals.**

Soil nutrient imbalance persists with almost 30% of land is degraded; the national **N:P:K ratio stands at 7.7:3.1:1,** significantly above the optimal 4:2:1 target for sustainable crop health.

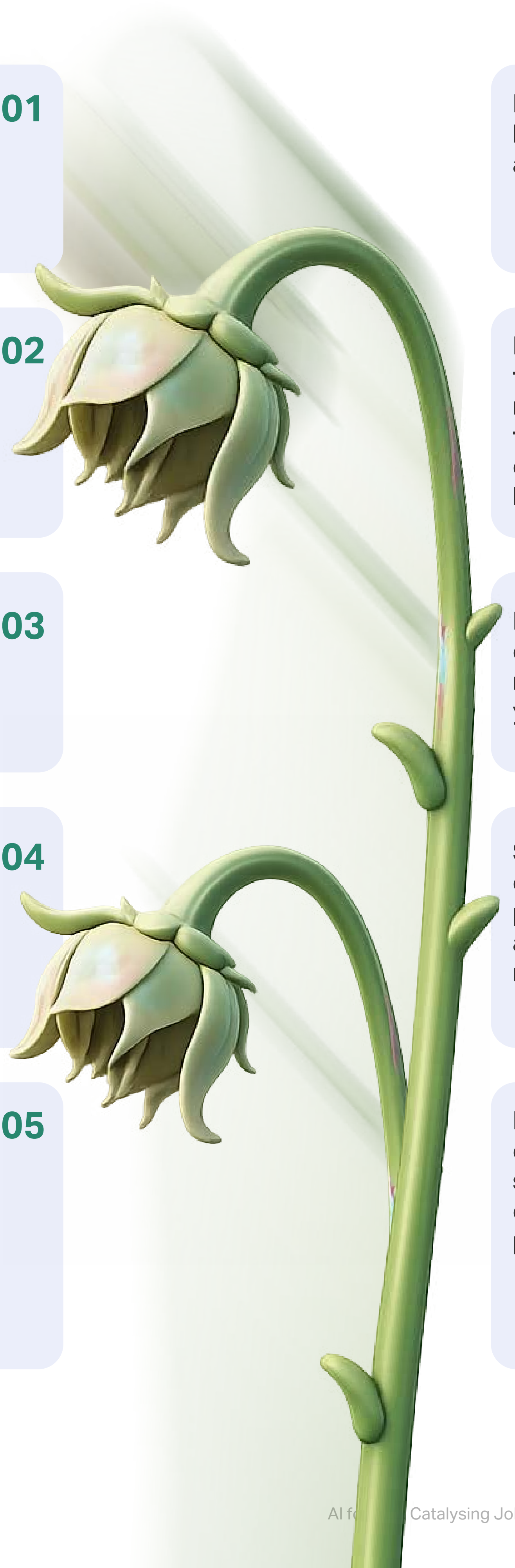
System inefficiencies further depress farmer incomes. **Post-harvest losses amount to 15-20% of produce,** equivalent to over USD 18 billion annually. **Farmers capture only 30-40% of the final consumer price** as against 80-85% in organized value chains in dairy due to value-chain asymmetries. Climate risks may compound these vulnerabilities, with some projections suggesting potential declines between 10-40% in key crop yields by 2080 under current trends, depending on adaptation and mitigation pathways. **300+ districts in India are at climate risk by 2030 and are projected to experience temperature rise by up to 2$^{o}$ C.** These constraints raise the bar for any technology agenda: **solutions must be cost-effective, locally operable and scalable under smallholder conditions.**

Indian agriculture now stands at an inflection point. The production model that successfully expanded output in previous decades must give way to precision-driven, resource-efficient, climate-resilient and market-linked agriculture. One emerging strategic priority is to build systems that optimize agriculture inputs, restore soil and water health, enhance productivity and improve farmer profitability by leveraging AI, digital public infrastructure and frontier biological innovation at scale.

**Source:** World Bank Data; World Economic Forum Data; USDA data; Department of Agriculture & Farmers' Welfare, Government of India – Agricultural Census 2015–16: All India Report; NABARD data; Niti Aayog Report - Revitalizing Rainfed Agriculture in India; Ashok Gulati, Marco Ferroni, and Yuan Zhou - Supporting Indian Farms: The Smart Way

# Opportunities for Transformation

India's agricultural system offers opportunities for improvement across ten key dimensions:



**01** Optimising input economics and balanced nutrient application

**02** Strengthening demand signals and aligning production with consumption patterns

**03** Enabling scale efficiencies for smallholder farmers

**04** Improving cultivator identification and benefit targeting

**05** Integrating fragmented data ecosystems across landholdings, registries, and cropping data

**06** Bridging last-mile advisory gaps

**07** Enhancing farmer value realization through efficient market linkages

**08** Building climate resilience and yield stability

**09** Strengthening crop protection and pest management

**10** Expanding risk coverage and streamlining claims processes

## Input imbalances affecting soil health and farm economics

India's fertilizer support framework has ensured widespread access to crop nutrients. However, the current N:P:K application ratio stands at 7.7:3.1:1, significantly above the optimal 4:2:1 benchmark associated with sustainable soil health. This imbalance reduces fertilizer-use efficiency and increases long-term cultivation costs. Soil micronutrient stress, including widespread zinc deficiency, is linked to adverse child nutrition outcomes. Excess nitrogen application also leads to nitrous oxide emissions (a greenhouse gas with ~273 times the warming potential of $CO_2$) and nitrate leaching into groundwater.

India is also water-stressed, with per-capita availability (~1,486 $m^3$ in 2021) trending toward the scarcity threshold of 1,000 $m^3$/person/year by 2031. Groundwater depletion is geographically concentrated-Central Ground Water Board assessments highlight over-exploited aquifers in Punjab, Haryana, Western UP, Rajasthan, Gujarat, Karnataka, and Tamil Nadu. Current irrigation support structures present an opportunity to incorporate incentives for water-use efficiency. Public investments in agricultural R&D, irrigation infrastructure, rural roads, and extension have demonstrated marginal returns 5–10 times higher than equivalent input-linked expenditure.

Evolving fertilizer and irrigation support design alongside precision input management and increased R&D allocation presents significant opportunities to improve farm economics while restoring the natural resource base.

## Strengthening demand signals and aligning production with consumption patterns

Household diets have diversified steadily; consumption is shifting from cereals toward pulses, dairy, fruits, and vegetables. Production patterns, however, remain concentrated in rice and wheat, which dominate procurement operations. This creates periodic cereal surpluses and associated carrying costs, while land and water remain allocated to cereal-heavy systems. The MSP and procurement framework has successfully ensured food security for staple grains; complementary mechanisms, such as demand forecasting, diversified procurement pilots, and price signals for alternative crops, present an opportunity to better align production with evolving consumption and nutrition patterns.

## Enabling scale efficiencies for smallholder farmers

Over 85 percent of Indian farmers operate on small or marginal holdings, with an average plot size of 0.7 hectares. While smaller farms can be intensively cultivated, capturing scale efficiencies in mechanisation, aggregation, quality control, and market access remains a challenge. Shared-service models, custom hiring centres, and farmer collectives (such as FPOs and cooperatives) present opportunities to unlock scale benefits without requiring land consolidation.

## Improving cultivator identification and benefit targeting

Tenancy arrangements in Indian agriculture often remain informally documented, making it difficult to identify actual cultivators. This limits access to credit, insurance, and direct benefit transfers for tenant farmers and sharecroppers.

Perfecting land records is a complex legal and socioeconomic challenge. Cultivator-status credentials based on self-declaration and multi-source verification (such as cropping evidence, input transactions, and community attestation) present an opportunity to improve benefit targeting without waiting for comprehensive tenancy reform. India's AgriStack initiative, which is already making significant progress in creating authenticated farmer identities linked to land records, offers a natural foundation to build upon, extending its landowner identification framework to also recognize and verify actual cultivators, including tenant farmers and sharecroppers.

## Integrating fragmented data ecosystems across landholdings, registries, and cropping data

Critical datasets like land records, farm registries, soil profiles, & cropping data have historically been scattered across agencies and formats. AgriStack Initiatives such as the Digital Crop Survey and Soil Profile Mapping are addressing this; opportunities remain to further enhance interoperability and accessibility to accelerate innovation and targeted service delivery.

## Bridging last-mile advisory gaps

India has built strong agricultural research capabilities through ICAR, state agricultural universities, and KVKs. However, translating research into timely, localized, and actionable advice for farmers remains uneven. Traditional extension channels face capacity constraints, and advisory content varies across states and languages. The recently announced Bharat-VISTAAR (Virtually Integrated System to Access Agricultural Resources), a multilingual AI platform integrating AgriStack data with ICAR's package of practices represents a significant step toward building digital public infrastructure for agricultural extension.

Building on this foundation, significant headroom can be made across the farming cycle.

- Field preparation: optimal timing, location, and quantity of nutrient application
- Planting: crop selection, spacing, depth, and pressure requirements
- Crop protection: hyperlocal pest and disease information, appropriate input quantities
- Crop calendar planning: response to weather shifts and market price movements

## Enhancing farmer value realization through efficient market linkages

Farmers currently capture as low as 30-40% for perishable produce (RBI Bulletin, 2019; 2024) compared to 80-85% in organized cooperative value chains such as Amul (GCMMF Annual Report, 2023). Fragmented market linkages, multiple intermediaries, and limited access to organized procurement reduce negotiating leverage and keep farmers as price takers. Inconsistent grading and quality standards further weaken price discovery. Strengthening aggregation, standardizing quality assessment, and enabling direct linkages to organized buyers present opportunities to improve farmer share of end-market value.

## Building climate resilience and yield stability

Climate volatility is increasing. More frequent heat stress, erratic rainfall, and extreme weather events are disrupting sowing windows and crop growth cycles. Over 300 districts face climate risk by 2030, with projected temperature increases of up to 2°C. Production variability is rising while input costs remain largely fixed, increasing downside risk for farmers. Climate-resilient varieties, adaptive crop calendars, and early warning systems present opportunities to stabilize yields and reduce farmer exposure to weather-related losses.

## Strengthening crop protection and pest management

Shifting weather patterns and intensified cultivation are increasing pest and disease incidence, shortening control windows, and raising infestation severity. Farmers often respond with higher and more frequent pesticide application, which increases costs and can accelerate resistance. Early detection systems, targeted interventions, and integrated pest management approaches present opportunities to reduce crop losses, lower input costs, and improve produce quality.

## Expanding risk coverage and streamlining claims processes

Crop insurance currently covers approximately 30% of gross cropped area. Where coverage exists, enrollment, assessment, and payout processes can be slow or contested, leading to delayed post-loss recovery and continued reliance on informal borrowing. Simplified enrollment, faster claims assessment, and transparent payout mechanisms present opportunities to expand effective coverage, reduce farmer vulnerability to shocks, and accelerate recovery after crop loss.

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# The Architecture for High-Impact Agri-Tech

**The objective function for AI and technological solutions is to restore the resilience of the natural resource base, improve farmer economics and strengthen the institutional foundations that allow markets and services to function efficiently. Technology must enable the following:**

## Drive Precision and Resource Sustainability

AI should be applied first to improve the quality and specificity of on-farm decisions. The priority must be to help farmers use inputs only where and when they are needed, raise efficiency, and reduce long-term ecological stress. Precision must be treated as a goal for India to shift away from input-heavy growth towards sustainable, regenerative production systems.

## Enable High Price Realisation for the Farmer

AI solutions must address the root causes of lower realizations by improving how produce moves from farm-gate to end buyers. This means strengthening direct linkages to organized procurement, enabling aggregation to improve negotiating leverage, and standardising quality and grading. Solutions should also reduce forced selling and losses by improving storage and cold-chain planning.

## Be Built on Shared Digital Infrastructure and Responsible Data Use

Tech must be built on common, interoperable digital rails rather than stand-alone applications. It is important that solutions connect core public datasets and registries such as identity, land records, crop and sowing data, soil and weather information, and market transactions. This shared foundation improves targeting and monitoring, reduces repeated verification, and enables multiple solutions to plug into the same data backbone.

To scale under smallholder conditions, interventions need to be affordable to adopt, locally operable, and verifiable in their impact. In practical terms, every AI use case should make economic sense for all stakeholders: farmers (input reduction, yield uplift, higher share of consumer value), agri-tech enterprises, and the government (subsidy burden reduction, improved subsidy targeting, reduced leakage).

# AI has Transformative Potential across the Agri Value Chain

**AI and technology have seen implementation across multiple parts of the agricultural value chain. The following use cases reflect where meaningful impact is emerging**

# 6 Domains

- Smart Crop Planning and Demand Forecasting
- Input optimisation and Precision Agriculture
- Predictive Crop and livestock Health and Diagnostics
- Market Transparency and Value-Chain Transparency and Efficiency
- Financial Inclusion in Agri
- Knowledge Delivery at Scale using GenAI

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## Smart Crop Planning and Demand Forecasting

Predictive analytics and machine learning can analyse vast datasets, including historical price trends, soil health, weather forecasts, and global trade patterns, to recommend optimal crops before the sowing season. These models align farm production with real-world market demand while accounting for soil health and expected weather conditions, mitigating cycles of gluts and shortages and reducing crop-failure risk and input inefficiencies that arise from poor crop -land - climate fit, alongside price volatility and distress selling.

- Wadhwani Center for Government Digital Transformation is collaborating with state governments to create AI roadmaps where systems advise farmers on the best crops to sow by integrating soil health cards with local climatic data.
- "ITCMAARS is ITC's FPO-led 'phygital' (App + Call centre) platform that delivers hyperlocal crop and weather advisories including soil-test based nutrition, AI-enabled crop diagnostics, and market linkages, while enabling traceable, high-quality sourcing.

## Input Optimisation and Precision Agriculture

Advances in remote sensing, IoT-enabled soil and weather monitoring, and geospatial analytics are enabling plot-level decision support for water, nutrient, and agrochemical application. Machine learning models trained on historical yield data, soil health profiles, and micro-weather patterns can generate precise recommendations such as when to irrigate, optimal fertilizer dosage by growth stage, tillage depth calibrated to soil compaction levels, and seed placement for maximizing germination rates. These data-driven systems can materially improve input-use efficiency while reducing groundwater stress and soil degradation.

Multiple successful PoC and pilots show the viability of the use case

- Fasal's IoT-based system combines soil moisture sensors, crop-stage tracking, and micro-climate data to guide irrigation and pesticide scheduling for horticulture farmers. According to the company, deployment across 75,000 acres between 2020 and 2023 has contributed to savings of approximately 52 billion litres of water, 127,000 kg of pesticides, and 55,000 metric tons of GHG emissions.
- The Saagu Baagu initiative in Telangana integrated AI-based advisory with soil testing and crop management showed a 9% reduction in input use, translating into a significant per-acre income delta.
- John Deere has demonstrated AI-enabled seeding and variable-rate application technologies (such as "See and Spray" and seed singulation) that can significantly reduce chemical use with reported savings ranging up to 70% and improve planting accuracy, raising resource efficiency at scale.
- Punjab Agricultural University has documented the use of precision machinery including variable-rate applicators and smart sprayers for targeted input application, reporting input cost reductions of approximately 15%.
- Portable spectroscopy tools such as NIR and LIBS sensors can provide rapid, low-cost estimates of soil nutrient levels, organic matter, and pH at the field level. These do not yet match laboratory-grade accuracy, but offer

sufficiently indicative readings to guide more tailored fertilization decisions than blanket recommendations. As calibration datasets grow, these tools have become increasingly viable as a first screen, with lab testing reserved for periodic validation.

These examples show AI and technology being used not just to increase output, but to cut wastage and regenerate the resource base.

## Predictive Crop and Livestock Health and Diagnostics

Satellite and drone-based multispectral imagery can detect crop anomalies (pest infestations, disease onset, nutrient deficiencies) before they are visible to the naked eye, through deviations in vegetation indices. At the farm level, smartphone image recognition and low-cost livestock wearables enable similar early detection at minimal cost. Layering this observational data with weather patterns, historical outbreak records, and crop phenology allows predictive systems to anticipate events and recommend timely, localised interventions reducing yield loss and unnecessary chemical use.

- Fasal's platform combines continuous sensor data with crop science models to track crop-state and trigger actionable alerts for disease, stress, and irrigation needs at farm level across multiple horticulture crops.
- The Government of Maharashtra is working with research institutions to monitor crop conditions via remote. sensing and AI models, with a focus on detecting crop health issues and supporting precise interventions.
- Brainwired (WeSTOCK) uses an IoT ear tag and ML algorithm to monitor livestock health and identify conditions such as sickness and pregnancy, generating alerts for farmers.

## Market Transparency and Value-Chain Transparency and Efficiency

### Technology interventions are emerging across three levers of the market-to-buyer journey

- Quality measurement and grading: Computer vision and spectroscopy-based tools can objectively assess produce quality at the point of sale, enabling more consistent, transparent pricing that reduces the information asymmetry farmers face in manual, subjective grading systems.
- Price discovery and market intelligence: Platforms aggregating real-time mandi prices, demand signals, and logistics data can help farmers make better-informed decisions on when and where to sell, reducing distress sales and exposure to price volatility.
- Digital market linkages: Aggregation platforms and digital auction systems can connect smallholder supply to organised buyers, reducing dependence on intermediary-driven pricing in traditional mandis and lowering transaction costs.

Together, these use cases could make produce more tradeable, improve transparency, and increase the share of consumer value captured at the farm-gate.

### ✦ Quality measurement and grading

- Intello Labs has deployed more than 50 AI-driven grading machines in apple supply chains. These create transparent, multi-grade pricing before auctions, reducing information asymmetry and ensuring that farmers know expected prices for each quality band.
- AgNext's IoT-enabled quality assessment systems deploy rapid, objective measurement of produce quality and quantity at aggregation points, replacing subjective "visible-lot" inspections. By digitally assessing entire consignments in seconds, the technology eliminates systematic undervaluation by buyers and ensures farmers are paid prices that accurately reflect the true quality of their produce.

### ✦ Price discovery and market intelligence

- AgriBazaar reports leveraging historical price patterns, real-time market arrivals, and global supply–demand signals to guide optimal selling decisions. These predictive insights help farmers avoid distress sales during market gluts and strategically time market entry, reducing exposure to extreme price volatility and improving price realization.

### ✦ Digital market linkages

- ITC's MAARS platform is building models that connect farmer clusters and FPOs to emerging "quick commerce" and attribute-based demand (for example, specific brix levels in tomatoes or food-safe spices), shifting value addition closer to the farmgate and helping farmers capture a greater share of end-market value.

## Financial Inclusion in Agri

AI can improve how the system identifies genuine cultivators, assesses crop and credit risk, and targets subsidies and insurance. This tackles the chronic issues of informal tenancy, suboptimal subsidy targeting and limited risk coverage.

- ✦ SatSure's satellite and AI-driven risk intelligence platforms use continuous crop health monitoring and environmental risk prediction to enable parametric insurance solutions. By linking automated payouts to predefined triggers such as drought intensity or flood exposure, the system eliminates manual loss assessments and ensures rapid, transparent financial relief to farmers.
- ✦ Upaj, a digital agri value chain solution from Absolute uses proprietary data (Mandi prices, Market accessibility, Yield estimation of a crop, cropping pattern, Ground water level) to underwrite farmers for agri and insurance solutions.
- ✦ Maharashtra's MahaDBT portal which links Aadhaar-authenticated farmer profiles with land records and scheme eligibility data has been used to route Direct Benefit Transfers across multiple agricultural subsidy programmes (MahaDBT, Government of Maharashtra).

## Knowledge Delivery at Scale using GenAI

AI, especially GenAI, can radically compress the distance between research institutions and smallholders. It can translate complex agronomic knowledge into farmer-friendly, vernacular guidance, delivered on-demand via chat, voice, or local intermediaries, and tailored to context.

- The Ministry of Agriculture is already building AI interactive advisory that can answer farmer queries on what to plant, when to sow, how to manage pests, and when and where to sell, backed by integrated soil, weather, and market data through the VISTAAR platform. The platform is integrated with BHASHINI to provide multi-lingual support to farmers across the country.
- Digital Green has evolved from video-based extension to an AI-powered advisory platform, cutting advisory cost per farmer by an order of magnitude and scaling to millions of farmers, with documented income gains in specific crops like chilli and groundnut.
- Maharashtra is developing AI-embedded extension systems and a state-level "AI and emerging tech" hub to channel research outputs into field-ready solutions, including remote-sensing based advice on crop health and pest risks. Punjab Agricultural University is using AI-driven machinery and advisory networks to diffuse precision practices, supported by KVKs and farmer advisory services.

These examples show that AI is starting to act as a force multiplier for extension, converting scattered research and local data into personalised, real-time, multilingual guidance at scale.

However, advisories must remain anchored in verified ground reality. Without up-to-date and validated soil/land/crop information, even strong AI recommendations can become irrelevant or counterproductive; systems should therefore integrate real-time data validation and farmer feedback loops as a standard design requirement. Adoption also depends on phygital delivery: combining AI guidance with consistent field-level touchpoints (FPO staff, extension workers, local champions) so trust is built through relationships and demonstrated outcomes.

# AI in Agriculture could potentially create new kinds of Employment

Increasing digitisation in agriculture will open many new employment opportunities:

## Smart machinery sales and allied services

- On-ground salesforce for Agri-drone/ smart machinery OEMs (For sales of OEs and spares).
- Entrepreneurs providing Drone/ Machine-as-a-service for farmers, across agri-input spraying, crop monitoring (e.g.: Water management specialists deploying sensor/IoT-enabled irrigation solutions, Pollination-as-a-service: bee boxes + sensor-enabled monitoring).
- Operators of AI-enabled smart machines (e.g.: Drone operators for crop monitoring, agri spraying and surveying of land parcels).
- Technicians for infrastructure support (connectivity/GPS readiness and on-field troubleshooting).
- Fleet management professionals for shared machinery.
- Calibration and compliance technicians for precision equipment (interfaces, calibration, operator SOP adherence, safety checks) to support certification and safe scaling.
- Custom-hiring and fleet utilization coordinators (dispatch, scheduling, routing) to improve movement and timely utilization of shared machinery assets.

## AI-led farm advisory and knowledge services

- Field scouts/data collectors to set up systems for farm-level data capture.
- AI-led farming consultants providing crop advisory leveraging AI tools.
- AI-based farmgate grading and quality assessment professionals (e.g.: Quality Assaying as a Service (QUAS) professional providing portable, on-ground quality testing at farms, mandis, warehouses and processing units).
- Knowledge digitisation and curation roles (structuring research outputs into machine-readable repositories that can feed advisory and GenAI systems).

## Training, adoption and ecosystem support services

- Drone pilot trainers to train farmers/ rural entrepreneurs.
- AI tool trainers (data collation and conversational training of AI tools).
- Trust and assurance roles (periodic audits, compliance checks, transparency and grievance assurance).
- "Digital/AI champions" as trained village-level operators and facilitators.

As highlighted in the roundtable discussions, micro-entrepreneurs providing services such as scanning, grading, dehydration, and advisory support are already generating meaningful monthly incomes (~Rs. 15000-25000/month) in rural areas. It was also noted that the expansion of drone services, precision operations, and digital extension could create significant new employment opportunities by 2030.

