Bridging the farm-tech divide: Lessons from AgTech diffusion in India

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सत्यमेव जयते

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MESSAGE

It gives me immense pleasure to know that the Federation of Indian Chambers of Commerce and Industry (FICCI) and PwC are publishing this timely knowledge report on the theme of AgTech diffusion among smallholder farmers in India.

Achieving the vision of a Viksit Bharat requires a modern and resilient agricultural sector, where technology plays a pivotal role. In this context, India's AgTech startup ecosystem, having established a strong foundation over the last decade, is now deepening its impact. These startups are providing customized and sustainable solutions to make the agriculture value chain more profitable and remunerative.

Over the last decade, the Government of India (GoI) has introduced various key policy interventions to nurture and strengthen this ecosystem. The true success, however, lies in the effective diffusion of these innovations to our smallholder farmers. The growth and sustainability of Agri startups have a direct bearing on their socioeconomic conditions through employment generation and bringing farm prosperity. It is therefore an opportune time to focus on building last-mile delivery mechanisms and innovative business models that make these technologies accessible and affordable.

I congratulate the FICCI team for taking a step to facilitate the deserving and innovative agri startups in the country. As proposed in the report, agri startups must look-out for market-ready solutions with a full-proof scalability plan, specifically designed for smallholder adoption, while garnering support from ecosystem players and building requisite partnerships.

I feel this report is a very timely and ready reckoner for taking informative decisions to enable the diffusion of AgTech among our smallholder farmers. I am sure this report and its frameworks for driving farmer adoption will prove to be useful for all stakeholders connected with the agriculture sector.

(Bhagirath Choudhary)

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Foreword

India's agriculture sector remains the backbone of the country's economy, even as it faces rising uncertainties related to climate change, soil degradation, high input costs, and price volatility. With traditional practices yielding limited gains, strategic modernisation has become an imperative. Over the past decade, AgTech startups have emerged as key drivers of innovation across the value chain offering hyperlocal advisory, scale-neutral machinery, sustainable inputs, market linkages, affordable storage, IOT and traceability tools, and inclusive BFSI services helping farmers enhance productivity and income.

However, scaling these innovations sustainably requires a holistic approach. Enabling farmers and farmer producer organisations (FPOs), village level entrepreneurs (VLEs), and digitised retailers is central to accelerating AgTech's adoption. Peer influence plays a critical role in technology adoption among smallholder farmers, with first-time adopters often motivated by observing successful outcomes within their community. Initiatives such as Rythu Bharosa Kendras, Maha FPO, AgriMitra, and Mahila Krishi Doots can further support this model.

Despite the vast potential, a serious farm-tech divide persists, with AgTech reaching less than 15% of India's 146 million farmers.[1] Moving from fragmented, top-down pilots to a market-led full-stack approach is essential to unlock the full potential of AgTech. This paper, **Bridging the farm–tech divide: Lessons from AgTech's diffusion in India** analyses differentiated adoption patterns of AgTech and highlights how phygital models which leverage FPOs, VLEs, and digitally-enabled retailers serve as effective last-mile anchors. The recommendations presented in the paper could provide a blueprint for accelerating AgTech's adoption at scale.

The government is working towards strengthening the role of AgTech in the country's agriculture sector with digital public infrastructures (DPIs) such as India Stack and AgriStack, the AgriSURE Fund, production liked incentives (PLIs) for food processing, and credit guarantees for FPOs and MSMEs. Regulatory sandboxes, shift to performance-based incentives, scaling up blended finance, API-first governance, clear farmer data rights, and revamping Krishi Vigyan Kendras (KVKs) and farmer institutions are the next strategic imperatives for AgTech's growth. By working together, the sector can build an ecosystem where technology is accessible, affordable, and trustworthy, and could play an essential role in realising the sector's growth to $3 trillion and beyond by 2047.[2]

FICCI remains committed to fostering collaboration and developing the ecosystem which can accelerate the transformation of India's agriculture sector. I'm confident that this report will serve as a key reference for policymakers, industry leaders, investors, academia, and startups in driving a more productive, competitive, and future-ready agriculture sector that empowers the farming community.