# Unlocks for Scaling AI in Indian Agriculture

India's AI-in-agriculture agenda can scale when enabling conditions for adoption and viable service delivery are in place. Three considerations inform this paper.

First, AI is an accelerator of good policy, not a substitute for it. Policy alignment supports scale.

Second, government and market roles can be complementary. Government can focus on regulatory stewardship, public data governance, interoperable digital rails, standards certification, and outcome-linked incentive design. Farmer-facing applications and services (advisory, grading, procurement, logistics, embedded finance) can be delivered by the private sector and farmer institutions (FPOs/cooperatives), operating on common digital infrastructure.

Third, states are a critical implementation layer. Electricity pricing, market regulations (APMCs), extension capacity, and land/tenancy administration are largely state led; state engagement will be important for national AI programs to move beyond pilots.

The Government of India has already made significant progress through the Digital Agriculture Mission, which includes AgriStack, Krishi Decision Support System, Digital Crop Survey, and Soil Profile Mapping. The considerations below are intended to complement and build upon these initiatives.

## Government & Regulators

Government and regulators can play two complementary roles: (i) policy evolution to strengthen incentive alignment and market efficiency, and (ii) programmatic execution to build digital public infrastructure (DPI), standards, and institutional capacity that enable responsible, scalable AI adoption.

### ✦ Policy considerations – incentives, regulation, and market rules

#### Evolving support structures toward high-ROI investments and targeted delivery

Policymakers can consider a phased exploration of direct cultivator support mechanisms alongside existing input subsidies. Digital farmer identity systems, linked transaction data, and remote sensing-based crop verification now make it technically feasible to design outcome-linked transfers; for instance, calibrated to output levels or verified area under cultivation that strengthen price signals and reward input efficiency. Farmers who optimise inputs would retain more as net income, while data-driven targeting reduces diversion to non-agricultural uses.

- The Sub-Mission on Agricultural Mechanisation (SMAM) could be expanded to include AI-enabled and precision implements, such as Variable Rate Applicators (VRT), GNSS-based auto-steering systems, smart spraying solutions, and precision planters, accelerating input efficiency beyond pilots.
- Savings from improved targeting could be considered for redeployment toward high-ROI agriculture R&D and validated AI-enabled interventions (research, trials, resilience infrastructure).

### Strengthening cultivator identification alongside ongoing tenancy improvements

- A cultivator-status credential could be explored, based on self-declaration plus multi-source verification (e.g., remote-sensed cropping evidence, input transactions, tenancy affidavits/ community attestation, and FPO/ cooperative records).
- Scheme design can consider operating effectively within the current land record environment, while tenancy documentation continues to improve over time.

### Regulatory clarity for AI-enabled farm operations and markets

- Standards for grading and quality: commodity-wise, AI-readable grade schemas (attributes, tolerances, defect taxonomies) could be developed, mapped to existing standards where applicable.
- Safety and compliance frameworks for AI-enabled equipment: regulatory frameworks and technical standards for electronic control systems in tractors and AI-enabled implements (interfaces, safety, calibration, certification) could be considered.
- Drone operations for agriculture: clear, uniform operating rules and permissions (standard SOPs, predictable approvals, audit requirements) could help scale spraying, scouting, and data capture.

## ✦ Programmatic execution (DPI, Data, Standards, and Institutions)

### Governance and execution of Agri-DPI

- Building on the Digital Agriculture Mission and AgriStack's existing architecture, a dedicated multi-stakeholder entity (structured as a public interest utility) could be considered to govern core Agri-DPI components. India's DPI track record offers direct precedents: UIDAI for identity, NPCI for payments where independent, purpose-built institutions accelerated ecosystem adoption and built multi-stakeholder trust.
- The current models have laid important groundwork; a dedicated entity could build on this by strengthening ecosystem onboarding, certification processes, and API governance at the pace the market requires.
- Such an SPV could also publish reference architectures and APIs; maintain shared registries; operationalise data exchange with consent, auditability, and security; manage certification of grade/ diagnostic models and devices; and run compliance and grievance mechanisms.
- Under the AgriStack framework, farmer-facing services beyond core utilities would be delivered by private players, cooperatives, and FPOs building on common rails.
- As Aligned in The Agri Collaboratory workshop report, explore adopting 5 non-negotiable governance tests ('DPI Sutras') for Agri-DPI:
  - Keep the infrastructure neutral and protect the citizen-market-state relationship.
  - Safeguard citizen empowerment and privacy through consent-based controls.
  - Prevent lock-in through interoperability.
  - Establish techno-legal regulation combining technical safeguards with legal oversight.
  - Enable public-private innovation collaboration with clear public-interest guardrails.

### Data and Knowledge foundations

- An open-by-default approach to agricultural data could be considered: non-personal datasets held by public agencies could be published with metadata, quality tags, and refresh cadence, with standards improved iteratively.
- To reduce duplication and cost of dataset creation, reusable, templatised, open-source data collection protocols (including field formats, sampling standards, and validation rules) could be developed for use by government, academia, startups, and supervised student-led field programs.
- Agricultural research repositories (ICAR, universities, state agriculture universities) could be digitized and made machine-readable.

### Reference standards for interoperability

- AgriStack has already established foundational identifiers (Farmer ID, Plot ID). Building on this base, a targeted set of extensions could address remaining gaps geo-referencing conventions, crop calendar and input taxonomies, soil parameter schemas, and commodity-grade attribute libraries enabling AI-derived outputs to be comparable across states and buyers.

### Enabling use-case delivery

- **Agri-commerce:** Digital commerce in agriculture could be made private-sector led, with government's role focused on providing interoperable rails APIs and workflows for buyer discovery, e-contracts, logistics, payments, and grade/weight reconciliation. ONDC components could be leveraged where fit is strong, with agri-specific extensions built on Agri-DPI where needed.
- **Innovation ecosystem:** State-level regulatory sandboxes such as Telangana's AI sandbox initiative Aikam, could provide structured approval pathways that accelerate pilots without compromising safety or accountability. Partnerships spanning startups, FPOs, KVKs, agribusinesses, and research institutions can prevent siloed experimentation, with predictable funding windows tied to performance thresholds enabling successful pilots to progress to rollout.
- **National Grading Standards:** A future national framework could be instituted to certify AI-based grading machines against officially notified grading standards. This framework may include model calibration protocols to account for seasonal, varietal, and regional variations; continuous monitoring for model and data drift; and independent third-party audits to verify adherence, identify bias, and reduce false rejections. Such mechanisms would be critical to building trust and nationwide acceptance.

## Agribusinesses

Agribusinesses and large buyers are well-positioned to drive transparency and efficiency in agricultural markets. The core opportunity is shifting from opaque, negotiation-based procurement to systems where quality is objectively measured, pricing is transparent, and settlement is faster, improving farmer realisations while reducing procurement risk.

### ✦ Anchor procurement on objective quality measurement

- Deploy computer-vision grading and automated sorting at procurement points (mandis, packhouses, warehouses) so that quality assessment becomes standardised and auditable rather than subjective.
- Integrate grading outputs into procurement and ERP systems so digital grades become the basis of transaction.
- Invest in ongoing model governance, seasonal recalibration, drift monitoring, third-party audits.

### ✦ Make pricing transparent and quality-linked

- Upgrade warehousing with IoT-based monitoring (temperature, humidity, stock movement) to reduce spoilage and create auditable quality trails.
- Adopt digital warehouse receipts with immutable audit logs to reduce fraud and enable faster collateralised lending. Over time, explore tokenised receipt systems that automate lien marking and settlement workflows across warehouses, lenders, and farmers.

## Agri-Startups & Technology Providers

Startups are critical to translating technology into practical tools for farmers. The key is reaching farmers sustainably and integrating with the public infrastructure being built. Three strategic priorities:

### ✦ Prioritise high-impact, near-term AI use cases for both D2F (Direct to Farmer) & Assisted (e.g., via FPOs, extension workers)

- Starting from farmer journeys rather than AI techniques can sharpen focus: "what to sow," "when/how to irrigate and fertilize," "when to harvest," "where/how to sell".
- Prioritized use cases with near-term, proven economic value can be developed for two archetypes: D2F (Direct to Farmer) and Assisted models (ecosystem enablers such as FPOs, NGOs, extension workers).
- Multi-season, multi-state, agro-climatic validation with clear benchmarks (accuracy, adoption, ROI, false positives) can help avoid overfitting to pilot conditions before scaling.

### ✦ Build on top of Agri stack and contribute to strengthen it

- Solutions can be built on AgriStack and relevant public digital rails to reduce onboarding friction, enable interoperability, and improve data portability.
- Collaboration with farm mechanization OEMs (e.g., providing inputs to IoT-based machinery providers on AI optimisation) can accelerate adoption.
- Interoperable solutions that plug into agriculture DPI layers, e-NAM upgrades, and state data exchanges can enable AI models to access authenticated data and push back certified insights.
- Structured data, models, and documentation can be contributed back to AgriStack to strengthen the shared ecosystem.

## Farmer Institutions, NGOs, FPOs, Local Ecosystem Actors

Farmer collectives, NGOs, and local ecosystem actors are essential to aggregating smallholders, enabling technology adoption, and ensuring AI solutions reflect ground realities and equity considerations.

## ✦ Strengthen farmer collectives to leverage AI to maximize farmer value realization

- FPOs, cooperatives, and producer groups can be expanded and professionalized to aggregate produce, host shared AI-enabled infrastructure (such as grading machines and scanners), and negotiate better prices using digital quality data.
- Farmer collectives can serve as vehicles for price discovery and negotiation, leveraging AI-driven grading and marketplace tools to reduce the disadvantage smallholders currently face in marketing.

## ✦ Leverage AI to upskill farmers

- AI-based advisory platforms piloted by NGOs can be scaled, using chatbots and digital tools to bridge advisory gaps at the last mile while preserving alignment with public extension content.
- FPO-level and NGO-level governance structures can guide the use of farmer data, manage consent, and ensure AI systems reflect local priorities and constraints.

## ✦ Promote inclusive participation, especially of women and youth

- Women farmers and local youth are often underrepresented in structured agricultural advisory systems and market-facing roles, despite their high participation in farm operations and growing digital familiarity. With targeted training, they can be enabled to act as digital and AI champions within villages, operating AI-enabled services as local micro-entrepreneurs.
- Safeguards can be incorporated so technology adoption does not displace vulnerable populations: pairing mechanization and AI deployments with reskilling, role redesign, and inclusive operator/service-provider pathways can help ensure the transition creates opportunity rather than exclusion.

# Research Institutions, Academia, & Private Sector

## ✦ Make agricultural knowledge AI-ready

- Systematically digitise ICAR and university research outputs into machine-readable formats that can feed advisory and decision-support systems. This includes crop-specific package of practices, trial data, pest/disease libraries, and soil-climate-yield relationships.

## ✦ Advance AI in Agri research

- Explore structured partnerships where institutions provide domain expertise and field trial infrastructure, while startups contribute engineering capability and farmer reach. Priority areas: AI-assisted seed breeding, precision machinery calibration, crop-protection models. Publish cost and impact data openly.

## ✦ Support validation of AI models

- Multi-location, multi-season trials with published performance metrics are essential before AI recommendations are generalised. Research institutions are uniquely positioned for this independent validation role, building public trust in technology-driven advisories.

# Moving from Insight to Execution – Action Agenda

## A coordinated action agenda can operationalize key priorities.

| *Activity Area* | *Scope/Issue Covered (non-exhaustive)* | *Key Stakeholders to be included in the group* |
|---|---|---|
| **Precision agriculture and resource sustainability** | **Policy:**<br>- Consistent with the Economic Survey 2025-26 which recommends modest urea price increases paired with per-acre direct income transfers policymakers can explore a phased shift from embedded input subsidies toward direct cultivator support<br><br>**Programmatic:**<br>- Building on Krishi-DSS, measurement and verification capabilities could be extended to include input transaction trails, anomaly detection, and audit protocols alongside existing remote-sensing crop verification and soil data<br>- Certify safety and performance standards for tech-enabled innovation e.g., variable-rate applicators, smart sprayers and drones (interfaces, calibration, operator SOPs, liability) | **Lead**<br>MoA&FW, Dept. of Fertilisers, States<br><br>**Others**<br>Agri-DPI SPV + State DPI cells, Input firms, CHCs, FPOs, village entrepreneurs, OEMs |
| **Farmer value realisation and market efficiency** | **Policy:**<br>- Complementary mechanisms to support diversification toward horticulture, livestock, and fisheries could be explored, aligned with evolving domestic consumption and nutrition patterns. This has been noted in the Economic Survey 2025-26 as well<br>- Transparent price discovery, AI-based quality grading, and direct market access can be supported through digital infrastructure and standards<br><br>**Programmatic:**<br>- A National Demand Forecasting and Crop Planning Engine that integrates<br>  › Consumption and nutrition trends<br>  › Trade and price signals<br>  › Procurement/stock data<br>  › Agro-climatic suitability<br><br>And publish as district-level crop opportunity maps and seasonal advisories. | **Lead**<br>MoA&FW, States (APMC), Dept. of Food & PD<br><br>**Others**<br>Agri-DPI, e-NAM and ONDC rails, Agribusiness buyers, mandis, warehouses, FPOs, logistics and fintech players |

| *Activity Area* | *Scope/Issue Covered (non-exhaustive)* | *Key Stakeholders to be included in the group* |
|---|---|---|
| **Shared digital infrastructure and data policy** | **Programmatic:**<br>✦ Standards for grading, sorting, and AI-enablement could be developed<br>✦ National standards for data interoperability and consent could be defined through AgriStack and ADeX, reducing the cost of accessing clean, labeled datasets. Clarity on public-interest vs. commercial data access could be established<br>✦ Building on AgriStack, core registries and identifiers (Farmer ID, Plot ID, Cultivator Credential ID), APIs, and consent/audit layers could be expanded to enable seamless, consent-based data flow across advisory, credit, insurance, and procurement systems | **Lead**<br>MoA&FW, MeitY, States<br>**Others**<br>Agri-DPI SPV, Platforms, startups, research institutions, FPO ecosystems |

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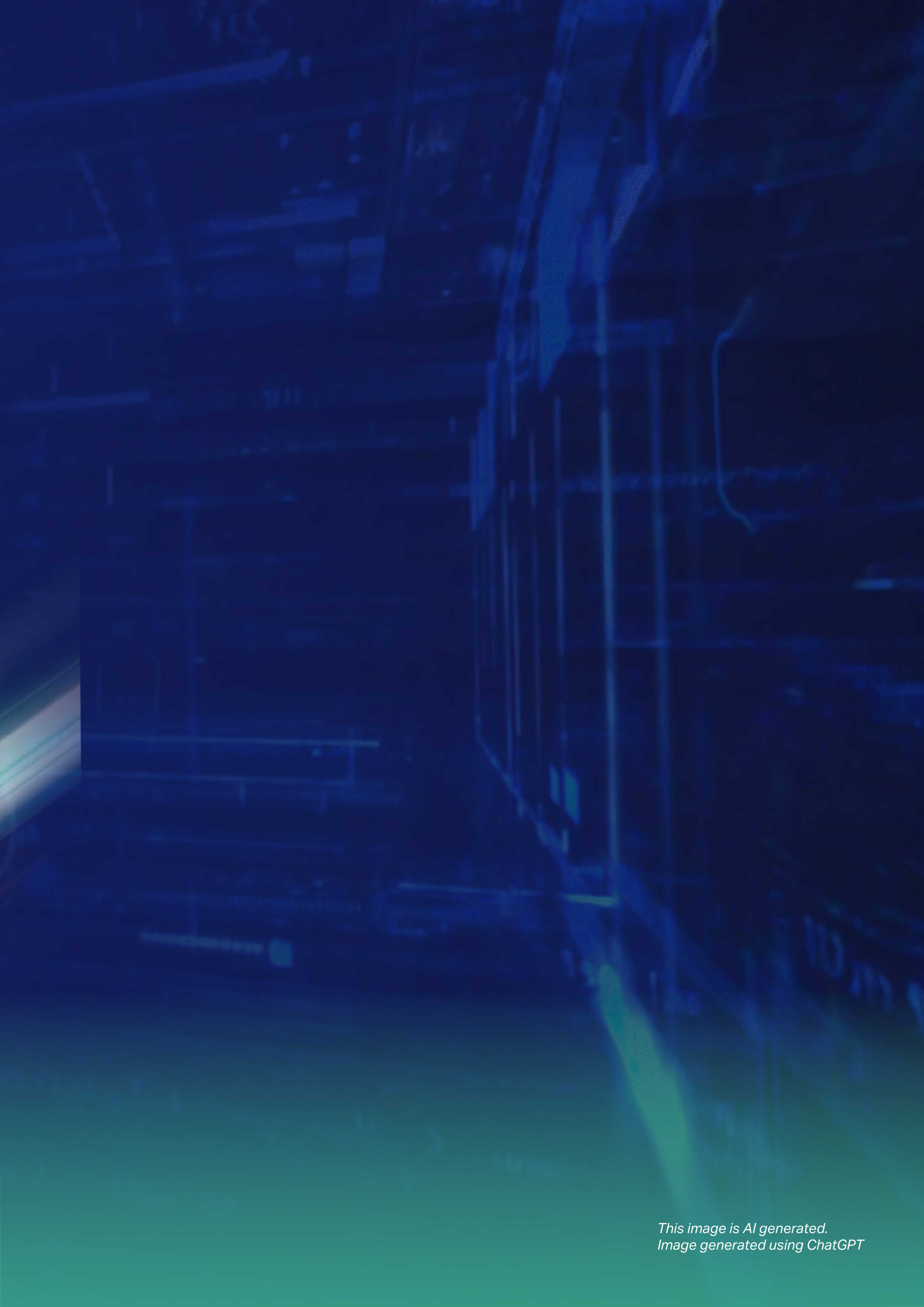
# Amrit Vidya

## AI in Indian Education



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# Executive Summary

With more than 14 lakh schools, over 24 crore students, and over one crore teachers spread across a very varied landscape of boards, languages, and institutional contexts, India runs the largest education system in the world. The nation has successfully addressed a fundamental national priority by achieving a historic expansion of access and enrolment over the past few decades. The digital rails needed for population-scale delivery have been further established through digital public investments such as DIKSHA and NDEAR, as well as extensive connectivity initiatives. However, learning outcomes continue to be a significant challenge despite this scale.

The ASER evidence highlights some foundational gaps. COVID-related disruptions also exacerbated these, leaving a majority of learners 2–3 grade levels behind in foundational literacy and numeracy. These early gaps tend to compound over time, leading to disengagement, higher dropout rates, and poor preparedness for secondary education, higher education, and the workforce. The National Education Policy (NEP) 2020 squarely recognised this challenge and hence called for a shift from subject mastery to foundational mastery, reasoning, and competency-based learning. The government is also making substantial investments to strengthen digital infrastructure in school education, reflecting recognition of these gaps. This push is being reinforced by national programs like BharatNet, which is expanding rural broadband as a backbone for last-mile school connectivity, and Samagra Shiksha, which provides the implementation vehicle for ICT-enabled schooling through funding for smart classrooms, digital labs, and teacher capacity-building.

India has achieved scale in education, but quality and equity remain uneven across teachers, students, parents, and administrators. Teachers balance instructional and administrative demands, many students lack tailored academic support, and parents have limited visibility into learning progress. Despite growing data availability, administrators still face challenges in converting insights into timely, targeted interventions.

Artificial intelligence currently offers a unique opportunity to break these boundaries when implemented as an "enabling layer" rather than as a standalone solution. The report treats artificial intelligence as a force multiplier, increasing human potential, the quality of learning, and the quality of system governance, not as a tool to automate past inefficiencies. A high-impact education technology architecture will need to be built around six priorities: unlocking teacher effectiveness, bridging the digital divide, promoting reasoning skills over memorisation, facilitating multilingual and transparent parental engagement, powering institutional intelligence, and ensuring the safe and human-centric use of technology.

AI can deliver tangible impact across the education value chain. For students, it enables foundational diagnostics, personalised remediation, Socratic tutoring that builds reasoning rather than answer dependence, concept visualisation, and accessibility for learners with disabilities. For teachers, it can automate grading, reporting, and lesson preparation, freeing time for mentorship and differentiated instruction. For parents, AI communication in local languages improves engagement, supports digital well-being guidance, and simplifies access to scholarships. For administrators, predictive analytics can flag dropout risks, optimise resource allocation, and turn fragmented data into actionable intelligence. At the last mile, voice-based AI models can extend quality learning to low-connectivity and underserved settings.

AI adoption also opens new employment pathways in education, spanning teacher support roles, assessment and content services, accessibility support, training and onboarding, and digital well-being counselling. When paired with appropriate training and governance, these roles strengthen both learning systems and employment outcomes.

Realising this potential requires system-level shifts. Governments could set a clear objective function for AI in education centered on learning outcomes, teacher enablement, and student well-being while strengthening digital public infrastructure, reforming assessment towards competency-based models, and establishing safety and usage standards. Prioritising inclusive, teacher-first, and reasoning-led solutions would be advantageous for EdTech providers. Administrators could refocus classroom instruction to emphasise lifelong learning, agency, and mastery.

India has made education more accessible than it has ever been. Delivering high-quality learning, reasoning, and adaptability at the same scale presents the next opportunity. When used properly and methodically, AI can hasten this shift and enable transformation at scale.

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# India’s Education Landscape

*Scale, Structural Realities, and Digital Foundations*

The Indian education ecosystem is the **world's largest schooling system, encompassing over 14 lakh schools, 24 Cr children, and more than 1 crore teachers across 66+ school boards.** Government schools account for approximately 69% of institutions and enrol around 51% of students, while private schools represent about 23% of institutions and serve roughly 33% of students; the remaining share is distributed across other categories. Over the past decades, India has achieved a historic expansion of access and enrolment, addressing a long-standing national priority. Alongside this expansion, challenges in learning quality remain to be addressed.

According to ASER, even in 2018 (before the pandemic), only 44% of Grade 5 children in rural India could read a Grade 2 level text and just 28% could do basic division. ASER 2022 showed these figures dropped to 38.5% and 25.6% respectively, reflecting pandemic learning loss. The latest ASER 2024 shows a recovery, with 44.8% now able to read at Grade 2 level and 30.7% able to do division, but this still means more than half of Grade 5 students lack foundational literacy and nearly 70% cannot do basic division. These unresolved learning deficits compound in middle and secondary grades, increasing dropout rates and undermining readiness for higher education.

Against this backdrop, the **National Education Policy (NEP) 2020 was introduced, prioritising foundational literacy and numeracy** while calling for a shift toward critical thinking, creativity, collaboration, and communication competencies that transcend traditional subject boundaries. However, operationalising this vision remains constrained by persistent system bottlenecks. Overall, only 57% of schools in India have a computer or digital device for teaching, and just 54% have an internet connection as of FY25 (UDISE+ 2023-24, Moed), limiting the ability to leverage EdTech. The large digital divide is even more challenging as the gap between urban and rural schools in terms of digital infrastructure and internet access is 24% and 29%.

The **government is making substantial investments to strengthen digital infrastructure** in school education, reflecting recognition of these gaps. This push is being reinforced by national programs like BharatNet, which is expanding rural broadband as a backbone for last-mile school connectivity, and Samagra Shiksha, which provides the implementation vehicle for ICT-enabled schooling through funding for smart classrooms, digital labs, and teacher capacity-building. At the same time, I**ndia has established significant Digital Public Infrastructure in education platforms such as Diksha, hosting over 3.6 lakh pieces of content,** demonstrating the country's ability to build scale ready digital rails across 126 Indian languages. Complementing this, India's Digital Public Assets for Education and Research (DPAER), through the NDEAR framework, provides foundational digital infrastructure that enables states to build interoperable, inclusive, and context specific education solutions at scale. The challenge now lies not in content availability alone, but in ensuring quality, coherence, teacher enablement, and effective use at the classroom level. This challenge has become more urgent as artificial intelligence reshapes the global education ecosystem.

# Core Challenges in the Indian Education Sector

**India has achieved scale in education, but quality and equity remain uneven. As AI reshapes learning, unresolved gaps across infrastructure, teachers, students, and governance threaten to limit its transformative potential.**

## Challenges for Teachers

- Educators often have limited time for direct student interaction due to administrative responsibilities.
- Single-teacher schools serve approximately 3.3 million students, presenting opportunities for technology-enabled support.

## Challenges for Students

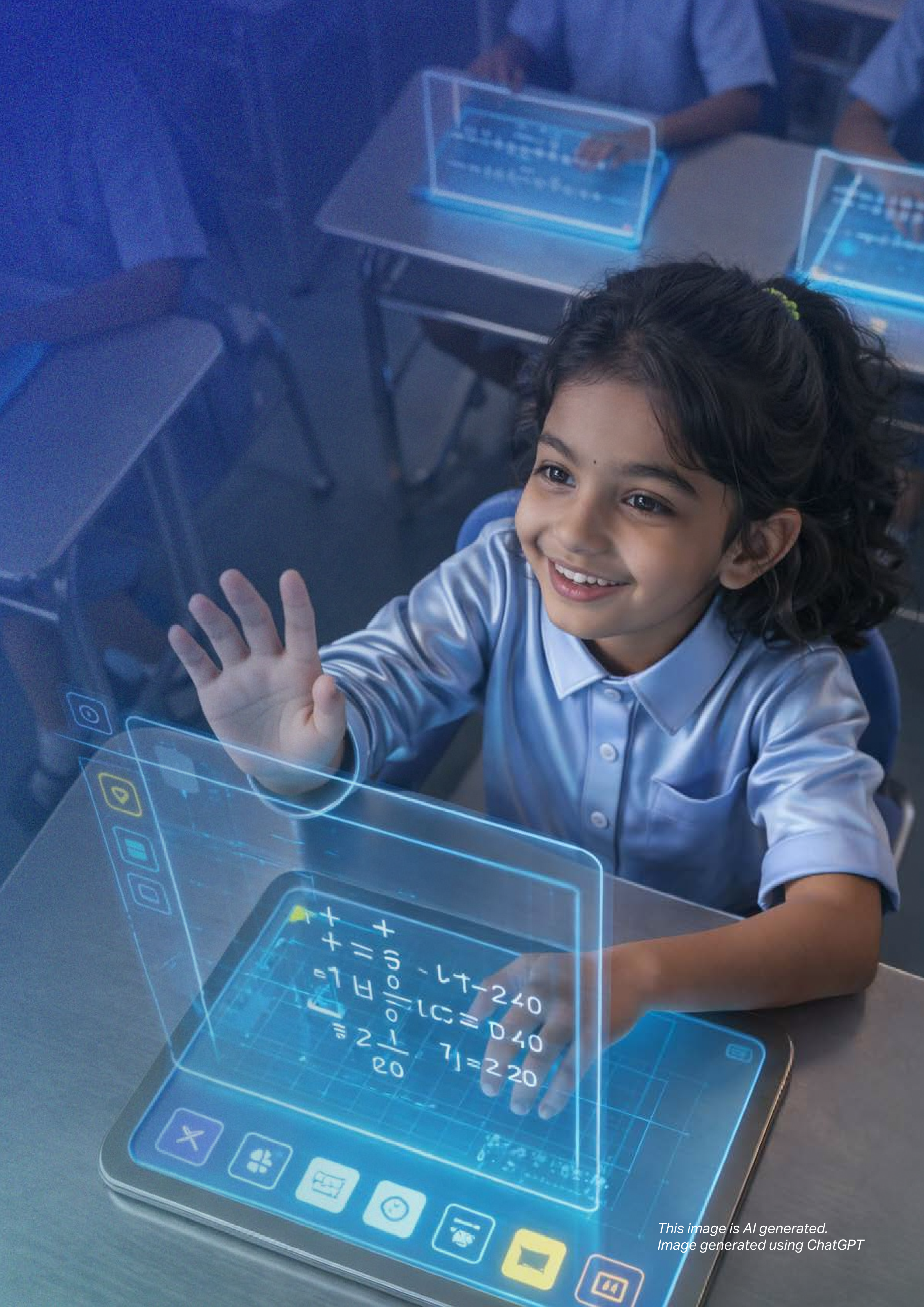
- The "Ignored 90%": In many classrooms, instruction is geared toward the top 10% of learners, leaving the average student in the back rows hesitant to ask questions and falling behind.
- Foundational gap: Over-reliance on content recall and subject mastery has led to many Class 5 students performing 2-3 years below grade level, reflecting limited emphasis on mastery and competency-based learning.
- Limited digital penetration and access: Most teachers and students lack reliable access to personal digital devices, constraining individualised instruction, real-time assessment, and differentiated remediation. Where digital tools do exist, they are often shared, intermittent, or underutilised, preventing technology from meaningfully closing learning gaps.
- Cognitive Safety: Students face high risks from cyberbullying, addiction, and exposure to deepfakes.

## Challenges for Management, Administrators, and Policy Makers

- Reporting and Compliance Burden: Administrators face recurring demands from boards, regulators and accreditation bodies for evidence and metrics. With limited automation, teams spend disproportionate time compiling reports.
- Resource Allocation and Financial Constraints: Budget limits force difficult trade-offs across staffing, infrastructure, learning materials, and student support.
- Data-rich but insight-poor decision-making: While institutions collect large volumes of data across attendance, assessments, finance, and operations, administrators often lack the analytical tools and skills to translate this data into actionable insights. Hence, early warning signals are missed, interventions are delayed, and data functions more as a reporting artifact than a driver of strategic decisions.
- Change Management and Capability: Adoption of digital enablers (where available) is uneven due to limited training and workload pressures.

## Challenges for Parents

- Communication Gaps and Limited Engagement: The communication between parents & school is often one way and inconsistent. Working parents and those with language or digital access barriers are disproportionately excluded from meaningful engagement.
- Lack of Real-Time Academic Insights: Parents typically receive performance signals only after tests, or when problems escalate. They have limited visibility on daily learning progress and foundational gaps, thus delaying corrective action.
- Need for Parenting Guidance and Resources: Many parents want practical guidance on study routines, motivation, screen time boundaries and mental well-being; but lack credible, accessible resources.
- Fragmented and opaque access to financial aid: Scholarship and aid programs are dispersed across multiple agencies and platforms, with complex eligibility criteria and application processes. Low-income families often lack awareness, guidance, and capacity to navigate these systems.
- Limited Career and Pathway Guidance: Parents lack reliable guidance on academic streams, vocational pathways, and emerging career options, leading to decisions driven more by convention than by student aptitude or labour-market relevance.
- Limited Awareness of AI in Education: Many parents lack understanding of how AI tools are being used in their child's learning, what data is collected, and how they can support AI-augmented education at home.



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# The Architecture for High Impact Education Tech

A national framework for educational AI and technology could be designed to bridge structural gaps in the sector and strengthen the interaction between students, teachers, parents, and administrators.. Technology must function as an enabling layer and as a bounded support for expanding access, augmenting human capacity, improving learning quality, and aligning policy with outcomes rather than as a standalone solution. The architecture could be anchored in six foundational pillars:

## From Subjects to Skills

AI-enabled education must move beyond subject-based content delivery to competency-based capability building:

- Mathematics → Numerical reasoning, problem-solving, logical thinking
- Science → Scientific inquiry, evidence evaluation, systems thinking
- Languages → Communication, expression, comprehension
- Social Studies → Perspective-taking, civic reasoning, contextual analysis

This aligns with NEP 2020's vision and global frameworks (OECD, World Economic Forum) that emphasise transferable competencies over domain specific content recall.

## Unlocking teacher effectiveness

Teacher effectiveness is the strongest in-school determinant of student learning. The framework should distinguish between academic administration (lesson planning, grading, assessment design) where AI can augment teacher quality and general administration (attendance reporting, compliance submissions, survey forms) which should be automated or restructured so it no longer falls on teachers. Freeing teachers from both enables their transformation into high-impact mentors focused on motivation, socio-emotional development, and values-based learning.

## Bridging the Digital Divide

The framework should leverage Digital Public Infrastructure (DPI) and hub-and-spoke models to provide shared access not only to connectivity and platforms, but also to essential hardware such as computers and learning devices across under-resourced schools. Without reliable access to devices for teachers and students, digital and AI-enabled learning remains structurally inaccessible. Treating connectivity and basic computing hardware as core public utilities is therefore critical to preventing geographic and socioeconomic marginalisation and to ensuring equitable participation in technology-enabled education.

### Promoting Guided Reasoning and Competency-Based Learning

AI in education should prioritise reasoning and conceptual understanding over answer delivery, enabling students to think with AI rather than rely on it. Platforms and tools must be designed for Socratic, discovery-based interaction prompting students to work through logic rather than receive ready-made solutions. Alignment of assessment with competency-based evaluation is essential to reinforce this shift in classroom and platform design.

### Enabling Transparent and Multilingual Parental Engagement and guidance

Limited parent involvement driven by lack of awareness, language barriers, and one-way communication is a persistent gap, particularly in government schools.
The architecture must build a structured pathway: from awareness (what AI tools are used, what data is collected) to understanding (how their child is progressing) to active participation (supporting learning at home, making informed academic and career decisions). AI-driven tools should deliver personalised, vernacular updates and guidance through accessible channels, such as IVR, WhatsApp, SMS covering learning progress, study routines, digital wellbeing, and career pathways.

### Powering Institutional Intelligence and Predictive Management

Educational administrators should be able to deploy AI to integrate fragmented datasets into actionable institutional intelligence. Predictive analytics can anticipate dropout risks, optimize resource allocation, and streamline complex processes such as enrolment, scheduling, and scholarship access.

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# Mapping AI Solutions to India's Education Problem Set

AI can be deployed as a force multiplier across all stakeholders to bridge systemic quality and equity gaps. Evidence from large-scale deployments in India and other middle-income countries shows that the highest returns emerge when AI is embedded across the full education value chain rather than as isolated learner-facing tools:

**Students:** Personalised Learning, Mastery, and Career Readiness

**Teachers:** Productivity Enablement and Human-Centric Interaction

**Parents:** Inclusive Engagement and Home Learning Support

**Administrators:** Institutional Intelligence and System Optimisation

**Last Mile Delivery:** Access, Inclusion, and Local Empowerment

## Students: Personalised Learning, Concept Mastery, and Career Readiness

- **Foundational diagnostics:** AI enables continuous assessment of early literacy and numeracy (e.g., reading fluency, pronunciation, basic arithmetic), allowing gaps to be identified early even in large classrooms where individual diagnosis is otherwise infeasible.
- **AI Tutoring:** Platforms like Khanmigo and OpenAI's Study Mode guide students through logic rather than providing direct answers, which enables discovery-based learning.
- **Personalised Adaptive Learning (PAL):** AI identifies specific "nanoskills" such as a hurdle in fraction division and provides targeted remediation to bridge foundational grade-level lags, directly reaching the students who fall behind in one-pace classrooms.
- **Immersive Concept Mastery:** Extended reality (XR) enablers, such as the University of Michigan's XR studio, allow students to conduct experiments safely in virtual labs or visualise complex structures like the human body.
- **Inclusive Accessibility:** AI-powered features like Microsoft Immersive Reader provide text to speech, real time captioning, and sign language narrations for students with visual, hearing, or learning impairments.

## Teachers: Productivity Enablement and Human-Centric Interaction

- **Administrative Relief:** The 'Guru Mitra' AI tool "buys back" time for human-centric mentorship by automating administrative burdens like grading, data entry, and reporting.
- **Automated Evaluation:** Systems like Gradescope or IIT Bombay's ASAG model reduce grading time significantly, allowing teachers to focus more on student engagement. A large-scale program for using AI for "Assessment to Action" adopted by the Rajasthan government (with BCG, Wadhwani foundation, and Playpower Labs) resulted in systematic reduction of students performing below grade-level across 13 districts.
- **Differentiated Content Generation:** Teachers can use AI to create classroom activities tailored specifically for beginner, intermediate, and advanced learners in local languages.
- **24/7 Teaching Assistants:** AI-powered "companions" provide teachers with real time coaching on the subjects they teach and the methodologies, helping them transition from content deliverers to high touch mentors.
- **Paper-to-digital workflows:** AI-driven digitisation of worksheets and exams converts paper-based assessments into structured data, eliminating manual entry and accelerating feedback cycles at scale.
- **Support for descriptive and higher-order assessments:** AI-assisted grading of long-form and open-ended responses enables richer evaluation without increasing teacher workload.

## Parents: Inclusive Engagement and Home Learning Support

- **Vernacular Communication:** AI automates the drafting of personalised progress reports in 126+ local languages, helping parents in low English literacy communities remain active participants in their child's learning.

- **Real-Time Learning Dashboards:** AI-powered parent dashboards deliver simplified, vernacular updates on daily learning activity, foundational skill progress, and early warning signals moving from post-exam reporting to continuous visibility.
- **Digital Well-being Guidance:** AI assistants coach parents on managing their children's digital safety, protecting them from risks like cyberbullying, screen addiction, and deepfakes.
- **Safe Home Use Coaching:** Educators use AI to guide parents on facilitating structured educational device use at home, such as the 30-minute weekly practice sessions implemented in Maharashtra.
- **Career and Pathway Navigation:** AI assistants help parents explore academic streams, vocational options, and emerging career pathways matched to their child's aptitude and local labour-market signals, reducing reliance on convention-driven decisions.
- **Scholarship and Aid Discovery:** Specialised AI assistants (e.g., Scholarship Bot) help families identify and apply for financial aid tailored to their child's academic and personal profile.

## Administrators: Institutional Intelligence and System Optimisation

- **Predictive Risk Detection:** Administrators use AI to analyse attendance and performance trends to identify student dropout risks months in advance for proactive human intervention. Vidya Samiksha Kendra (VSK) model integrates data from millions of schools into unified dashboards to pinpoint district-level learning deficits and service delivery hotspots.
- **From data collection to decision intelligence:** AI translates fragmented administrative data into actionable insights, reducing reliance on manual reporting and intuition-driven decisions.
- **Intelligent Campus Services:** Institutions deploy AI for automated IT helpdesks, predictive facilities maintenance, and secure access management.
- **Admissions and Aid Guidance:** AI-powered conversational assistants streamline the admissions lifecycle, providing students with instant, personalised guidance on enrolment and scholarship discovery.

## Last Mile Delivery: Access, Inclusion, and Local Empowerment

- **Multilingual Sovereignty:** The development of sovereign Indian LLMs (under the BHASHINI initiative) ensures educational content is culturally relevant and accessible in regional dialects.
- **Panchayat Level Agency:** AI-enabled access points allow elected village leaders (Sarpanches) to use data to address local school dropouts and coordinate resources via Gram Sabhas
- **Global Mobility Training:** The NSDC utilizes AI-driven language avatars and simulations to train rural youth for international job roles, such as healthcare and caregiving.
- **Voice-based vernacular tutoring:** Voice-led AI tutors explain concepts in local languages, bridging the gap in rural areas facing qualified teacher shortages.

# Job Creation through AI Adoption in Education

Increasing digitisation and AI adoption in education open multiple new job opportunities. These include, but are not limited to:

### Teacher-centric roles and allied professional services

- On-ground instructors supporting teachers with AI-assisted lesson planning, differentiated content, and classroom activities.
- Assessment and evaluation specialists managing AI-assisted grading, diagnostics, and competency-based assessments.
- Pedagogical coaches and teacher mentors using AI insights to support classroom practice and continuous improvement.

### AI-led learning support, content, and knowledge services

- Local-language content curators adapting and validating AI-generated learning material for regional curricula.
- Subject matter reviewers ensuring accuracy, curriculum alignment, and age-appropriate use of AI outputs.
- Accessibility support staff using AI tools to support students with disabilities (speech-to-text, captions, assistive formats).

### Training, adoption, and ecosystem support services

- Teacher trainers building AI literacy and classroom-ready usage among in-service educators.
- AI tool trainers supporting schools and colleges in onboarding and day-to-day use of AI platforms.
- Digital well-being counsellors supporting students on screen use, mental health, and online behaviour.

When paired with teacher training, local-language capacity, and clear governance, AI adoption can strengthen education as both a **learning system and a major employment generator.**

# System Level Shifts Required to Unlock AI's Potential in Education

# Government and National Policymakers: Creating the Enabling Environment

## ✦ A National Mission for AI in Education

- **Empowered Governance:** Building on existing structures such as NETF and NDEAR, a focused, empowered body (potentially an SPV) could be explored to drive policy, and act as the central authority for evaluating pilots, approving scale-ups, and aligning funding across states.
- **Define the objective function for AI in Education:** Without redefined objectives, AI in education risks optimising wrong problems. Policies could be designed to ensure AI addresses learning outcomes rather than simply automating legacy practices. Key priorities should include.
  - Teacher-first innovation, where AI supports teachers by reducing workload and improving classroom effectiveness.
  - Shift towards competency-based learning, focusing on mastery and learning outcomes rather than subject mastery.
  - Board equivalence, enabling comparable learning outcomes and student mobility across education boards.

## ✦ Build Comprehensive Digital Public Infrastructure (DPI)

- **Sovereign Indian LLMs:** India centric, multilingual Large Language Models could be further developed trained on local data to support 126+ local languages leveraging Bhashini, ensuring culturally relevant responses for native language education. These assets should be funded as long-term public goods through predictable budget allocations rather than short-term project financing.
- **Unified Education Platform:** A single integrated platform could serve as the national backbone for AI-enabled education, bringing together student-facing learning tools (diagnostics, adaptive learning, practice), teacher-facing support (lesson planning, grading, coaching), parent communication (vernacular progress updates, guidance), and administrative dashboards (attendance, performance, early warning systems). This could be built on existing rails like DIKSHA and NDEAR.
- **Parent Engagement Infrastructure:** A national framework for parent communication could be developed, enabling schools to deliver vernacular, bite-sized guidance on AI in education, helping parents progress from awareness to understanding to active participation in their child's learning journey.
- **Content over infra focus:** Prioritising high-quality, curriculum-aligned digital content and teacher readiness before large-scale hardware deployment can help avoid device underutilization. Quality-based (Q1) procurement for content development recognises its nature as a reusable public good.
- **Skill Demand Data Bank:** Explore building a "skill demand data intelligence bank" that uses APIs to integrate job portals and Ministry of Labor data, creating a real-time graph of industry needs to guide learners.
- **Increase internet access to bridge digital divide:** Building on BharatNet and Samagra Shiksha digital infrastructure investments, internet and digital access in government schools could be further accelerated, specifically targeting the ~40% of schools that currently lack connectivity.

## ✦ Reform Assessment and Regulatory Frameworks

- **Enable a shift toward competency-oriented learning:** Reform national board exams to emphasise demonstrated competencies like reasoning, application, and judgment over content recall.
- **Leverage assessment data for continuous improvement:** Evaluate mechanisms that use aggregate assessment signals and error patterns to inform curriculum design, pedagogical practices, and teacher support.
- **AI Usage Policy by Age and Context:** Clear guidelines could be developed defining appropriate AI tool usage across age groups specifying which tools are suitable for which grades, contexts requiring supervision versus independent use, and rules around AI assistance in assessed work.

## ✦ Establishing AI Literacy Across All Boards

- A nationally consistent AI literacy framework could be established covering both technical fundamentals and responsible application. This would include age-appropriate understanding of how AI systems work, their limitations, practical use of AI tools, identification of misinformation and deepfakes, data privacy, ethics, and clarity on when human judgment must override AI output.
- Integration across the education system should be prioritised over standalone instruction. Embedding AI literacy across subjects, supported by a minimum level of structured learning each year, could normalize use and evaluation.
- Implementation would benefit from clearer institutional ownership. Expanding the AI Samarth program and assigning dedicated public education portfolios could improve coordination, funding discipline, and accountability without over-centralisation.
- The focus should remain on application literacy. The aim is to develop informed, critical users of AI, capable of judgment and discernment, not technical specialists.

# EdTech and AI Startups: Grounded and Responsible Innovation

## ✦ Prioritise solutions for teachers

- **Lesson Planning:** Startups should facilitate the "Teaching at the Right Level" (TaRL) approach by enabling the automatic generation of differentiated content. This allows a single teacher to support beginner, intermediate, and advanced learners within the same physical classroom, addressing the reality that many students function several grade levels behind their current enrolment.
- **Assessment Generation and Analysis:** As MCQ-based evaluation has largely been automated, the next frontier for EdTech startups lies in supporting the assessment of subjective, open-ended, and higher-order responses. AI should assist teachers in evaluating written explanations, problem-solving approaches, and creative work by highlighting reasoning quality, misconceptions, and rubric alignment, while preserving human judgment and final decision-making authority.
- **Teacher Self Coaching:** To replace episodic, one-off workshops, EdTechs must provide 24/7 AI powered

pedagogical coaches. By analyzing classroom recordings, these tools offer non-judgmental feedback on instruction styles and protocol adherence, empowering teachers to own their professional growth without administrative pressure.

## ✦ Design Student Solutions for Reasoning & Critical thinking

- **"Study Mode" Standards:** Develop Socratic tutoring standards (like OpenAI's Study Mode or Khanmigo) that guide students through logic and discovery rather than providing direct answers.
- **Nanoskill Identification:** Develop diagnostic tools that break curricula into "nanoskills" to provide targeted remediation the moment a student hits a specific cognitive hurdle.

## ✦ Support Inclusive, Human-Centric Low-Tech Innovation

- **Multi-modal and multilingual:** Develop high utility multi-modal AI interfaces that integrate voice, text, and visuals to support instruction across 126 plus regional languages, ensuring that vernacular education remains culturally relevant and inclusive.
- **Low Connectivity Solutions:** Co-create voice driven and offline friendly AI tutors for environments where internet access is unstable, but smartphone usage is high.
- **Assisted Access Models:** Partner with the government to deploy tools via Common Service Centres (CSCs) to reach low literacy and marginalized populations.
- **Human-centric design and engagement:** Prioritise intuitive, low-friction user experiences grounded in local contexts, using age-appropriate gamification, storytelling, and feedback loops to sustain engagement.

# Education Institutions: Experience and Discussion Hubs

## ✦ Redefine the Role of Educator

As machines manage information delivery, human teachers must pivot to high-touch facilitation that technology cannot replicate. This transition requires a cultural shift where educators prioritise:

- **Motivation and Mentorship:** Teachers inspire curiosity, purpose, and sustained engagement in learning by acting as "super teachers" who capture attention and motivate students beyond what automated systems can achieve. Educators support students in finding meaning in education beyond narrow employability outcomes by guiding in discovery-based learning and helping students navigate complexity rather than supplying ready-made answers.
- **Ethical guidance:** Teachers provide ethical and moral guidance in environments increasingly shaped by AI-generated content. They help students critically evaluate information and navigate risks such as misinformation and low-quality synthetic outputs. Educators shape learners into responsible users and creators of technology grounded in integrity and accountability.
- **Social learning:** Teachers enable collaborative learning and peer interaction within schools. They foster teamwork, empathy, communication, and leadership through guided social engagement. Schools remain essential spaces for interpersonal skill development.

## ✦ Shift Classroom Practice Toward Mastery and Agency

Institutions should move away from rigid, age-based pacing toward learning based progression, where students advance only after demonstrating deep understanding of core concepts.

- **Continuous Formative Assessment:** It is recommended to move away from high stakes terminal exams toward real time diagnostic tools that identify specific learning gaps and provide instant feedback.
- **Peer Learning and Collaboration:** Repurposing physical class time for group problem solving and debate.
- **Project Based Application:** Replacing process-based delivery with project led models that mirror the real-world demands of the workforce, fostering skills like systems analysis and complex problem solving.
- **Reduced Fear of Failure:** AI provides a non-judgmental space for trial and error, allowing students particularly those in the "ignored 90%" to build confidence through "small wins".

## ✦ Explicitly Addressing Student Well-being and Safety

AI creates significant opportunities for student engagement, personalised support, and accessible learning. Realising these benefits requires thoughtful management of associated risks, not as barriers to adoption but as design considerations for responsible implementation.

- **Combating Social Isolation:** Institutions should reinvest AI efficiency gains into physical "ground games" and peer-to-peer interaction to preserve real-world relationships, interpersonal skills, and team leadership.
- **Addressing Misinformation and Deepfakes:** AI literacy must include formal training on deepfake awareness and disinformation, teaching students to critically evaluate AI outputs, biases, and hallucinations instead of accepting them as absolute facts.
- **Shielding Students from Cyber Harm:** With cybercrimes against minors rising, safety training must be embedded in core curricula, enabling students to recognise online exploitation and seek human support when facing digital threats.

## ✦ Prepare Students for Lifelong Learning, Not Fixed Careers

In an AI-driven economy, careers are expected to shift repeatedly as traditional roles are disrupted and new, technology augmented opportunities emerge. This creates a landscape where technical credentials decay faster than ever before, often losing their professional relevance within a matter of months. Consequently, adaptability becomes the core skill for survival, necessitating a fundamental shift in education from a focus on mere employability toward the pursuit of meaning and purpose.

To achieve this, it is recommended that schools and colleges teach the following:

- **How to Learn:** Cultivate the habit of "unlearning and learning" to foster the deep curiosity needed to independently acquire new professional competencies as industry requirements evolve.
- **How to Work with AI**: Implement integrated programs where AI is utilised across various domains such as commerce, law, or medicine to ensure graduates apply technical tools as "aids for problem solving" within their specific fields.

- **How to Evaluate AI Outputs:** Train students as "critical consumers" who possess the discernment to judge the accuracy and bias of generated content, empowering them to identify "AI slop" and algorithmic misinformation.
- **How to Retain Human Judgment and Accountability:** Reinforce that human accountability and moral responsibility for final decisions cannot be outsourced to algorithms, as machines lack the nuanced empathy and contextual reasoning required for complex problems.

Beyond cognitive skills and career readiness, education could address self-awareness, svabhav (innate disposition), helping students understand their strengths, tendencies, and growth areas, as well as svadharma (one's own duty), guiding them toward discovering their unique contribution. As AI handles routine tasks, human meaning increasingly comes from purpose-driven work connecting individual capability to collective need.

### Agile Curricula and Experiential AI Training

- AI-enabled rapid curriculum refresh: Traditional five-year curriculum cycles are no longer sufficient to keep pace with AI technologies that evolve significantly every six months. Institutions should adopt annual innovation cycles, using AI to scan emerging industry practices, analyze skill demand signals, and assist faculty in rapidly updating syllabi, course materials, and assessments so graduates remain industry relevant.
- AI Clinics: Universities should establish "AI Clinics" modelled after the structured practical training found in legal aid clinics. In these settings, students perform pro bono AI projects for small businesses and nonprofits that lack the resources to hire professional technology consultants. This allows students to gain hands on experience solving real world problems using actual datasets, effectively bridging the gap between classroom theory and the practical demands of the modern workforce.

## Teacher & Workforce Training Institutions: From Workshops to Continuous Coaching

### Training all educators

- **Karmayogi Integration:** Extend digital capacity programs like Mission Karmayogi to all educators, training them first to use AI for productivity, then to teach with it.
- Continuous, personalised coaching tools could supplement episodic workshops analysing classroom practice (with teacher consent) and providing specific, actionable feedback mapped to National Professional Standards for Teachers (NPST).

### Create Specialised Cadres

- **New Professional Roles:** Certify new roles such as AI curriculum specialists and data-driven learning designers to lead institutional transformation.
- **Cluster Leadership:** Equip Cluster Resource Persons (CRPs) with AI coaches to help them transition from "informal inspectors" to lead learners and influencers.

## Shift from Qualification to Confidence

- Training centers must bridge the gap between academic theory and practical, AI-augmented global workplace competencies, training rural youth for international job roles through language avatars and simulations.

## Last Mile District Cadre: Local Agency and Shared Resources

- A hub and spoke model anchored at Cluster Resource Centers will enable solo teachers to access advanced resources. AI-powered, voice-based learning tools will deliver immersive, multilingual instruction to students in low bandwidth and remote villages, ensuring equitable access to quality learning.


*This image is AI generated.*
*Image generated using ChatGPT*

# AI solutions mapping

| | Current State | AI Enablers | Future State |
|---|---|---|---|
| **Students** | ✗ One-size-fits-all instruction geared to top 10%<br>✗ 2-3 grade levels behind in foundational skills<br>✗ Rote memorisation; high-stakes exam pressure<br>✗ Limited access to quality instruction by location<br>✗ No personalised learning path or pacing<br>✗ Learning defined by subject coverage rather than skills<br>✗ Teacher-led, adult-directed learning models | ✦ Unified national platform with adaptive learning<br>✦ AI diagnostics calibrated to exact learning level<br>✦ Voice-based multilingual tutors (any location)<br>✦ Competency tracking replacing exam scores<br>✦ Immersive XR labs for concept mastery | ✓ Instruction calibrated to exact learning level<br>✓ Competency-based progression, not exam scores<br>✓ Equal access regardless of location<br>✓ Critical thinking & discovery-based learning<br>✓ Career readiness with real-time skill mapping<br>✓ Shift from subject competence to skills and aptitude development<br>✓ Transition from adult-directed to self-directed learning<br>✓ Personalised learning journeys replacing whole-class instruction |
| **Teachers** | ✗ 60%+ time on grading, reporting, data entry<br>✗ Content delivery focus over mentorship<br>✗ Single-teacher schools serving 3.3M students<br>✗ Limited tools for differentiated instruction<br>✗ Uneven training & digital adoption | ✦ AI handles: diagnostics, content delivery, tracking<br>✦ Auto-grading (70% time saved)<br>✦ AI lesson planning & progress dashboards<br>✦ 24/7 AI teaching companions for support<br>✦ Guru Mitra for administrative relief | ✓ Freed from admin → focus on human connection<br>✓ Humans handle: judgment, relationships, values<br>✓ Motivation, ethics & socio-emotional development<br>✓ Differentiated support: beginner to advanced<br>✓ Transition from content deliverer to coach |
| **Parents** | ✗ One-way, inconsistent school communication<br>✗ Updates only after tests or when problems escalate<br>✗ Language & digital access barriers<br>✗ Insufficient guidance on supporting learning at home<br>✗ Fragmented scholarship/aid information | ✦ Real-time vernacular updates (126+ languages)<br>✦ AI-powered progress dashboards<br>✦ Personalised guidance on home learning support<br>✦ Digital wellbeing & safety coaching<br>✦ AI scholarship & aid discovery bots | ✓ Real-time visibility into child's learning journey<br>✓ Vernacular guidance on supporting progress<br>✓ Proactive alerts before gaps widen<br>✓ Inclusive engagement regardless of literacy<br>✓ Informed career & pathway guidance |
| **Admin** | ✗ Hours spent compiling manual reports<br>✗ Data-rich but insight-poor decision-making<br>✗ Dropout risks identified too late<br>✗ Resource allocation based on intuition<br>✗ Fragmented data across systems | ✦ Predictive analytics & early warning systems<br>✦ Unified dashboards (Vidya Samiksha Kendra)<br>✦ AI-powered enrollment & scheduling optimisation<br>✦ Automated compliance & reporting<br>✦ Real-time resource allocation insights | ✓ Predictive dashboards replace manual reporting<br>✓ Dropout risks flagged months in advance<br>✓ Data-driven resource allocation<br>✓ Real-time visibility across all schools<br>✓ Focus on strategic decisions, not data entry |

# Moving from Insight to Execution – Action Agenda

India built schooling access at an unmatched scale. The next national objective is learning, foundational mastery, reasoning, judgment, and lifelong adaptability, delivered across 14 lakh schools and 24 crore learners with uneven infrastructure and wide variability in classroom practice. AI can accelerate this transition, provided the system is designed around the right objective function. A small number of action groups with clear mandates and time-bound output should be empowered to deliver this agenda.

## Quick Wins (Lower Effort, Immediate Value)

Existing tools, low infrastructure, fast deployment,visible outcomes

- Automated grading and evaluation
- Lesson planning assistance
- Video summarisation for teacher prep
- Vernacular parent progress reports
- Administrative chatbots
- Teacher coaching via classroom video analysis
- Diagnostic assessments
- Scholarship and aid discovery bots
- Predictive dropout analytics

## Strategic Investments (Longer Term, Transformational)

Needs multi-year, cross-system integration, high policy leverage

- Sovereign Indian LLMs
- Fully integrated education platform
- Personalised Adaptive Learning platforms
- XR and immersive learning

| *Activity Area* | *Scope/Issue Covered (non-exhaustive)* | *Key Stakeholders to be included in the group* |
|---|---|---|
| **Strategic Orchestration and Priority Setting** | ✦ A 12–18-month AI-in-Education execution portfolio could be published; the objective function on what needs to be solved by AI could be defined<br>✦ A national Learning Signal (key KPIs to track) could be defined: what gets measured gets improved (mastery progression, foundational recovery, engagement quality, teacher time recovered, safety incidents)<br>✦ A small Strategy Group could be established to keep coherence across boards/states and prevent fragmentation | **Lead**<br>Ministry of Education (MoE)<br>**Others**<br>NCERT, MeitY, CBSE, State Boards, CISCE and State Education Departments |
| **Regulatory and Adoption Enablers** | ✦ An AI Usage Policy by age and context could be developed: which tools are appropriate at which grades, supervision requirements, and rules for AI assistance in assessed work<br>✦ Standards for "guided reasoning" modes (Socratic tutoring) and restrictions on answer vending for assessed work could be established<br>✦ Institutional protocols could be set for cyberbullying, deepfakes, misinformation, exploitation risks, screen hygiene, escalation, and reporting pathways<br>✦ A nationally consistent AI literacy framework covering technical fundamentals and responsible application could be established as a mandatory component across all boards, with a minimum annual structured learning requirement | **Lead**<br>Ministry of Education (MoE)<br>**Others**<br>NCERT, State Education Depts, UGC, AICTE, MeitY |
| **SPV Structure, Linkages & Ecosystem Operating Model** | ✦ Explore designating NETF as the Operating Vehicle for the AI agenda, leveraging NDEAR/DIKSHA as the execution rails; create a new SPV only if otherwise<br>✦ Specify linkage model between DPI building blocks (NDEAR), content rails (DIKSHA), state systems, and service providers (interfaces, responsibilities, onboarding, compliance)<br>✦ Establish coordination mechanisms across central and state execution to reduce fragmentation and duplication<br>✦ Define whether the vehicle will publish reference architectures for prioritised use cases (diagnostics, practice, teacher copilots, parent comms, institutional dashboards) | **Lead**<br>Ministry of Education (MoE)<br>**Others**<br>MeitY; NIC; NITI Aayog; State Education Depts + State IT; DIKSHA/NDEAR teams |

| *Activity Area* | *Scope/Issue Covered (non-exhaustive)* | *Key Stakeholders to be included in the group* |
|---|---|---|
| **Shared Tools and Enablement Services (under SPV)** | ✦ Evaluate setting up a shared services catalogue required to execute the agenda: multilingual/voice utilities, offline packaging, content QA workflows, assessment item generation templates, safety tooling, analytics utilities – Potentially an integrated platform for education<br>✦ Publish and maintain an Education Reference Architecture pack including required standards/APIs, reference integration patterns (state Student Information systems ↔ DPI ↔ classroom tools), and shared reference components (identity/consent, audit/logging, SDKs)<br>✦ Define access, usage, service levels, and governance for these tools to ensure consistent adoption<br>✦ Create a rollout plan for shared tools and enablement services across priority states/districts/school clusters | **Lead**<br>SPV<br>**Others**<br>DIKSHA/NDEAR tech teams; NIC/state IT; NCERT/SCERTs (content and pedagogy governance) |
| **Teacher, Administrator and System Capacity Building & Skilling** | ✦ Design training pathways for teachers, school leaders, and administrators on adoption, safeguards, oversight, escalation, and classroom integration<br>✦ Define new enabling roles: AI coordinators (school/cluster), content validators, remediation facilitators, digital wellbeing counsellors, data stewards<br>✦ Establish training governance (standards, certification approach if needed, delivery partners) and adoption tracking | **Lead**<br>NCTE<br>**Others**<br>DIETs and teacher training institutions; State teacher academies |

# Conclusion: Guiding Principles for Execution

The breadth of actions identified in this report reflects the scale and complexity of the opportunity before India's education system. The preceding sections have examined challenges across stakeholders, mapped AI-enabled solutions, outlined system-level shifts, and proposed a structured execution agenda. To ensure that this breadth does not come at the cost of strategic clarity, the roundtable discussions converged on a set of guiding principles. These principles are intended not as additional recommendations, but as a frame to reiterate the essence of the report.

- Continuous learning is becoming the emerging baseline. As AI reshapes the economy, the relevance of any fixed credential or skill set is likely to diminish over time. This suggests that education may need to be seen less as a finite phase preceding a career and more as a lifelong process with the system increasingly focused on developing learners who can continuously acquire, update, and adapt their competencies.
- Two emerging realities should inform learning outcomes
    - The learning process itself is becoming increasingly AI-driven. Students will increasingly learn through and with AI systems, reshaping how pedagogy, assessment, and curriculum delivery are approached.
    - AI is getting increasingly embedded across professions and domains. Working effectively in any field will increasingly require fluency with AI as a tool.

Consequently, the most important capabilities the education system must develop are learning how to learn with AI & work alongside AI in any domain. Subject knowledge would remain important, perhaps increasingly as a vehicle for building these broader competencies.

- Change will happen at an uneven pace, and planning should reflect this. Budgetary, infrastructure, institutional capacity, and AI tool maturity constraints are likely to impose different timelines across states and school types. It would be prudent to design an execution strategy for a phased, uneven rollout rather than assume uniform adoption
- Not everything needs to wait. Some elements are foundational. While the pace of change will vary, certain building blocks could be considered essential from the outset. Shared AI-based learning systems, supporting personalised learning calibrated to individual capability and aptitude, and the Digital Public Infrastructure enabling access to them fall into this category. These could be rolled out in modules, phases, or by subject, but the architecture must ideally be in place early. It is worth emphasising that AI-based learning systems are fundamentally different from the digitisation of existing content; they involve adaptive diagnostics, personalised pathways, and guided reasoning, and would benefit from being procured on a Quality-based (Q1) criterion. Other elements, including physical infrastructure, hardware deployment, and large-scale capacity building, which constitute the bulk of the financial outlay could be phased in as budgets permit, and procured through L1 or QCBS systems.
- A distinction between ends and means may help maintain strategic clarity
    - The ends-foundational mastery, the ability to learn and work with AI, equitable access, and lifelong adaptability, are relatively stable objectives.
    - The means-specific tools, platforms, and delivery models detailed in this report, are derived and would likely need to evolve in response to what becomes technologically possible, what works in practice, and what proves cost-effective.

Building structured feedback loops into the execution framework could help ensure that course corrections are made as evidence emerges.

# Amrit Udyog

## AI in Indian Manufacturing

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*Image generated using ChatGPT*

# Executive Summary

Manufacturing is an important part of India's economy. It contributes about 16-17% to the country's GDP, provides jobs for over 110 million people, and supports goals like self-reliance, export growth, and job creation. Over the past decade, programs such as 'Make in India,' 'Atmanirbhar Bharat,' and 'Production-Linked Incentive' have helped the sector grow. India is now the world's second-largest steel producer, and new industrial hubs are being developed in many states. The goal is to increase manufacturing's share of GDP to 25% by 2047, which will require steady progress over the next twenty years.

This shift entails addressing the existing structural hurdles, especially in the MSME segment, which comprises more than 70 million enterprises and accounts for almost 45% of exports. The Indian labour productivity in the manufacturing sector is about one-fourth of the overall global average. Moreover, most of the plants in the MSME segment work at less than 60% Overall Equipment Effectiveness.

Quality outcomes are similarly constrained. Heavy reliance on manual inspection and operator skill leads to inconsistent defect detection, increased rework, and limited knowledge sharing. The absence of common data standards and interoperable systems prevents improvements from spreading across shifts, plants, and suppliers. Technology adoption is further hindered by skill gaps, employee resistance, and uncertainty about return on investment. Limited access to formal credit compounds these challenges. With only about 20% of micro and small businesses able to secure bank financing, a significant funding gap remains, making modernisation difficult.

These challenges are often interconnected and can reinforce one another. When capital is scarce, it is harder to adopt new technology, leading to lower productivity and quality. If quality is inconsistent, it becomes difficult to reach organised buyers and export markets. This reduces revenue and limits reinvestment. Small steps toward digitisation or one-off pilot projects have not been enough to solve these problems.

Recent advances in artificial intelligence provide practical solutions to address these challenges at scale. By targeting real issues and considering the entire system, AI enhances existing lean practices instead of replacing them. IoT devices and sensors deliver real-time updates on machines and processes. AI supports predictive maintenance, automated quality checks, optimised scheduling, and data-driven decision-making. Integrating these tools into daily operations enables MSMEs to shift from individual reliance to consistent, repeatable outcomes.

For that, the report highlights that, to realise this potential, AI adoption must be considered a system-wide change, not a technology deployment. Four principles are critical: designing for scalability from the outset; treating industrial clusters and value chains, not individual firms, as the unit of adoption; prioritising outcomes over technology sophistication; and strengthening applied industry-academia collaboration focused on shopfloor problems.

The report outlines complementary roles for startups, MSMEs, anchor corporates, and the government. Startups must move from pilots to MSME-ready, outcome-linked solutions. MSMEs should adopt problem-first, cluster-based approaches. Anchor corporates can enable standardisation, traceability, and capability building across supplier ecosystems. The government can act as an ecosystem architect, providing shared infrastructure and trusted digital frameworks.

AI in manufacturing could potentially act as a near-term lever to convert fragmented growth into scaled competitiveness, strengthening productivity, quality, resilience, and job creation across India's manufacturing base.

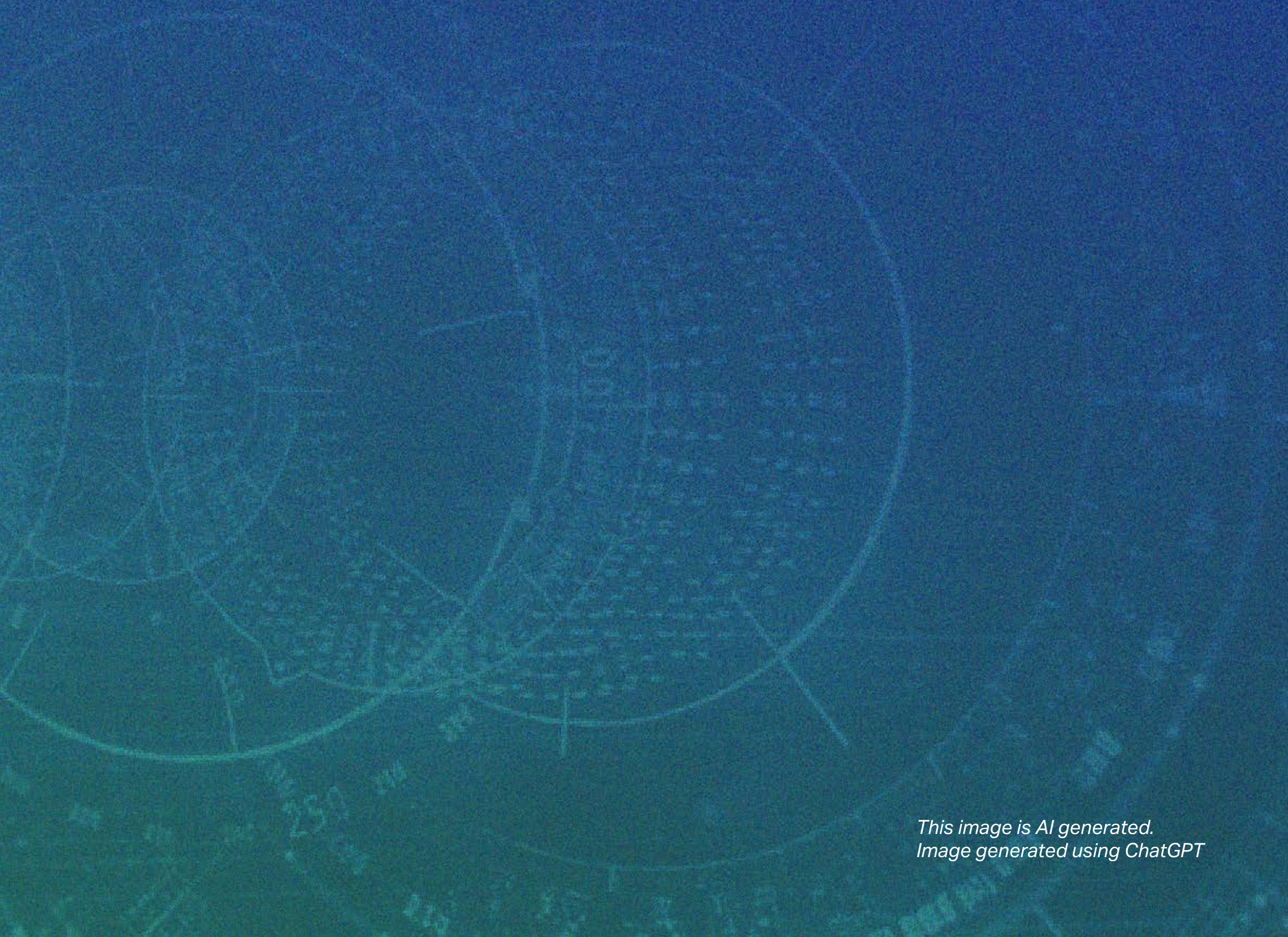

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*Image generated using ChatGPT*

# India's Manufacturing Today

Manufacturing is central to India's economy, accounting for 16-17% of GDP and employing over 110 million people. It supports national objectives of self-reliance and export competitiveness.

In the past decade, India has made notable progress. India's crude steel production has grown from ~97 (FY13) to ~200 MT, (FY25), with the National Steel Policy targeting 300 MT by 2030-31. India is now the world's second-largest crude steel producer, with output of 151 MT in FY25 (Ministry of Steel, GOI). Mobile phone exports grew from ₹1,500 crore in 2014-15 to over ₹2 lakh crore in 2025, while import dependence dropped from 75% to nearly zero (MeitY). Manufacturing clusters have expanded in Gujarat, Tamil Nadu, Karnataka, and Uttar Pradesh. Much of this progress traces back to sustained policy initiatives such as Make in India, Atmanirbhar Bharat, and PLI schemes, which have attracted investments of ₹1.88 lakh crores and created over 12 lakh jobs (PIB/DPIIT).

India aims to increase manufacturing's share of GDP to 25% by 2047. That will require annual sector growth of about 15% for over two decades. MSMEs will be critical. Of the 70+ million Udyam-registered MSMEs in India, about one-third are in manufacturing, and supply components to major producers in automotive, electronics, pharmaceuticals, and engineering. MSMEs contribute nearly 45% of India's exports and anchor industrial employment in smaller towns and clusters.

However, MSME productivity has lagged and has been held back by four persistent challenges.

- **Low productivity:** India's manufacturing labour productivity is about 25% of the global average, and most plants operate below 60% OEE.
- **Inconsistent quality:** Quality outcomes remain uneven and often depend on individual operator skill rather than standardised processes, limiting reliability and buyer confidence.
- **Lagging technology adoption:** Robot density is just 7 per 10,000 workers, compared with 162 globally, (IFR World Robotics), ERP penetration is low, and many firms still rely on spreadsheets and paper logbooks.
- **Limited access to capital:** Only about 20% of micro and small enterprises receive formal bank credit, resulting in an ₹30 lakh crore financing gap (SIDBI) that constrains investment in productivity-enhancing technology.

Recent advances in AI offer practical solutions. Computer vision can standardise quality inspection. Predictive analytics can minimize unplanned downtime. AI-enabled credit assessment can help close the financing gap for MSMEs without traditional documentation. These tools are already deployed globally. For India, scaling them across the MSME sector can turn persistent weaknesses into competitive strengths and accelerate the returns on existing policy investments.

**Note:** MSME: Micro, Small, and Medium Enterprises
**Source:** Government of India, Press Information Bureau (PIB); World Bank Data; World Economic Forum Data; WEF, MeitY, Report – Tranforming Small Businesses, An AI Playbook for Indian MSMEs; NITI Aayog - Viksit Bharat @2047 manufacturing growth targets and policy statements; World Steel Association Data; BCG Analysis

# Structural Challenges in Manufacturing in MSME

Despite sustained growth in India's manufacturing output, MSMEs continue to face weak productivity, inconsistent quality, and limited integration into organised value chains. These challenges are systemic and mutually reinforcing, limiting MSMEs' ability to scale reliably and convert cost advantages into durable competitiveness. Four structural constraints stand out.

## Productivity

- Limited automation across the manufacturing value chain, leading to lower output and higher cost structures
- Many MSMEs operate below efficient scale, with small order sizes limiting the ability to absorb fixed costs or invest in improvements

## Quality

- Inconsistent quality outcomes, with high dependence on manual inspection and operator skill
- Limited standardisation and lack of interoperable systems, making it difficult to track, learn, or replicate improvements across sites

## Technology

- Low ERP adoption, with most firms relying on spreadsheets and manual records for planning and costing
- Skill gaps, workforce readiness issues, and organisational resistance slowing technology adoption
- Limited supply chain visibility, leading to input disruptions and demand volatility

## Capital

- Limited access to formal credit, with only 20% of micro and small enterprises accessing bank finance
- High upfront costs for technology enablement, combined with perceived uncertainty on ROI

## Productivity

### ✦ Limited automation across the manufacturing value chain, leading to lower output and higher cost structures

India's manufacturing labour productivity is roughly 25% of the global average. Low automation intensity is a primary driver. Robot density stands at 7 per 10,000 manufacturing workers, compared to a global average of 160. Most MSME plants operate at OEE levels below 60%, well short of the 80-90% achievable with automation. This gap translates into structurally higher unit costs, often nullifying India's labour cost advantage. Without automation, throughput stays constrained, cycle times remain long, and output quality depends heavily on manual effort.

### ✦ Many MSMEs operate below efficient scale, with small order sizes limiting the ability to absorb fixed costs or invest in improvements

Indian manufacturing is highly fragmented. A large share of MSMEs operate below efficient scale, with small batch sizes, variable demand, and inconsistent throughput. This makes it difficult to amortize fixed costs, justify capital investments, or sustain continuous improvement initiatives. Low volumes also reduce bargaining power with buyers and suppliers, and limit the data needed to institutionalize learning across batches or shifts. Productivity gains, where they occur, remain localized and do not compound.

## Quality

### ✦ Inconsistent quality outcomes, with high dependence on manual inspection and operator skill

Quality outcomes in MSME manufacturing remain highly variable. Visual inspection by the human eye remains the dominant quality control method across many sectors, even as tolerances tighten and throughput increases. This creates three problems:

- First, defect detection is subjective and varies across shifts, operators, and plants, leading to high rates of rework, scrap, and customer complaints.
- Second, manual inspection struggles to detect micro-defects, process drift, and early signals of quality degradation, resulting in downstream failures rather than preventive correction.
- Third, quality learning does not compound: corrective actions remain reactive, and improvements at one site do not transfer to others.

Taken together, these issues concentrate quality control in the hands of a few experienced individuals, making outcomes highly person-dependent and vulnerable to attrition. This directly undermines buyer confidence and restricts MSME participation in organised procurement and export supply chains, where consistent first-pass yield and documented, auditable quality assurance are baseline requirements.

### ✦ Limited standardisation and lack of interoperable systems, making it difficult to track, learn, or replicate improvements across sites

MSMEs operate with a mix of legacy machines, standalone software, and manual workflows. There is no common standard for how machines report status, how defects are classified, how jobs are logged, or how production events are recorded. Data remains siloed across production, quality, maintenance, and procurement. This lack of interoperability blocks system-level improvement. Isolated digitisation efforts remain disconnected, making AI deployment costly, slow, and vendor-dependent. Without shared taxonomies and reference architectures, solutions that work in one factory fail to scale across clusters or states.

## Technology

### ✦ Low ERP adoption, with most firms relying on spreadsheets and manual records for planning and costing

ERP adoption among MSMEs remains a structural gap. Many firms continue to use spreadsheets, PDFs, and paper logbooks for production planning, quality tracking, and costing. The cost, complexity, and disruption of ERP implementation, combined with unclear ROI, discourage adoption. This leaves MSMEs without a reliable digital backbone for operations. Without structured systems, data remains inconsistent and person-dependent, decision-making slows, and scaling becomes difficult. The digitisation gap is often the primary barrier to modernising MSME manufacturing operations.

### ✦ Skill gaps, workforce readiness issues, and organisational resistance slowing technology adoption

While India has a surplus of labour, it lacks a workforce trained to operate modern manufacturing systems. Vocational and technical education often remains misaligned with industry needs, focusing on legacy skills rather than CNC operation, robotics, or digital quality systems. The cost of training for advanced manufacturing makes workforce attrition particularly expensive for MSMEs, discouraging investment in upskilling when returns are uncertain. Organisational resistance compounds the problem. Middle management in many MSMEs, often long-tenured employees with limited exposure outside the firm, may perceive new technologies as threats to their roles or authority. This leads to passive resistance, delayed adoption, or parallel manual processes that dilute impact.

### ✦ Limited supply chain visibility, leading to input disruptions and demand volatility

MSME supply chains remain vulnerable to input, logistics, and demand shocks. Raw material price volatility, delayed inputs, logistics bottlenecks, and sudden demand swings hit MSMEs hard because of limited buffers and weak forecasting. Without integrated planning and real-time visibility, disruptions cascade into production delays, cash-flow stress, and missed deliveries, prompting reactive responses such as line stoppages or costly spot sourcing. Recent global disruptions, including the pandemic, geopolitical tensions, and shipping delays, have exposed this fragility. Fragmented supply chains with weak digital coordination struggle to reconfigure sourcing or meet buyer commitments under pressure.

## Capital

### ✦ Limited access to formal credit, with only 20% of micro and small enterprises accessing bank finance

India's MSME sector faces a large formal credit gap. Only about 20% of micro and small enterprises access scheduled bank credit; medium enterprises fare slightly better but remain underserved. SIDBI estimates an addressable MSME credit gap of ~₹30 lakh crore. Collateral requirements, gaps in credit history, and lengthy underwriting processes exclude many MSMEs from formal lending. This pushes firms toward informal or alternative financing at higher cost, constraining working capital and limiting investment in technology, capacity, or talent.

### ✦ High upfront costs for technology enablement, combined with perceived uncertainty on ROI

Technology adoption in MSMEs requires significant upfront investment in hardware, software, integration, training, and process redesign, often before any value is realised. For firms with thin margins and limited access to long-term financing, this is a difficult commitment. Returns are delayed and execution-sensitive: ROI depends on disciplined implementation, data quality, process standardisation, and workforce adoption. Partial or poor implementation significantly reduces payback. Many MSME owners assess ROI solely on short-term labour savings, undervaluing gains from quality improvement, uptime, yield, compliance, and risk reduction. This leads to underinvestment even where long-term economics are strong.

These four constraints interact. Limited capital restricts technology investment. Low technology adoption leads to inconsistent productivity and quality. Poor quality limits access to organised buyers and export markets, which constrains revenue and reinvestment. Breaking this cycle requires coordinated interventions across all four dimensions.

## The Vicious Cycle of Constraints


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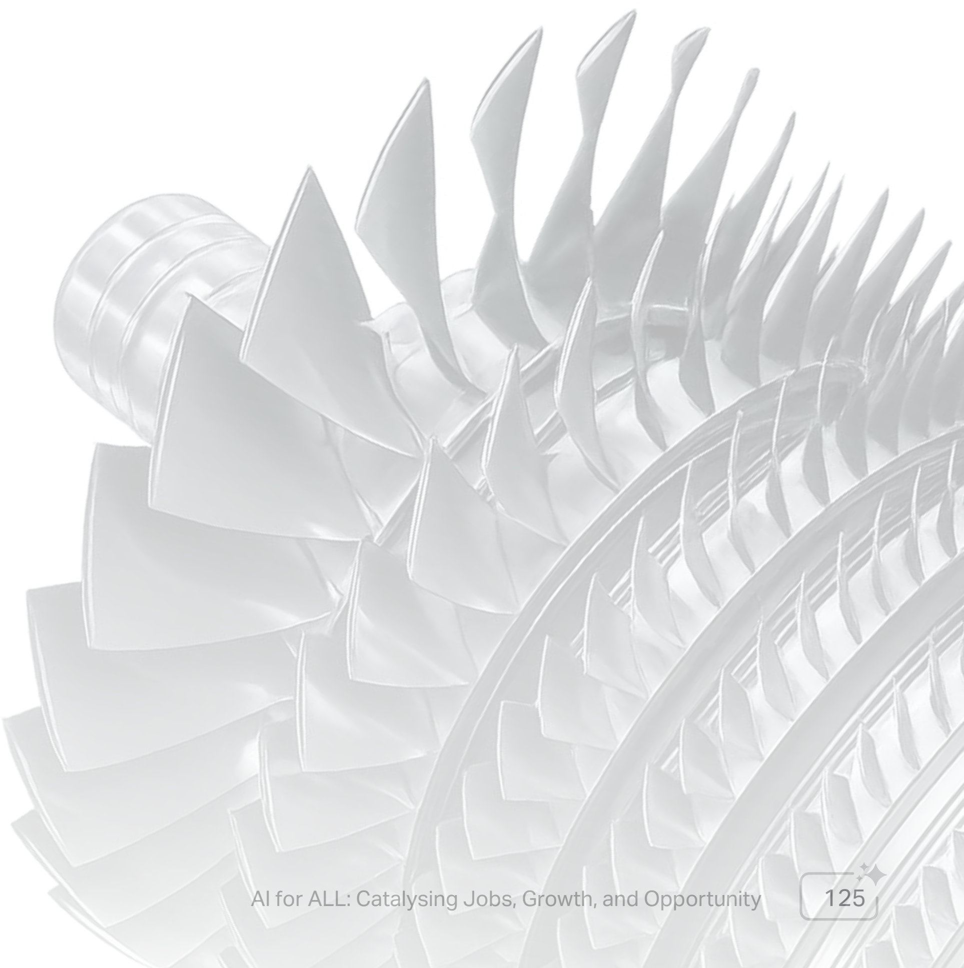
# How AI and Technology can Address Structural Constraints in Manufacturing

Technology and AI offer practical tools to address the structural constraints outlined above. Many of these solutions are not new, ERP systems, sensors, and automation technologies have existed for years, but what has changed is their accessibility for MSMEs. The upfront cost of hardware and connectivity has declined, and a growing domestic vendor ecosystem, supported by initiatives such as Startup India has made solutions more affordable and better suited to Indian manufacturing conditions.

At the same time, AI-enabled systems have moved from small pilots to large-scale deployment in leading enterprises, where they are delivering measurable gains in productivity, quality, and reliability. These firms are increasingly acting as role models and demand-side anchors, often requiring Tier-2 and Tier-3 suppliers to adopt similar systems, enabling MSMEs to shift from reactive, person-dependent operations to more consistent and scalable performance.

When applied in a problem-first, system-oriented manner, AI offers practical levers to address persistent constraints in Indian manufacturing, particularly in quality consistency, productivity, capital efficiency, workforce capability, and traceability. Leading manufacturers are not replacing lean operating systems with AI, but augmenting foundational lean practices such as line-centric teams, daily KPI huddles, and standardized maintenance routines with digital and AI layers. Deployed as an embedded decision-support capability rather than a stand-alone technology, AI connects equipment, enables predictive maintenance, and provides AI/ML-driven analytics that help operators and maintainers make faster, better decisions. This combination allows firms to translate fragmented operational data into actionable insight, reduce variability in outcomes, and scale reliable, repeatable performance under MSME operating conditions, rather than relying on heroics or manual supervision.



# Best in class companies are augmenting their lean operating system with digital and AI

## Lean operating system


01 Line centric teams

02 Core DMS (e.g., DH, CIL, CL, etc.)

03 Daily huddle boards for KPI tracking

Build operator capability to own and address their own losses through Line centric teams, foundational routines, daily problem solving, and optimised maintenance.

## AI-enabled smart factory


01 Predictive maintenance

02 More connected equipment

03 Automated centerlining

04 AI/ML driven remote analytics

05 Digital visual management systems

Leverage advanced analytics and automation to help operators and maintainers make better decisions and quickly optimise their machines.

## How AI will enhance the manufacturing environment

| | | | | |
|---|---|---|---|---|
| **Capabilities** | **Creating**<br>Based on various data sources | **Observing**<br>Processes & human actions | **Measuring**<br>Temp, pressure, velocity, ... | **Controlling**<br>PLC, NC, MC, RC, ... |
| **Data Type** | ERP data CRM data SC data | Pictures Videos | Time series data | Rigid Control Logic |

**AI Technology**

- **Deep Learning** — **Machine Learning**
- **Generative AI** — **Rule based**

## Potential application areas

**01 Product Design**
Generation of alternative models, designs etc. in product development process

**02 Material Handling**
Generation of synthetic data for pre-trained robots

**03 Automation Engineering**
Generation of program code for, e.g., process automation

**04 Equipment Maintenance**
Automated synthesis of (virtual) maintenance instructions

**05 Operator Support**
Automated creation of text-, image- & video-based Standard Operating Procedures (SOPs)

**06 Advanced Shopfloor Automation**
Embodied multi-modal model-based robotics for task automation (through integration of vision & language)

The sections below outline practical, AI-enabled solutions, illustrated with real-world examples that directly address these structural constraints in Indian manufacturing:

## Productivity

### Raising productivity and lowering costs through IoT, sensors, and shopfloor intelligence

IoT sensors and machine connectivity provide real-time visibility into equipment utilisation, energy consumption, and production status. Predictive maintenance models use vibration, temperature, and acoustic data to forecast equipment failures before they occur, reducing unplanned downtime. Digital dashboards replace manual tracking, enabling supervisors to identify bottlenecks as they occur rather than after the fact. GenAI tools can parse engineering drawings and automatically populate costing models, enabling MSMEs to generate quotes in hours rather than days without relying on a few senior engineers.

- Infinite Uptime uses vibration, temperature, and acoustic sensors combined with AI to predict equipment failures in steel, cement, and heavy manufacturing. The platform enables early intervention, reducing emergency maintenance and improving asset availability.
- SenseGiz provides IoT-based condition monitoring for motors and pumps used by Indian MSMEs, predicting failures and alerting maintenance teams to avoid costly downtime.
- Faclon Labs deploys IoT sensors for machine health monitoring in discrete manufacturing, designed for retrofit on legacy equipment so MSMEs can digitise without replacing machines.
- BFW, a Bangalore-based machine tool manufacturer, used process digitisation and AI-driven production management to expand revenue 4x in four years without adding manpower or floor space.
- Peer Robotics provides human-centric robotic automation that handles mundane, physically demanding tasks for worker in factories, improving manpower productivity.

## Quality

### Addressing quality inconsistency through AI-based inspection and predictive quality

Digital quality records and inline measurement systems replace paper-based inspection logs, laying the foundation for systematic improvement. Computer vision detects defects invisible to the human eye, including surface flaws, dimensional deviations, and soldering issues, enabling near-100% inspection at production speed. Predictive quality models correlate process parameters such as temperature, vibration, and tool wear with downstream defects, enabling intervention before value is added. Indian steel and Indian steel and electronics MSMEs report significant improvement in defect detection using these systems. For exporters, AI-generated inspection logs serve as a digital trust passport, supporting compliance with international standards without repeated audits.

- Tata Steel uses AI-based computer vision on rolling lines to detect surface defects in real time, linking defects to process parameters for corrective action and export-grade quality assurance.
- JSW deploys inline AI vision systems for surface inspection and quality grading of finished steel, replacing subjective manual checks.
- Mahindra & Mahindra uses computer

vision for weld inspection, surface finish checks, and assembly verification in automotive plants, supporting zero-defect manufacturing.

- Switchon provides quality inspection with an AI-powered vision system, resulting in zero-defect production lines across pharma, electronics, and FMCG industries.
- Syrma SGS Technology applies AI-enabled automated optical inspection to detect soldering defects on PCBs, with digital logs retained for global customer audits.

## Technology Adoption and Skills

### Bridging the skill gap through AI-assisted training, AR/VR, and workforce augmentation

Cloud-based ERP systems, now available at lower cost and complexity, provide MSMEs with a digital backbone for planning, costing, and quality tracking. AR/VR training tools allow workers to learn complex tasks in simulated environments, reducing ramp-up time and safety risk. Digital SOPs delivered through tablets or smart glasses standardize execution across shifts. AI-assisted tools act as a "silent supervisor," flagging missed steps and deviations in real time, helping less experienced operators perform complex tasks reliably. AI-powered supply chain tools improve demand sensing and visibility, helping MSMEs anticipate input disruptions and adjust sourcing proactively.

- Bosch has deployed AR-based work instructions across Indian plants to guide operators through assembly, quality checks, and maintenance, reducing errors and speeding up onboarding.
- TVS uses AR-assisted training to standardize shopfloor procedures across plants and supplier MSMEs, embedding best practices into daily operations.
- Companies like Autvrse and Skillveri have developed VR-based training for welding, CNC machining, and maintenance, that can be used by MSMEs and vocational training centres to build job-ready skills in risk-free environments.

## Capital

### Addressing capital constraints for MSMEs through AI-driven underwriting

Digital transaction records, GST data, and integrated invoicing systems create a verifiable trail of business activity that can be structured and shared with lenders. AI-enabled credit assessment models analyze transaction flows, order books, production data, and payment cycles to assess repayment capacity without relying on traditional collateral or audited financials. This can help address the ₹80 lakh crore financing gap by bringing more MSMEs into formal credit channels. AI-based demand planning tools also help MSMEs optimize inventory and working capital allocation.

- Lendingkart and Indifi use alternative credit models based on transaction and operational data to underwrite MSME loans faster and with less documentation.
- OfBusiness uses AI to integrate procurement, order flows, and supplier data, helping manufacturing MSMEs optimise raw material purchasing, production sequencing, and working capital.

These applications are not theoretical. They are being deployed in Indian manufacturing today, across large firms and MSMEs. The opportunity now is to accelerate adoption at scale, particularly among the MSME segment where the productivity and quality gaps are most acute.

# Unlocking AI at Scale – Principles and Recommendations

Unlocking the potential of AI in MSME manufacturing requires coordinated action across the ecosystem. No single stakeholder, whether MSMEs, large firms, technology providers, or government, can drive this transformation alone. The constraints outlined earlier are structural, and addressing them demands complementary shifts in behaviour, incentives, and operating models.

## Five guiding principles can help frame this effort:

**Scalability from the outset:** AI adoption in manufacturing should prioritize scalability from day one, rather than treating scale as a later consideration. Pilots that cannot operate under real shopfloor conditions, including heterogeneous machines, variable power and connectivity, workforce churn, and thin margins, are unlikely to translate into broader impact.

**Clusters as the unit of adoption:** Firm-by-firm AI adoption will remain slow and fragmented. Locational clusters (manufacturing hubs) and sectoral clusters (value chains) face common constraints and buyer requirements, enabling faster peer learning and replication. Interventions designed and evaluated at the cluster level, with cluster associations and anchor firms as implementation partners, are more likely to achieve scale.

**Outcomes over technology:** AI adoption should be driven by operational and financial results, not by technology maturity. Success should be measured through improvements in quality consistency, cost reduction, cash-flow predictability, and compliance readiness, rather than model sophistication or automation levels.

**Applied industry-academia collaboration:** India ranked 86st globally on industry-academia collaboration, in the Global Innovation Index (GII) 2024. Corporate R&D spending remains at roughly 1% compared to 5% in leading manufacturing economies. Collaboration needs to move beyond abstract research toward applied, shopfloor-relevant problem-solving for MSMEs.

**Awareness reduces resistance and accelerates adoption:** When middle management and supervisors clearly understand what AI can (and cannot) do, typical adoption timelines, and how AI augments rather than replaces roles, fear of job loss and loss of control reduces significantly, lowering organisational resistance and speeding up adoption.

India is not starting from scratch. A growing base of AI startups is already focused on manufacturing. Anchor corporates are investing in supply chain resilience and supplier capability. Government programs for MSME support, skilling, and digital infrastructure are expanding. The opportunity now is to align these efforts so that each stakeholder reinforces the others. The recommendations below outline how startups, MSMEs, anchor corporates, and government can contribute to making AI adoption a shared, scalable effort.

## Startups and solution providers: From technology pilots to MSME-ready deployments

- Target clusters, not individual MSMEs:
  - Individual MSMEs are often too small to justify customised deployments or deliver meaningful ROI for solution providers. Cluster-based targeting enables shared use cases, pooled demand, and faster adoption through peer effects. Startups should build sector-specific, integrated solutions designed around common operational needs within each cluster.
- Adopt outcome-linked commercial models:
  - MSMEs are wary of upfront costs with uncertain returns. Outcome-based pricing and risk-sharing models, where payments are linked to measurable improvements in quality, uptime, or yield, can help address trust and cash-flow concerns.
- Move from point solutions to integrated systems:
  - Standalone tools (e.g., a single IoT sensor) rarely deliver lasting value. Startups should focus on end-to-end solutions that address real operational problems and align with MSME realities.
- Design for hybrid and edge-first deployment:
  - Many MSMEs have concerns around data security, latency, and cloud costs. Solutions that support on-premise or edge execution for sensitive data, with optional cloud integration for analytics, are more likely to gain acceptance. Transparent pricing and compute-usage visibility help MSMEs avoid unexpected cost escalation.
- Design for safety and interpretability
  - Shopfloor AI must distinguish between deterministic applications (e.g., machine shutdowns, quality pass/fail) that require predictable, bounded outcomes, and probabilistic applications (e.g., demand planning, scheduling) where uncertainty is acceptable. In both cases, outputs should be interpretable by supervisors, with clear explanations rather than black-box scores.

## MSMEs: from fragmented experimentation to outcome-led adoption

- Pursue cluster-based adoption:
  - MSMEs can reduce cost and execution risk by adopting AI through clusters rather than going it alone. Cluster-based approaches enable shared infrastructure, pooled learning, and faster diffusion of proven use cases.
- Start with problem-first engagement:
  - Rather than accepting vendor-driven pilots, MSMEs should articulate their specific operational problems and require providers to demonstrate how their solutions address those problems under real conditions.
- Prioritise proven, ROI-linked use cases:
  - MSMEs should begin with use cases that have demonstrated returns,

such as predictive maintenance, AI-based quality inspection, or digital traceability, before expanding scope. Early wins build confidence and create a foundation for broader adoption.

## Anchor corporates: from optimisation to ecosystem enablement

- Lead standardisation across value chains:
  - Anchor corporates can establish common data taxonomies and interfaces across SKUs, parts, quality parameters, and process states, enabling AI deployment across multiple suppliers. Standardised data layers reduce fragmentation and make AI solutions easier to scale.
- Enable horizontal AI applications for supplier MSMEs:
  - Anchor firms can deploy reusable AI tools that MSMEs can adopt without deep technical capability, such as document intelligence for tenders, shared vision-based quality inspection, or planning tools. This allows suppliers to upgrade technologically while aligning with buyer requirements.
- Support workforce upskilling:
  - Anchor corporates can use CSR initiatives and training institutions to build a digitally skilled manufacturing workforce. This includes collaborating with ITIs and national skilling programs to modernise curricula and providing expertise-on-demand and mentorship to MSME promoters within their supply chains.
- Adopt outcome-based partnerships with startups:
  - Rather than traditional procurement, anchor corporates can move toward outcome-linked partnerships with AI startups, where payments are tied to measurable improvements in downtime, defects, or scrap.
- Drive supply chain traceability:
  - As leaders of value chains, anchor corporates can mandate and support digital traceability across their supplier base. Enabling MSMEs to maintain audit-ready digital records strengthens supply chain reliability and improves competitiveness in global markets.

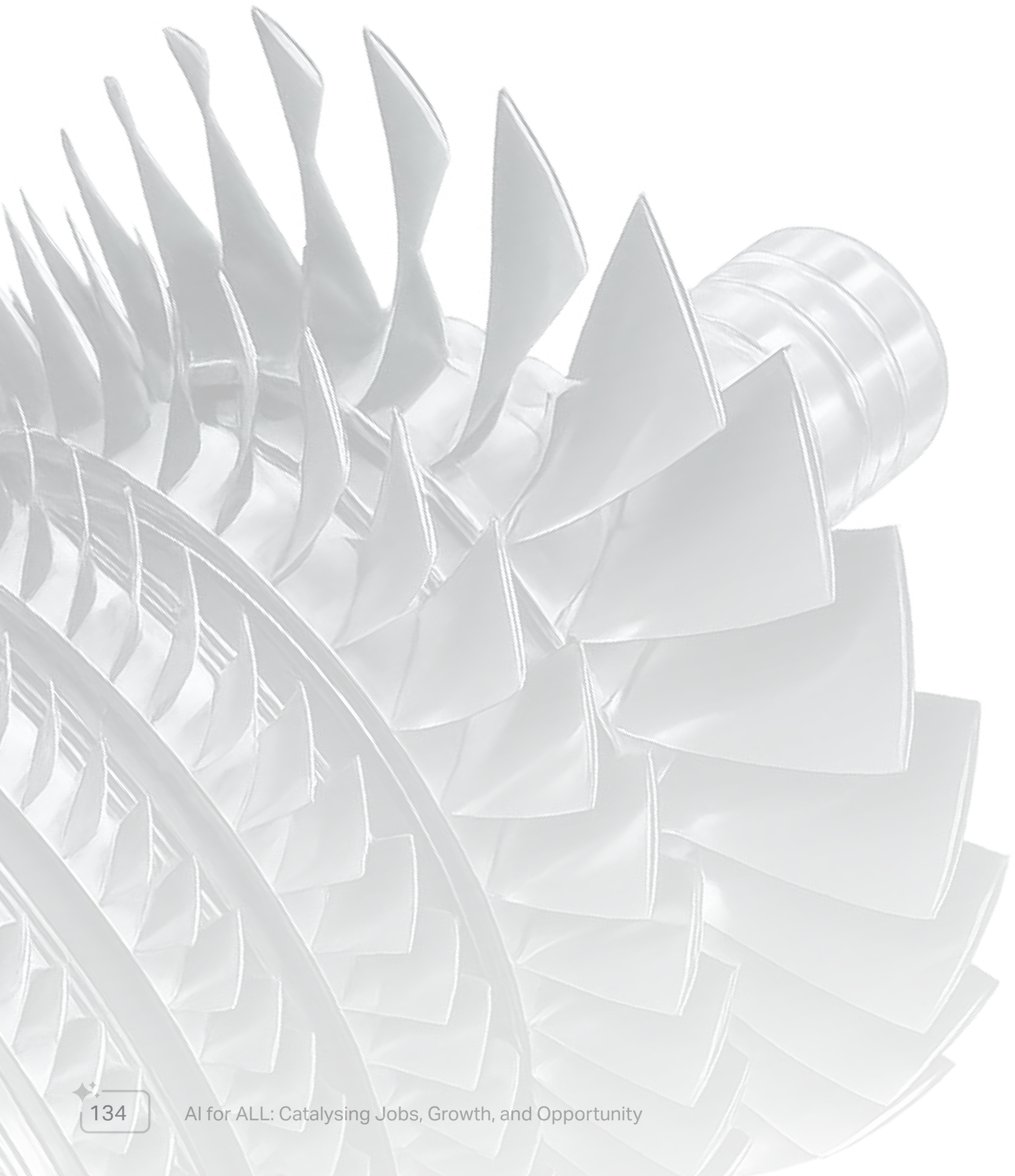
## Government as an ecosystem architect

- Build on existing MSME support infrastructure:
  - Programs such as the National Productivity Council (NPC), MSME Technology Centres, ZED (Zero Defect Zero Effect), and the Lean Manufacturing Competitiveness Scheme have established frameworks for MSME engagement.
  - Government can consider expanding these to include short-duration, on-site expert support for AI use case identification, roadmap development, and ROI estimation.
- Explore trusted, low-risk digital infrastructure:
  - Government can consider facilitating a manufacturing AI marketplace offering MSMEs access to vetted software, AI tools, and services in a transparent environment. This could help address concerns around pricing

opacity, cloud dependence, and data security. Such infrastructure could be complemented by credit facilitation mechanisms, such as those provided by SIDBI and MSME-focused financial programs.

- Provide shared infrastructure at cluster level:
  - The government can consider supporting cluster-level access to shared compute, edge infrastructure, and Small Language Models (SLMs) to reduce adoption costs. Public agencies could also continue funding time-bound pilots with clear scale-up or exit criteria, acting as an initial risk absorber for first-time MSME adopters.
- Align workforce and technical education with modern manufacturing:
  - Building on Skill India and NSDC frameworks, vocational and technical curricula could be further aligned with practices such as CNC operation, robotics, and AI-assisted inspection. Training can increasingly focus on functional, role-based AI usage rather than abstract theory.

When MSMEs, anchor corporates, startups, and government act in alignment, AI adoption shifts from isolated experiments to collective transformation. It becomes a mechanism for improving productivity, building trust across supply chains, and strengthening India's position in global manufacturing.

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# Employment and Job Creation: New Manufacturing Role Archetypes

GenAI tools and agents in Indian MSMEs can be "co-pilots" for employees rather than replacing them. This will drive a transition in the nature of roles and create new jobs across data capture, model training and supervision, compliance monitoring, data security, and hardware and software maintenance, among other areas.

## Data capture

- **Shopfloor data capture operators:** Workers capture real-time production events, including machine start/stop, downtime reasons, material changes, and quality issues, using mobile devices, tablets, or voice interfaces for GenAI to process.
- **Imaging staff capture data for vision models:** Operators collect images or short videos of parts, defects, assemblies, and processes using smartphones or fixed cameras. These datasets are used for AI-based quality inspection, training vision models, and validating outputs.
- **Document digitisation and tagging staff:** Workers upload, tag, and verify documents such as engineering drawings, SOPs, invoices, inspection reports, and compliance certificates. GenAI extracts parameters and metadata, while humans validate accuracy and handle edge cases.
- **Sensor installation and calibration assistants:** Semi-skilled workers install low-cost sensors, IoT devices, and vision systems, and perform routine calibration checks using AI-generated instructions. This supports continuous, reliable data generation.

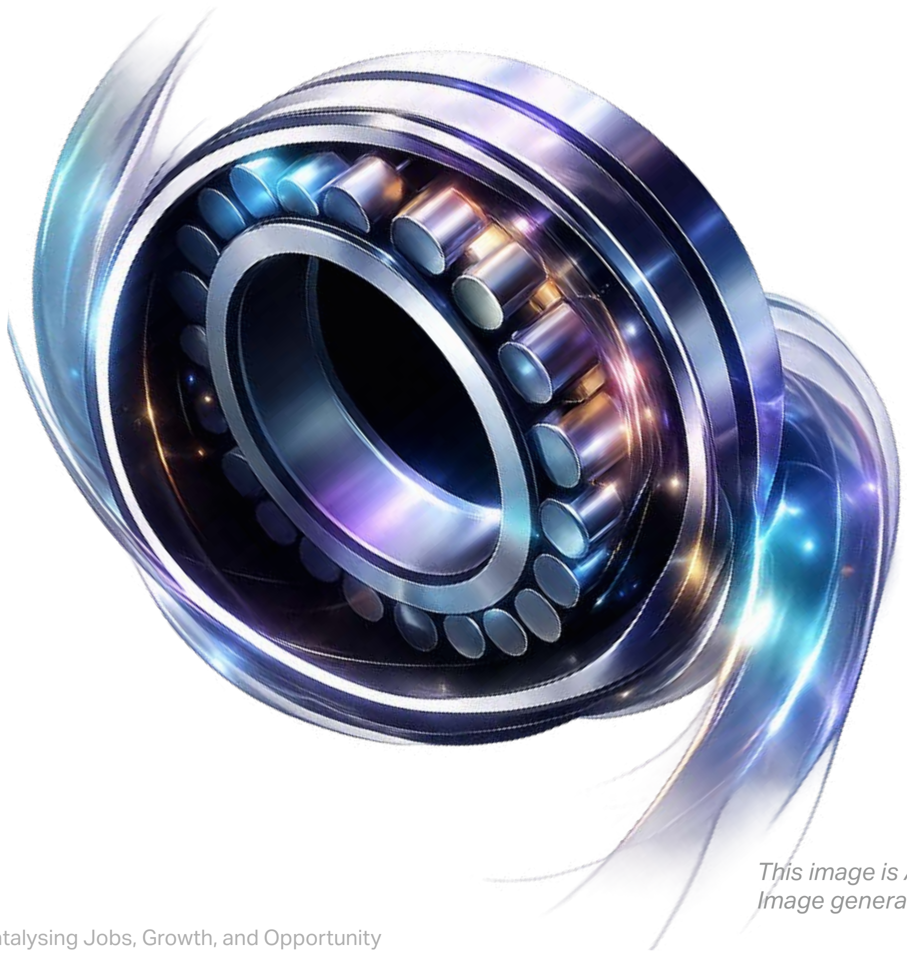
## Model training and supervision

- **Annotation and ground-truthing assistants:** Workers label defects, classify events, and confirm AI predictions (pass/fail, defect type, root cause).
- **Production exception and anomaly reviewers:** Workers review AI-flagged anomalies, such as unusual downtime, quality drift, or parameter deviations, and confirm whether action is required, escalating to supervisors when necessary.
- **Digital logbook and traceability staff:** Operators maintain AI-generated digital job cards, batch records, and traceability logs. They resolve exceptions flagged by systems and ensure records are complete for audits and buyer compliance.

## Compliance, Governance, and Ecosystem enablement roles

- **AI-assisted compliance monitoring staff:** Workers review AI-generated compliance outputs (quality records, batch histories, certificates) to ensure they align with applicable regulatory, buyer, and contractual requirements before submission.
- **Export documentation and filing assistants:** Operators support the preparation and validation of AI-generated export documentation (invoices, certificates of origin, test reports, customs filings), coordinating with logistics partners, CHAs, and banks as required.
- **Regulation interpretation and checklist operators:** Semi-skilled staff use GenAI tools to translate complex regulatory and buyer standards into actionable checklists; workers verify completion of required steps and flag gaps for corrective action.
- **Audit preparation and evidence coordinators:** Workers assemble and organize AI-generated audit trails, inspection logs, and traceability records ahead of internal audits, buyer audits, or regulatory inspections, reducing reliance on external consultants.
- **Data security and access control assistants:** Workers manage role-based access, consent, and data-sharing permissions for AI systems, ensuring that sensitive operational and compliance data is shared only with authorised internal and external stakeholders.

Across these roles, operators increasingly function as **AI co-pilots** interpreting system outputs, validating decisions, and handling exceptions rather than as manual executors.



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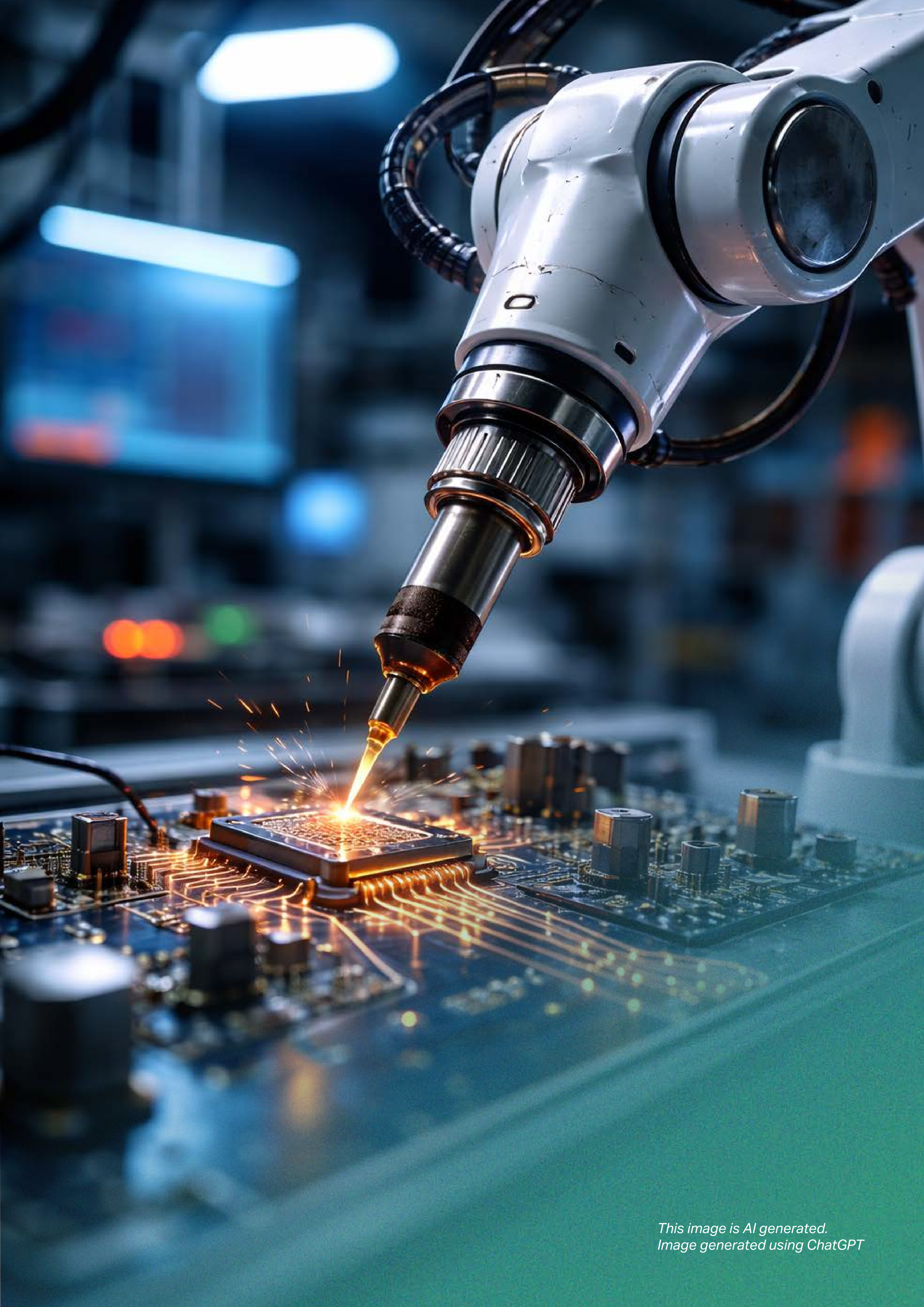

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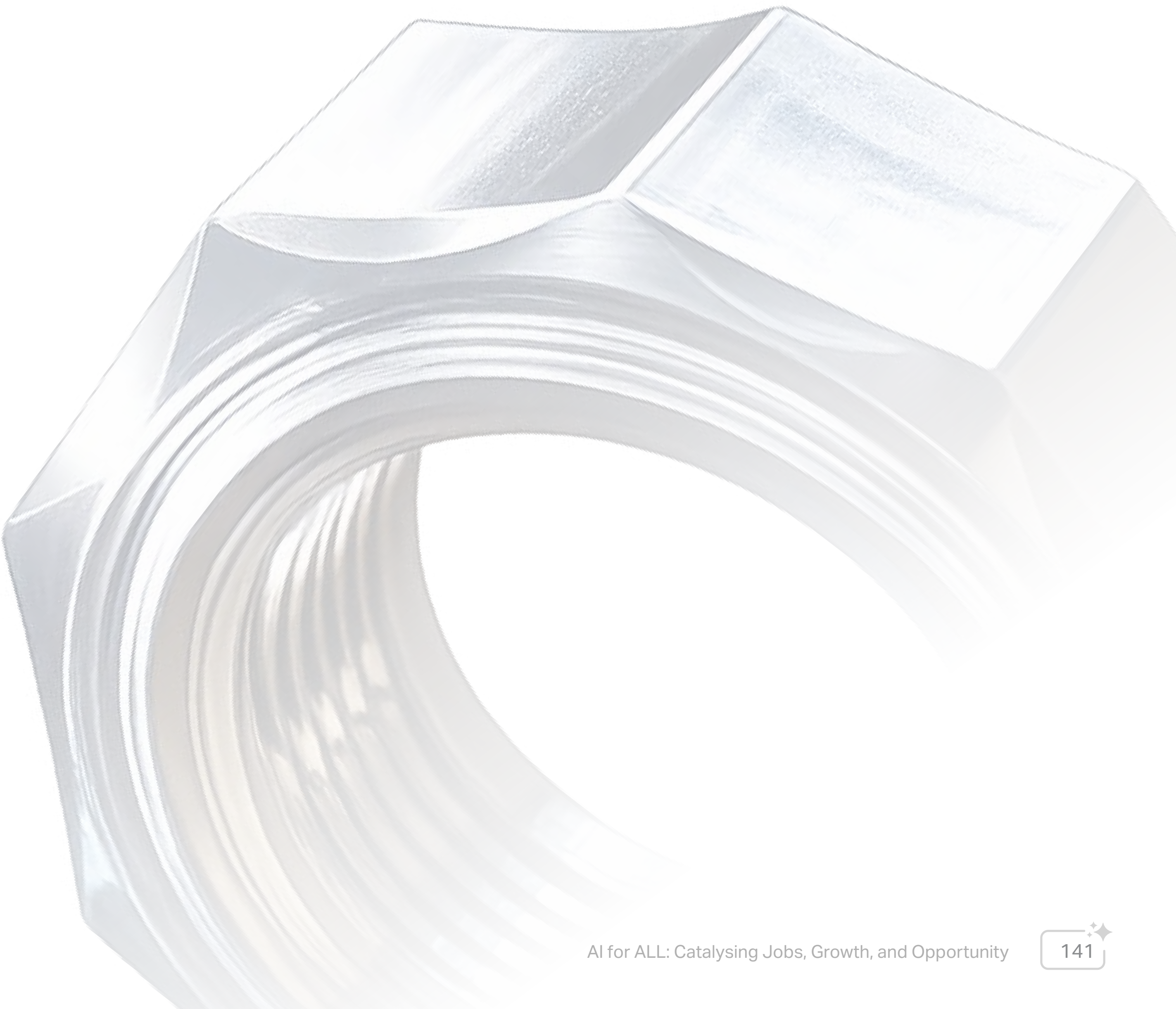
# Conclusion: From Pilots to Platforms

AI offers India a credible opportunity to leapfrog from fragmented, person-dependent manufacturing to scalable, competitive production systems but only if deployed as part of a coherent, system-level strategy. The priority is not maximum automation, but maximum reliability, trust, and integration across firms, clusters, and value chains.

This paper demonstrates that India's manufacturing constraints such as quality variability, weak traceability, skill gaps, trust deficits, and capital limitations are structural in nature. Incremental digitisation or isolated pilots will not be sufficient to overcome them. Instead, AI must be anchored in real operational KPIs, embedded into everyday workflows, and scaled through shared infrastructure rather than firm-by-firm experimentation.

By treating clusters as the unit of scale, building awareness and shared understanding through cluster institutions, aligning incentives across MSMEs, anchor corporates, startups, and government, and investing in shared infrastructure and Manufacturing AI Centres of Excellence, India can convert AI adoption from scattered pilots into durable platforms. Done well, this approach can unlock sustained productivity gains, deepen export integration, and create resilient manufacturing jobs at scale, positioning Indian manufacturing as a trusted and competitive participant in global value chains.



# Amrit Niti

## AI in Indian Financial Services

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# Executive Summary

Financial services are currently undergoing a major structural transformation. Over the last decade, India has built an exceptionally sophisticated digital financial system. The number of people with bank accounts has increased from 35% in 2011 to almost 90% in 2024. UPI enables almost 228 billion transactions each year. Fintech has acted as a force multiplier on this foundation. India is now the world's third-largest fintech ecosystem and is projected to reach $190 billion in revenues by 2030. More than half of new-to-credit customers are served by fintechs, and over 70% of fintech-led lending originates from Tier-2 cities and beyond. Across payments, credit, investments, and insurance, fintech innovation has pushed formal finance into segments long considered uneconomical.

Despite this progress, substantial headroom remains. India's MSME sector, comprising over 70 million enterprises that employ more than 110 million people, faces a credit gap of ~Rs. 30 lakh crore, concentrated largely among micro and small enterprises. On the retail side, secured lending, such as mortgages, remains significantly underpenetrated relative to peer economies, while a large share of individuals still lacks access to formal credit. Unsecured lending has expanded rapidly, but concerns about underwriting quality and default cycles underscore the need for better risk assessment rather than indiscriminate expansion.

Insurance penetration faces similar constraints. At 3.7% of GDP, roughly half the global average, India remains significantly underinsured. While public and private schemes now cover approximately 550 million individuals for health risks, nearly 700 million people still lack meaningful protection against health shocks, income loss, and lifecycle risks that can reverse years of economic progress.

The RBI's National Strategy for Financial Inclusion 2025-30 explicitly marks a shift from access to quality, from account ownership to active use of credit, insurance, and investment products. The foundational rails are now in place; the challenge is to deploy them intelligently.

Artificial intelligence is, therefore, the critical next lever. AI enables financial institutions to convert India's digital exhaust (payment data), consented financial records, and behavioural signals into better credit decisions, personalised products, fraud resilience, and scalable risk management. It enables small-ticket, high-volume segments to be served sustainably without resorting to exclusionary practices. A key shift is the emergence of agentic AI systems that can autonomously execute multi-step financial workflows within defined guardrails. In financial services, Agentic AI can now originate loans end-to-end, continuously monitor portfolios, trigger proactive interventions, and resolve routine service requests monitored with "human in the loop" systems.

As AI adoption deepens, it is expected to generate new roles spanning building, governing, and using of AI systems. Beyond core institutions, employment opportunities will also expand across fraud intelligence, data operations, vernacular AI services, and embedded finance infrastructure.

Realising this employment and innovation potential, however, requires moving beyond isolated pilots toward enterprise-wide AI strategies. Instead of using isolated pilots, enterprise-wide AI strategies are needed to recognise this shift. To manage vendor and geopolitical risks, institutions need to design modular, sovereign technology stacks, develop reusable horizontal capabilities, and incorporate responsible AI governance from the start. The adoption of common standards and the exchange of fraud intelligence must be made possible by industry bodies. To enable AI at scale, regulators can fortify domestic infrastructure and define data-sharing guidelines.

AI won't just increase the efficiency of financial services. It will redefine who can be served, at what cost, and with what precision. Those organisations that have integrated AI into their core operations and treat it as a strategic infrastructure component will have a sustainable competitive advantage over those that take an incremental approach to automating their processes. Digital Finance has begun its evolution into Intelligent Finance.

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# Financing India’s Growth Engine

India is entering a decisive phase in its economic trajectory. Over the coming years, the IMF expects India to account for around one-fifth of global incremental GDP growth. Financial services have been central to this transformation. In less than a decade, India has built one of the world's most advanced digital financial systems, achieving scale, speed, and inclusion.

At the core of this transformation lies India's Digital Public Infrastructure for finance. UPI has become the backbone of everyday commerce, processing 228 billion transactions worth ₹300 lakh crore in 2025 (NPCI), nearly half of global real-time payment volumes, while delivering close to 700 million daily transactions at success rates exceeding 99%. Built on the Jan Dhan-Aadhaar-Mobile trinity, financial account ownership has risen from 35% in 2011 to nearly 90% by 2024, (World Bank Global Findex 2025) with over 56 crore Jan Dhan accounts, the majority of which are held by women. Beyond payments and accounts, India has created globally distinctive data and market-enabling rails. The Account Aggregator framework, operational since 2021, enables secure, consent-based sharing of financial data, enabling credit decisioning beyond traditional collateral and documentation. OCEN is lowering the cost of small-ticket MSME lending, while ONDC is opening digital commerce to small merchants on equal terms. Together, these platforms combine scale with trust and innovation with accountability, a model increasingly referenced in global discussions on inclusive digital finance.

Fintech has acted as a force multiplier on this foundation. India is now the world's third-largest fintech ecosystem and is projected to reach $190 billion in revenues by 2030. More than half of new-to-credit customers are served by fintechs, and over 70% of fintech-led lending originates from Tier-2 cities and beyond. Across payments, credit, investments, and insurance, fintech innovation has pushed formal finance into segments long considered uneconomical.

Despite this progress, substantial headroom remains. India's MSME sector, over 70 million enterprises that employ more than 110 million people, faces a credit gap of ~Rs. 30 lakh crore (SIDBI), concentrated largely among micro and small enterprises. On the retail side, secured lending, such as mortgages, remains significantly underpenetrated relative to peer economies, while a large share of individuals still lacks access to formal credit. Unsecured lending has expanded rapidly but concerns about underwriting quality and default cycles underscore the need for better risk assessment rather than indiscriminate expansion.

Insurance penetration faces similar constraints. At 3.7% of GDP, roughly half the global average, India remains significantly underinsured (IRDAI, FY24). While public and private schemes now cover approximately 550 million individuals for health risks, nearly 700 million people still lack meaningful protection against health shocks, income loss, and lifecycle risks that can reverse years of economic progress (IRDAI; World Bank).

Policy thinking is beginning to align with this transition. The RBI's National Strategy for Financial Inclusion 2025–30 explicitly marks a shift from access to quality, from account ownership to active use of credit, insurance, and investment products. The foundational rails are now in place; the challenge is to deploy them intelligently.

Artificial intelligence is therefore the critical next lever. AI enables financial institutions to convert India's digital exhaust (payment

**Source:** World Bank, India Development Update; IMF growth contribution estimates; Boston Consulting Group (2025), India's UPI: The Global Benchmark for Digital Payments; International Monetary Fund, Fast Payments and Financial Inclusion; World Bank, Global Findex Database (2011–2024); BCG, GFF – Convergence, Human + AI For the Next Era of Finance data), consented financial records, and behavioural signals into better credit decisions, personalised products, fraud resilience, and scalable risk management. It enables small-ticket, high-volume segments to be served sustainably without resorting to exclusionary practices. A key shift is the emergence of agentic AI systems that can autonomously execute multi-step financial workflows within defined guardrails. In financial services, agentic AI can originate loans end-to-end, monitor portfolios continuously, trigger proactive interventions, and resolve routine service requests – all with “human in the loop”.

India is uniquely positioned to lead this shift. With over 17 million developers, one of the world’s largest AI talent pools, and a growing network of AI hubs beyond metropolitan centres, the country is emerging as a global AI innovation hub. Hundreds of Global Capability Centres now have explicit AI mandates.

The question facing India’s financial sector is how AI can be systematically embedded to deepen credit access, expand insurance coverage, improve risk outcomes, and ensure that the next phase of financial growth is faster, fairer, and more resilient. The sections that follow examine how banks, insurers, fintechs, and regulators are already using AI across the financial value chain and what ecosystem-level shifts are needed to unlock its full potential at scale.


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# Opportunities for Progress

AI offers opportunities to expand inclusion across the following areas:

## Large headroom in credit penetration across Retail and SME

- A large share of individuals and MSMEs remain outside formal credit, despite near-universal account ownership and strong demand for small-ticket loans.
- Credit exclusion is driven less by risk and more by economics: Customer acquisition, verification, underwriting, and collections costs are largely fixed, irrespective of loan size. Low-ticket loans are often commercially unviable under traditional operating models.

## Increasing costs and stagnant productivity in financial services

- Over the past decade, operating expenses in banking grew at a 12.1% CAGR , outpacing operating income at 11.2% (BCG FIBAC 2024), leading to a persistent rise in cost-to-income ratios.
- IT costs grew at a 16.8% CAGR, (BCG FIBAC 2024), significantly faster than overall operating income, with 55-65% of IT spend devoted to "run-the-bank" and regulatory requirements rather than productivity-enhancing transformation.
- Employee productivity (operating income per employee relative to cost) has remained largely flat over the last decade.

## Cyclical Stress in credit portfolio

- Rapid growth in personal loans and credit cards was followed by rising delinquencies, prompting the RBI to increase risk weights.

## Structural Stress on Deposits

- Credit growth has outpaced deposit mobilisation, pushing the credit–deposit ratio to a multi-year high.
- Household savings are increasingly financialised, shifting from deposits to mutual funds, insurance, and market-linked products.
- Banks face growing pressure to retain low-cost deposits amid competition with alternative savings instruments.

## Significant Headroom in Insurance Penetration

- Insurance penetration remains low at 3.7% of GDP (IRDAI, FY24), well below global averages.
- While public schemes have expanded coverage, over 400 million people remain underinsured.
- Key barriers include product complexity, limited transparency, limited vernacular support, and high distribution costs in Tier 2 and below markets.

## Access to investment solutions for the masses

- Despite rapid growth, less than 10% of Indian households invest in mutual funds or market-linked products, with participation heavily skewed towards urban and higher-income segments.
- Advisory and distribution do not scale for small investors: India has fewer than 1 investment adviser per 10,000 potential investors, making traditional, human-led advisory uneconomical for small-ticket investors outside the metros.

## Rising Scale and Sophistication of Fraud

- Fraud is increasingly contextual and network-based: RBI and NPCI note that modern fraud often involves mule networks, compromised devices, and coordinated activity spanning multiple banks and channels, rather than isolated bad actors.
- AI can be leveraged by fraudsters with increased sophistication.

## Climate Risk in Lending Portfolios

- A significant share of India's lending exposure is concentrated in districts vulnerable to climate-related risks, including floods, droughts, and heat stresss.

## Rising need for cybersecurity in a Digitised Financial System

- India's rapid digitisation of payments, lending, and service delivery has significantly expanded the cyber-attack surface across banks, NBFCs, insurers, and intermediaries. High-frequency, real-time systems are increasingly targeted by phishing, account takeovers, ransomware, and coordinated cyber-attacks.

## Need for Stronger Operational Resilience in Critical Financial Services

- Payments, credit access, and benefit delivery now operate at volumes where operational disruptions can have economy-wide consequences.
- In FY24, Core Banking Systems across banks suffered 50 instances of unplanned downtime and 130 to 150 instances of Mobile Banking, according to RBI.

# AI's Potential in Financial Services

**Artificial intelligence marks the next structural shift in financial services. Institutions that combine AI with human judgment are already seeing material gains.**

## Areas of impact

| Value Chain | Impact |
|---|---|
| **Call center Reimagination (TC copilots & voice bots)** | ✦ 30-40% cost savings through AI voice bots<br>✦ 10-15%+ increase in agent productivity<br>✦ 50-60% self-service customer support |
| **Front-line sales/RM co-pilots** | ✦ Insurance: 15-20% increase in agent productivity<br>✦ Wealth: 5-10% AuM growth, 2-3x higher conversion, 8-10x faster customer responses |
| **Credit & Operations Transformation** | ✦ 25-30% productivity gains for underwriters & 40-50% productivity gains for operation roles<br>✦ 2-5x faster turnaround improvements<br>✦ 50% accuracy improvement |
| **Marketing & hyper-personalisation** | ✦ 60-70% cost reduction/campaign |
| **Engineering productivity via coding co-pilots** | ✦ 10-40% engineering productivity improvement |

**Source:** BCG project experience globally & publicly reported numbers

# Improved Productivity across the value chain

AI and Agentic AI systems are reshaping how frontline, middle-office and back-office teams operate by automating routine tasks, augmenting judgment, and enabling organisations to handle higher volumes and greater complexity without a proportional increase in headcount. Select examples include:

- Relationship Manager (RM) copilots driving next-best actions and product recommendations.
- AI is significantly increasing the productivity of call centre operations, boosting agent efficiency by up to 30–40% through automating routine tasks, providing real-time assistance, and routing common enquiries to AI channels.
- AI agents are reducing manual follow-ups in mortgage and retail lending by 80-90% (BCG global experience), significantly improving RM productivity and conversion rates.
- Credit Approval Memo (CAM) automation addresses a key bottleneck in SME and corporate lending. Multiple lenders are using AI agents to automate the ingestion and analysis of bank statements, GST data, Account Aggregator feeds, alternate data sets, and financial documents, generating draft CAMs for review. This reduces turnaround time from days to hours, allowing credit officers to focus on judgment and exception handling.

## AI Agents powering the mortage journey

Mortgage Process

*Illustrative*

Mortgage application → Conditional approval → **Mortgage Decision Preparation** (Property valuation; Identity verification; Income & asset verification; Credit & background checks; Legal assessment; Technical assessment) → Mortgage decision → Client acceptance → Fulfillment & funding

**GenAI use case:**
- Automated check of submitted applications for missing or invalid documents
- Automated follow-ups with clients/brokers to collect missing data or documents
- Automated client engagement: initiations, reminders, guidance, and status updates
- Automated verbal and digital consent collection

**GenAI use case:**
- Automated doc identification, interpretation, and verification (income statements, tax docs, etc.)
- Automated data extraction and mortgage decision preparation
- Automated legal assessment via knowledge base/SOPs
- Document validation via OCR/validation APIs
- Customer and property assessment via CIBIL/Credit APIs

**GenAI use case:**
- Automated payouts andcollateral management triggered by GenAI

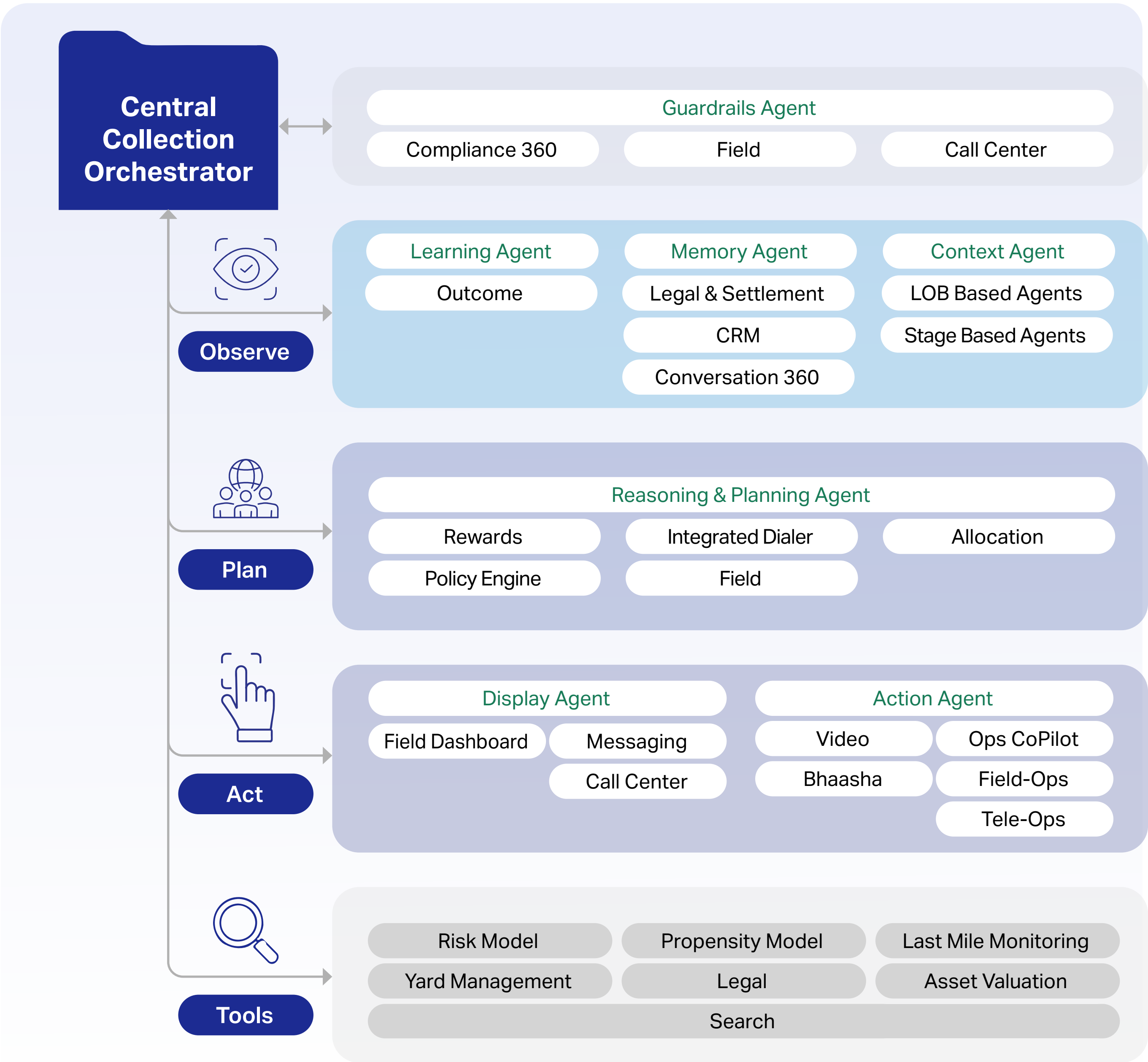
AI Agents: Relationship Agent; Document Collection Agent; Credit Assessment Agent; Legal Relationship Agent; Document Verification Agent; Fulfillment Agent

| Impact | 1/3 less documents to be submitted | 3-4x faster time to Yes from 1 week to 2 days | STP rate from 20% to 70% |
|---|---|---|---|

# Leveraging alternate data and AI collection agents to enable Low-Ticket financial services

- **Underwriting using alternate data** expands coverage to New-to-Credit (NTC) / underserved customers who lack formal documentation. AI models increasingly integrate:
  - UPI transaction flows to infer cash-flow stability.
  - Telco data to assess payment regularity and device continuity.
  - Satellite and remote-sensing data to evaluate land use and crop health.
- Smart, digital collections address one of the largest cost drivers in unsecured and small-ticket lending. AI-driven voice bots and digital nudges engage borrowers in local languages and escalate selectively to human agents. Platforms such as Spocto (Yubi Group) combine behavioural analytics with digital collections to reduce delinquencies and lower the cost-to-collect, supporting sustainable growth in unsecured portfolios (See below exhibit).

## Illustrative architecture of an Agentic Collections Orchestration system



## Hyper-Personalised Insurance Using AI and Alternate Data

AI enables offering unique insurance solutions to customers, with sharper risk pricing and simplified policy explanations.

- **Personalised underwriting** can leverage lifestyle data from wearables and apps to enable dynamic, behaviour-linked pricing. Select insurers now offer discounts based on step counts and fitness activity, aligning incentives with healthier behaviour.
- **AI-driven vernacular assistants** simplify policy explanations, exclusions, and claims processes in local languages. This reduces mis-selling, builds trust, and lowers the cost of serving Tier-2 and Tier-3 markets.

## Fraud Detection & Prevention

As digital finance scales, fraud has increased in both frequency and sophistication. AI enables institutions to move from reactive controls to real-time, system-level risk management. Contextual fraud detection uses AI to evaluate transactions based on user behaviour, device integrity, and network patterns rather than static rules. This reduces false positives while identifying coordinated fraud rings operating across institutions.

A growing set of financial infrastructure providers form the backbone of these capabilities:

- **HyperVerge:** provides AI-driven identity verification and face authentication, reducing onboarding fraud and impersonation risk.
- **Perfios and Yubi:** enable data-driven underwriting and lender–borrower matching by integrating financial data, analytics, and decisioning workflows.

## Asset Monetisation

Technology now enables unlocking new forms of asset-backed credit, making previously illiquid assets viable for lending and investment.

- The combination of AI and tokenisation opens new pathways for asset monetisation.
- Land records can be digitally verified, risk-scored, and tokenised for collateral-backed lending.
- Jewellery, art, and other movable assets can be authenticated and fractionalised.

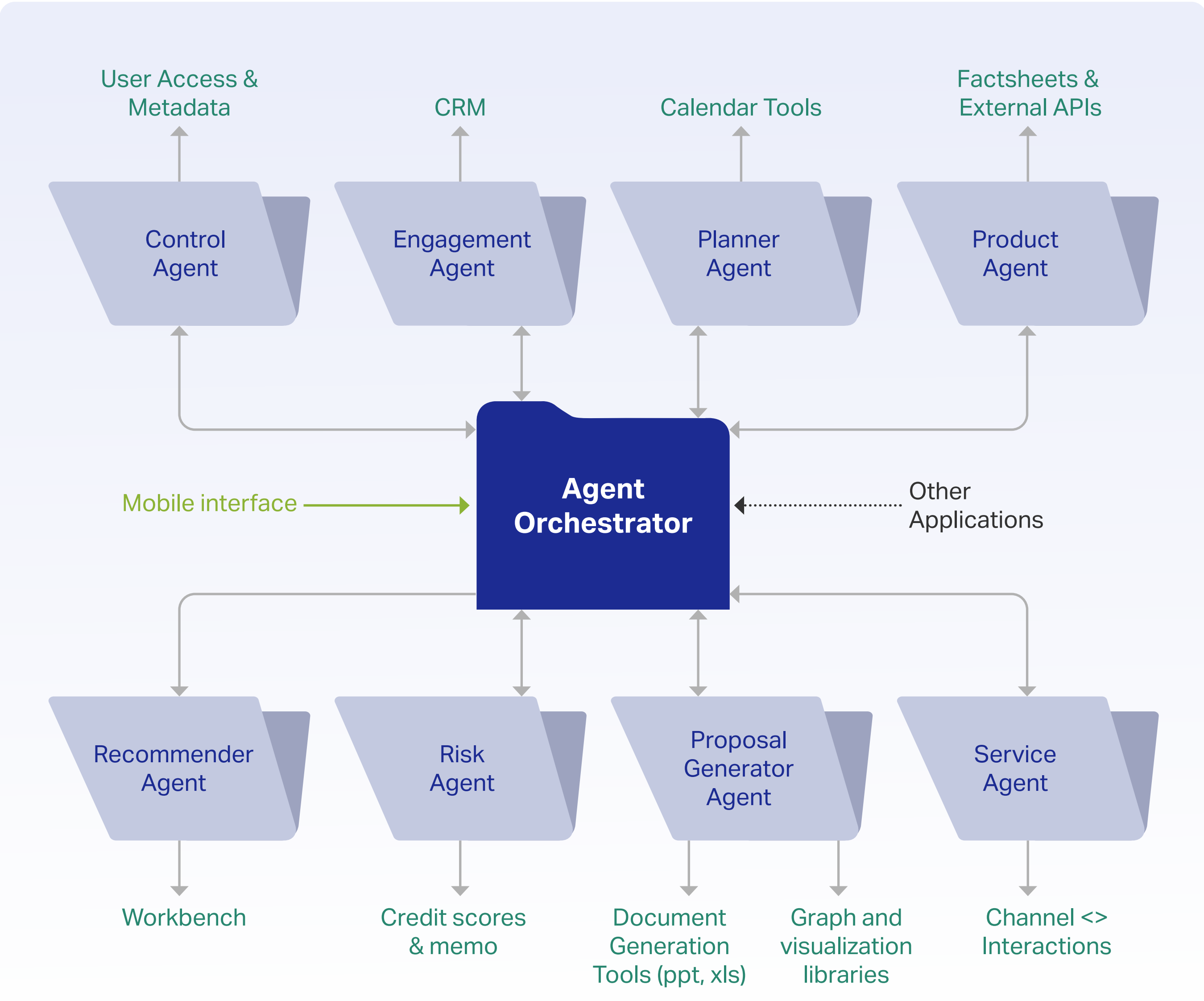
These approaches unlock credit against assets that are currently illiquid or underutilised.

## AI-Based Advisory for the masses

AI is transforming financial advisory from static, rule-based recommendations to continuous, personalised guidance tailored to individual goals and market conditions.

- Retail investment platforms use AI to analyse portfolios, risk appetite, income stability, and life goals, delivering recommendations that adapt as markets and customer circumstances evolve. This democratises access to high-quality advisory services that were previously limited to affluent customers.
- Deployments of AI based Wealth Relationship Agents in global contexts have yielded sustained productivity improvements. Wealth Managers have experienced a 5-6x increase in conversion, 2x faster generation of pitch books, and 3x more portfolio review bandwidth, leading to a 10-15% increase in Net New Assets in Wealth (BCG Experience).

## Agentic orchestration for wealth advisory services



# Employment Implication

**We expect the rise of 3 new categories of jobs in financial services – roles that build AI, roles that govern AI, and roles that use AI.**

# Roles that Build AI

AI systems in finance are only as effective as the data, models, and infrastructure that support them. This creates sustained demand for roles focused on building and maintaining AI capabilities.

## ✦ Data Creation and Operations

- Data operations and annotation professionals
  - Structure, clean, label, and validate data used in credit underwriting, fraud detection, claims processing, surveillance, and compliance.
- Field and frontline data capture roles
  - Capture MSME cashflows, transaction behaviour, documentation, voice interactions, images, and other unstructured inputs that feed AI-driven risk and pricing models.

## ✦ Model Development and Training

- Model training and tuning specialists
  - Build and Retrain models, monitor drift, stress-test performance, recalibrate thresholds, and improve accuracy across market cycles and customer segments.
- AI engineers and platform specialists
  - Build and maintain model pipelines, deployment infrastructure, monitoring systems, and integrations with core banking, insurance, and payments platforms.

# Roles that Govern AI

- Model risk management and validation professionals
  - Conduct independent validation, bias and fairness testing, explainability checks, documentation, and audit readiness for regulators.
- AI decision audit and explainability officers
  - Review automated decisions (credit, claims, pricing, surveillance), generate human-readable explanations, and ensure outcomes are contestable and defensible.
- AI compliance, incident management and policy professionals
  - Ensure adherence to financial regulations, consumer protection norms, data protection requirements, and internal governance frameworks.
  - Lead responses to model failures, hallucinations, false positives, systemic bias events, or regulatory breaches, including remediation and reporting.

# Roles that Use AI

Roles that apply AI in business processes, customer engagement, and ecosystem coordination.

# Unlocking AI's Potential in Financial Services

# Traditional BFSI

- Develop a cohesive, enterprise-wide AI strategy:
  - 36% of CXOs do not yet have a coherent AI strategy (BCG-GFF report 2025). Institutions need to move from fragmented experimentation to a unified roadmap (see Exhibit 10-point program) and focus on big rocks, not point-solution POCs.
  - Reimagine and reinvent the value chain end-to-end. Focus on capability-driven, scalable transformation across the value chain, where 70–80% of the value lies.
  - Look beyond efficiency to AI-enabled business model innovation. Pursue hyper-personalised products built from real-time client conversations and AI-driven signals to unlock entirely new sources of competitive advantage and revenue.
  - Build Horizontal, Reusable AI Capabilities.
  - Develop horizontal capabilities such as knowledge retrieval, content summarisation, multi-modal content generation, conversational interface, data analytics & visualization, &

**Reshape existing value chains**

Most companies attempt this ...

**Activity Level | Use case driven | Incremental**

Focus on off-the-shelf solutions; single use cases, e.g.,

- Meeting summary
- Code development
- Calendar management
- Knowledge database

**Table-stakes** | **20-30% of value**

**Reimagine value chains E2E**

... but near-term value is here...

**Value chain level | Capability driven | Scalable**

Select value chains and reshape them using chains of use cases, e.g.,

- KYC/Client onboarding/LOS journey
- Credit underwriting
- Customer service/contact center

**Competitive advantage** | **70-80% of value**

**Re-Invent new business models**

... while long term opportunities lie here

**Futuristic | Business-model driven | Radical**

Re-imagine business models and/or create new sources of competitive advantage/revenue, e.g.,

- Hyper-personalised products from real-time client conversations
- Real-time CIO signals based on client needsCustomer service/contact center

**True differentiation** | **New value streams unlocked**

## AI Enterprise Foundation Capabilities

### Governance

- 01 AI Strategy
- 01 Data Governance
- 01 Adoption of Technologies
- 01 Free[4] AI Readiness (RBI)

### Operating Model

- 06 Secure ML[3] & LLM[2] Ops
- 03 Product/Platforms Orientation
- 10 Partnership Ecosystem
- 02 Roles & Responsibilities
- 02 Process Reimagination

### Talent & Skills

- 04 C-suite Expertise in AI
- 04 Talent Sourcing & Skills Plan
- 04 AI Talent

### Culture & Change

- 01 Innovative Culture
- 01 Risk-informed Culture
- 01 Change Management

### Data & AI Platforms

- 07 Data Analytics
- 05 Data Management
- 06 AI Platforms
- 07 Model Quality & Performance
- 06 AI Tools

### Cybersecurity

- 06 3rd Party Risk Management
- 06 Data Security & Protection
- 06 Cybersecurity (inclusing AI)

### Risk+RAI[3] Practices & Tools

- 08 Responsible AI Governance
- 08 AI Compliance (RAI)
- 08 AI Model Guardrails

### AI Delivery Office

- 03 Rapid Ideation & Testing
- 09 Product Development Pipelines & Cycles
- 09 AI Implementation Guardrails
- 03 AI Portfolio
- 10 Partner/Vendor Selection

## Key Success Factors

- 01 Crafting an integrated strategy with AI
- 02 Re-imagining workflows with AI
- 03 Institute an agile organisational mindset
- 04 Invest in AI-powered talent
- 05 Unlocking your data
- 06 Enhancing your AI stack
- 07 Tailoring models for scalability & performance needs
- 08 Deplying AI responsibly
- 09 Ensuring executional certainly & monitoring
- 10 Enabling capability build with the right partners

● Algorithm ● Technology ● People, Organisation & Processes

software engineering co-pilot which can be deployed across value chains.

- Build AI Tech stacks that enable Modularity and Operational Sovereignty:
  - The AI technology stack is evolving faster than most procurement cycles. Foundational models are improving quarter on quarter, inference costs are falling sharply, and today's leading model may not be tomorrow's. In this environment, lock-ins are risky.
  - Architect modular, interoperable stacks. Decouple application logic from any single model provider to adopt better, cheaper capabilities as they emerge without rewriting systems.

- » Be selective: commodity solutions for safe and sovereign solutions are critical. For applications tied to competitive advantage, regulatory obligations, or operational continuity, treat inference sovereignty as strategic infrastructure; the cost of ownership is insurance against existential disruption.
- » Develop diversified technology stacks to mitigate geopolitical and vendor concentration risks. Avoid single-vendor or single-geography lock-in for critical AI infrastructure. Maintain optionality model ecosystems, cloud providers, and chip architectures ensuring the institution can pivot if trade restrictions, sanctions, or export controls disrupt access to any one stack.

✦ Deliver new products/solutions that cater to new customer segments via AI led Delivery Models

- » Double-down on financial inclusion use cases such as AI-driven underwriting using alternate data and robo-advisory for mass-market investors can expand addressable markets while improving inclusion.
- » Institutions that balance efficiency with growth-led AI use cases capture higher long-term value and create new employment opportunities.

✦ Strengthen Cybersecurity capabilities

- » Financial institutions may need to develop cybersecurity capabilities tailored to AI systems, covering model endpoints, training data pipelines, API integrations, and third-party AI services.
- » As AI becomes embedded in payments, credit decisioning, and fraud detection, vulnerabilities in these systems can enable new forms of financial crime or system manipulation at scale.

✦ Leverage AI to Enhance Operational Resilience and Risk Detection

- » Financial institutions should use AI to strengthen their own resilience by deploying predictive monitoring systems that detect anomalies, system degradation, or potential failures before they cascade into outages.
- » For core operations such as credit, payments, and compliance, deploy open-source models on owned infrastructure. The key question: can the organisation operate if external access is severed, even in a low-probability scenario?
- » Measure "Intensity of Downtime," not just uptime SLAs. When AI fails due to vendor restrictions, geopolitical actions, or attacks, how severe will the impact be? Build fallback mechanisms and switching capability for critical functions where a single outage could halt operations.
- » AI-powered tools can continuously analyze transaction patterns, system logs, and network traffic to identify early warning signs of operational stress, cyber threats, or infrastructure vulnerabilities in real time.
- » Automated incident response systems could accelerate recovery by diagnosing root causes, recommending remediation steps.

## Industry Bodies and Associations

Industry bodies' ability to convene, standardise, and aggregate makes them central to scaling AI responsibly across the financial ecosystem.

- Enable Shared AI Infrastructure
  - Facilitate the creation/adoption of centralised or federated repositories for fraud signals, mule account intelligence, and high-risk patterns that no single institution can build alone.
  - Support the development of shared, anonymised training datasets for common AI use cases such as fraud detection, credit risk, and AML, with appropriate privacy safeguards.
- Develop Common AI Standards
  - Lead the development of practical, implementable standards for AI model documentation, validation, bias testing, explainability, and audit trails.
  - Align standards across banking, insurance, payments, and capital markets to reduce fragmentation and compliance burden.
  - Ensure standards are informed by real operational constraints and evolve with technology, rather than remaining static or overly prescriptive

## Fintechs and Technology Providers

- Treat Responsible AI as a Core Product Feature
  - Embed responsible AI capabilities such as bias testing, explainability, model documentation, and audit trails into products by design rather than as add-ons.
- Design for India context: Vernacular and Accessibility
  - Build AI systems capable of operating across India's linguistic diversity.
  - Enable vernacular support across conversational interfaces, document processing, customer onboarding, and service interactions.

## Regulators and Policymakers

India's regulators have historically enabled innovation while safeguarding systemic stability. Unlocking AI at scale now requires a shift from building enabling infrastructure to accelerating adoption, clarifying data usage norms, and aligning governance across the financial system.

- Ensuring Self-Sufficiency in Financial Services
  - As AI embeds itself in critical functions, credit decisioning, payments, fraud detection, supervision, institutions may want to retain control, auditability, and operational continuity, especially given geopolitical and vendor concentration risks. India could invest in building or adapting domain-specific foundational models trained on domestic financial data and regulatory contexts.

- Leveraging India's "2-20" Data Centre opportunity
  - India generates roughly 20% of global data but hosts only 2% of global data-center capacity (BCG-GFF report 2025). This presents an opportunity to scale domestic infrastructure over the next decade.
  - Closing this gap represents a significant opportunity, scaling to an 8% share (~17 GW) of global DC capacity by 2030 with a longer-term pathway to capture a 20% share in line with India's data footprint.
- Unlocking proprietary data for AI Development through clear frameworks
  - Much of India's fintech innovation has historically emerged through bank-fintech partnerships, where solutions are co-developed and later adopted at scale by traditional BFSI institutions. For AI to succeed, data sharing must be clearly governed but explicitly enabled. Clear regulatory guidance on what forms of anonymised data sharing are permitted under defined safeguards would unlock collaboration without compromising privacy.
  - The DPDP Act establishes a unified privacy framework, but perceived ambiguity persists around whether anonymised, non-PII data can be shared with partners for AI model development. Explicitly clarifying "what is allowed" is critical to reducing institutional risk aversion and preventing data silos from limiting AI innovation.
- Centralised, Ecosystem-Level Fraud Intelligence
  - Fraud today operates at ecosystem scale, while detection remains institution-specific. In health insurance alone, Medi Assist-BCG report estimates annual fraud losses of up to Rs. 10,000 crores, driven by duplicate claims, inflated billing, and coordinated provider networks that individual insurers cannot detect in isolation.
  - Reserve Bank Innovation Hub (RBIH) and NPCI have both developed fraud detection platforms; success will depend on broad-based adoption and consistent data contribution by BFSI players.
  - Similar approaches are emerging in insurance, with proposals for centralised fraud data stacks under IRDAI, underscoring the need for cross-sector alignment in fraud intelligence.
- Unlocking Innovation
  - Risk-tiered sandboxes can replace one-size-fits-all experimentation models, allowing low-risk AI use cases to scale faster while applying stronger controls to higher-risk applications.

Given that many AI systems are probabilistic rather than deterministic, outcome-based oversight focusing on thresholds for bias, error rates, and false positives may be more effective than prescriptive process rules.

# AI Roles of the Future

AI Diagnostic Imaging Technician

Health AI TrustMark Assessor

NCD Digital Care Manager

AI-Powered Claims Analyst

Soil-Climate-Yield Data Scout

Model Risk & Validation Officer

Head of Manufacturing AI Clusters & Centres of Excellence

Assisted Telemedicine Facilitator

Telehealth Hub Coordinator

Clinical AI Scribe Operator

Financial Data Annotation & Ops Specialist

AI-Assisted TB Triage Operator

Smart Irrigation & Water Management Specialist

AI Accessibility Support Specialist

Chief Process Automation Officer

Precision Agriculture Drone Operator

AI Decision Auditor

Tokenisation & Digital Asset Specialist

Digital Pathology Coordinator

Crop Insurance AI Claims Processor

Population Health Intelligence Analyst

AI Credit Underwriting Analyst

Health Data Structuring Analyst

Director–Industrial Data Platforms & AI Enablement

Scholarship & Aid Discovery Bot Operator

Digital Well-being Counsellor

Variable Rate Application (VRT) Calibration Technician

Health DPI Integration Specialist

**Healthcare** **Agriculture** **Manufacturing**

AI-Enabled ASHA/ANM Support Specialist

Head of Predictive Operations & Asset Intelligence

AI-Enabled Farmgate Grading Technician

AI-Assisted Grading & Evaluation Specialist

Credit Approval Memo (CAM) Automation Specialist

Chief Digital Traceability & Compliance Officer

AI Diagnostic Assessment Specialist

Wealth AI Relationship Agent Operator

AI Livestock Health Monitor

Adaptive Learning Platform Coordinator

Agentic Mortgage Operator

Chief MSME Productivity & Competitiveness Officer

AI Ethics & Safety Officer (Health)

AI Crop Advisory Agent

FPO Digital Aggregation Coordinator

Local Language Content Curator

Chief Manufacturing Intelligence Officer

Teacher AI Coach

Robo-Advisory Platform Manager

Immersive Learning (XR) Lab Technician

Climate-Resilient Crop Planning Analyst

AgriStack Data Steward

Digital Mandi Intelligence Analyst

Insurance AI Underwriting Specialist

**Education** **Financial Services**

# Appendix: Acronyms and Abbreviations

## Healthcare

| | |
|---|---|
| **ABDM** | Ayushman Bharat Digital Mission |
| **ABHA** | Ayushman Bharat Health Account |
| **AIIMS** | All India Institute of Medical Sciences |
| **API** | Application Programming Interface |
| **ASHA** | Accredited Social Health Activist |
| **BIS** | Bureau of Indian Standards |
| **CDSS** | Clinical Decision Support System |
| **CHO** | Community Health Officer |
| **COPD** | Chronic Obstructive Pulmonary Disease |
| **CRP** | Cluster Resource Person |
| **CSC** | Common Service Centre |
| **DPDP Act** | Digital Personal Data Protection Act |
| **EHR** | Electronic Health Record |
| **FHIR** | Fast Healthcare Interoperability Resources |
| **HbA1c** | Glycated Hemoglobin |
| **HIMS** | Hospital Information Management System |
| **HMIS** | Health Management Information System |
| **ICMR** | Indian Council of Medical Research |
| **ICU** | Intensive Care Unit |
| **MLHP** | Mid-Level Health Provider |
| **MoHFW** | Ministry of Health and Family Welfare |
| **NABH** | National Accreditation Board for Hospitals & Healthcare Providers |
| **NABL** | National Accreditation Board for Testing and Calibration Laboratories |
| **NCD** | Non-Communicable Disease |
| **NHA** | National Health Authority |
| **NHM** | National Health Mission |
| **OCR** | Optical Character Recognition |
| **OOPE** | Out-of-Pocket Expenditure |
| **OPD** | Outpatient Department |
| **PHC** | Primary Health Centre |
| **PPP** | Public–Private Partnership |
| **SAM** | Severe Acute Malnutrition |
| **TB** | Tuberculosis |
| **XR** | Extended Reality |

# Appendix: Acronyms and Abbreviations

## Agriculture

| | |
|---|---|
| **AI** | Artificial Intelligence |
| **AgriStack** | Agriculture Digital Stack Initiative |
| **APMC** | Agricultural Produce Market Committee |
| **API** | Application Programming Interface |
| **AR** | Augmented Reality |
| **BHASHINI** | Bhasha Interface for India |
| **CHC** | Custom Hiring Centre |
| **$CO_2$** | Carbon Dioxide |
| **DPI** | Digital Public Infrastructure |
| **ERP** | Enterprise Resource Planning |
| **FPO** | Farmer Producer Organisation |
| **GHG** | Greenhouse Gas |
| **GNSS** | Global Navigation Satellite System |
| **ICAR** | Indian Council of Agricultural Research |
| **IoT** | Internet of Things |
| **KVK** | Krishi Vigyan Kendra |
| **LIBS** | Laser-Induced Breakdown Spectroscopy |
| **LLM** | Large Language Model |
| **MAARS** | Metamarket for Advanced Agricultural and Rural Services |
| **MoA&FW** | Ministry of Agriculture and Farmers' Welfare |
| **MSP** | Minimum Support Price |
| **NIR** | Near-Infrared |
| **OEM** | Original Equipment Manufacturer |
| **ONDC** | Open Network for Digital Commerce |
| **PoC** | Proof of Concept |
| **R&D** | Research and Development |
| **SIDBI** | Small Industries Development Bank of India |
| **SMAM** | Sub-Mission on Agricultural Mechanization |
| **SPV** | Special Purpose Vehicle |
| **VISTAAR** | Virtually Integrated System to Access Agricultural Resources |
| **VR** | Virtual Reality |
| **VRT** | Variable Rate Technology |

# Appendix: Acronyms and Abbreviations

## Education

| | |
|---|---|
| **AI** | Artificial Intelligence |
| **AICTE** | All India Council for Technical Education |
| **AR** | Augmented Reality |
| **ASER** | Annual Status of Education Report |
| **CBSE** | Central Board of Secondary Education |
| **CRP** | Cluster Resource Person |
| **CSC** | Common Service Centre |
| **DIET** | District Institute of Education and Training |
| **DIKSHA** | Digital Infrastructure for Knowledge Sharing |
| **DPAER** | Digital Public Assets for Education and Research |
| **DPI** | Digital Public Infrastructure |
| **ERP** | Enterprise Resource Planning |
| **ICT** | Information and Communication Technology |
| **LLM** | Large Language Model |
| **MoE** | Ministry of Education |
| **NCTE** | National Council for Teacher Education |
| **NDEAR** | National Digital Education Architecture |
| **NEP** | National Education Policy |
| **NETF** | National Educational Technology Forum |
| **NSDC** | National Skill Development Corporation |
| **NPST** | National Professional Standards for Teachers |
| **OCR** | Optical Character Recognition |
| **PAL** | Personalized Adaptive Learning |
| **QCBS** | Quality and Cost Based Selection |
| **SCERT** | State Council of Educational Research and Training |
| **TaRL** | Teaching at the Right Level |
| **UDISE+** | Unified District Information System for Education Plus |
| **UGC** | University Grants Commission |
| **VSK** | Vidya Samiksha Kendra |
| **XR** | Extended Reality |

# Appendix: Acronyms and Abbreviations

## Manufacturing

| | |
|---|---|
| **AI** | Artificial Intelligence |
| **AR** | Augmented Reality |
| **BCG** | Boston Consulting Group |
| **CHA** | Customs House Agent |
| **CNC** | Computer Numerical Control |
| **$CO_2$** | Carbon Dioxide |
| **DPIIT** | Department for Promotion of Industry and Internal Trade |
| **ERP** | Enterprise Resource Planning |
| **GenAI** | Generative Artificial Intelligence |
| **GHG** | Greenhouse Gas |
| **GII** | Global Innovation Index |
| **GNSS** | Global Navigation Satellite System |
| **IoT** | Internet of Things |
| **ITI** | Industrial Training Institute |
| **KPI** | Key Performance Indicator |
| **LLM** | Large Language Model |
| **MSME** | Micro, Small and Medium Enterprise |
| **MT** | Million Tonnes |
| **NSDC** | National Skill Development Corporation |
| **OEE** | Overall Equipment Effectiveness |
| **OEM** | Original Equipment Manufacturer |
| **PCB** | Printed Circuit Board |
| **PLI** | Production Linked Incentive |
| **R&D** | Research and Development |
| **ROI** | Return on Investment |
| **SIDBI** | Small Industries Development Bank of India |
| **SLM** | Small Language Model |
| **SME** | Small and Medium Enterprise |
| **SOP** | Standard Operating Procedure |
| **SPV** | Special Purpose Vehicle |
| **VR** | Virtual Reality |
| **ZED** | Zero Defect Zero Effect |

# Appendix: Acronyms and Abbreviations

## Financial Services

| | |
|---|---|
| **ABDM** | Ayushman Bharat Digital Mission |
| **AI** | Artificial Intelligence |
| **AML** | Anti-Money Laundering |
| **API** | Application Programming Interface |
| **BFSI** | Banking, Financial Services and Insurance |
| **CAM** | Credit Approval Memo |
| **CAGR** | Compound Annual Growth Rate |
| **CXO** | Chief Executive Officer (C-suite Executive) |
| **DPDP Act** | Digital Personal Data Protection Act |
| **ERP** | Enterprise Resource Planning |
| **FIBAC** | Financial Institutions Business & Analytics Conference |
| **FY** | Financial Year |
| **GDP** | Gross Domestic Product |
| **GenAI** | Generative Artificial Intelligence |
| **GFF** | Global Fintech Fest |
| **GST** | Goods and Services Tax |
| **IMF** | International Monetary Fund |
| **IRDAI** | Insurance Regulatory and Development Authority of India |
| **IT** | Information Technology |
| **KPI** | Key Performance Indicator |
| **LLM** | Large Language Model |
| **ML** | Machine Learning |
| **MSME** | Micro, Small and Medium Enterprise |
| **NBFC** | Non-Banking Financial Company |
| **NPCI** | National Payments Corporation of India |
| **NSFI** | National Strategy for Financial Inclusion |
| **OCEN** | Open Credit Enablement Network |
| **ONDC** | Open Network for Digital Commerce |
| **OTP** | One-Time Password |
| **PII** | Personally Identifiable Information |

# Appendix: Acronyms and Abbreviations

## Financial Services

| | |
|---|---|
| **PLI** | Production Linked Incentive |
| **PM-JAY** | Pradhan Mantri Jan Arogya Yojana |
| **PoC** | Proof of Concept |
| **QCBS** | Quality and Cost Based Selection |
| **RBI** | Reserve Bank of India |
| **RBIH** | Reserve Bank Innovation Hub |
| **RM** | Relationship Manager |
| **ROI** | Return on Investment |
| **SIDBI** | Small Industries Development Bank of India |
| **SLA** | Service Level Agreement |
| **SPV** | Special Purpose Vehicle |
| **UPI** | Unified Payments Interface |
| **ZED** | Zero Defect Zero Effect |

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