Jyoti Vij
Director General, FICCI

1 Economic Times, India needs unified agri-tech ecosystem to reach 86% of farmers left behind, 2025
2 Financial Express, "Structural gains may take India's agriculture to $1.4 trillion by 2035," 2024.

Message from FICCI

India's agriculture sector is evolving rapidly. Over the past decade, the sector has seen an unprecedented surge of innovation across the farm-to-market value chain, driven by expanding digital public infrastructure, improving rural connectivity, and a new generation of farmers increasingly open to technology-led solutions—and with the potential to host as many as 10,000 AgTech startups by 2030,[3] expanding digital public infrastructure, growing rural connectivity, and a new generation of farmers that are increasingly open to adopting technology-led solutions. Yet, the transformative potential of AgTech remains constrained by the farm–tech divide—a gap between the creation of technologies and their widespread adoption on the ground. Despite a vibrant innovation ecosystem, only a fraction of India's 150 million farmers[4] experience the benefits of these solutions.

This paper, **Bridging the farm–tech divide: Lessons from AgTech diffusion in India,** highlights the structural, behavioural, and infrastructural barriers that have limited the scale and speed of AgTech's adoption. It also charts a clear, actionable, future-ready roadmap to bridge this divide through a combination of establishing institutions, developing inclusive policies, harnessing capital, and adopting hybrid phygital models that strengthen trust and enable last mile connectivity.

As Chair of FICCI's Task Force on Agri Startups, I have had the privilege of working closely with entrepreneurs, investors, researchers, policymakers, farmer producer organisation (FPO) leaders, and on-ground practitioners. Across these engagements, one insight has consistently emerged: technology succeeds only when it becomes accessible, affordable, and trusted by smallholder farmers.

To unlock the next wave of growth in Indian agriculture, the sector must reimagine AgTech's diffusion—not as an afterthought but as the core strategy. This requires a new generation of rural service entrepreneurs, digitally empowered FPOs, interoperable public digital infrastructure, and a policy framework that rewards technology-led productivity, sustainability, and resilience. Startups, corporates, government agencies, and financial institutions must work together to build a self-sustaining ecosystem where innovation flourishes, risks are mitigated, and farmer prosperity becomes the central outcome.

The recommendations presented in this report highlight a framework which is a set of interconnected strategic imperatives designed to systematically bridge the farm-tech divide and offer a compelling blueprint for accelerating AgTech adoption at scale. If implemented strategically, this framework has the potential to drive India's agricultural sector towards the vision of Viksit Bharat 2047 and develop an agriculture economy that is globally competitive, climate-smart, digitally empowered, and inclusive.

I congratulate PwC India for their exceptional effort in developing this paper. I am confident that this paper will catalyse meaningful dialogue and inspire coordinated action across stakeholders. Together, let's leverage AgTech solutions to ensure that every farmer regardless of geography, land size, gender or income, can benefit from innovation.



Hemendra Mathur
Chair, FICCI Task Force on Agri Startups

3 India has potential to have 10,000 agri-tech start-ups by 2030: Bharat Innovation Fund
4 World Economic Forum, 2025. Future Farming in India: A playbook for scaling artificial intelligence in Agriculture

Message from PwC

India's agricultural sector is undergoing a significant transformation led by the convergence of agricultural sciences and emerging technologies. Over the last few years, there has been a remarkable surge of innovation in AgTech, which is projected to grow to a market size of $34 billion by 2027.[5] However, this technological progress also highlight a farm-tech divide where the challenge is not the availability of technology but its large-scale adoption by smallholder farmers.

This paper, Bridging the farm-tech divide: Lessons from AgTech diffusion in India, presents an overview of why, despite a vibrant ecosystem of over 3,000 AgTech ventures and strong investor interest, AgTech solutions still reach less than 15% of India's 146 million farmers.[6] The analysis points towards systemic inefficiencies like fragmented value chains and infrastructure deficits, leading to the indication that AgTech companies could pivot from models requiring high capital investment to those based on operating expenses, thereby accommodating the limited purchasing power, risk aversion, and adoption behaviours of smallholder farmers.

AgTech adoption has been successful in instances where better unit economics prevail, particularly in efficiency-focused markets, but struggles in resilience-focused markets of India, where structural challenges such as high monsoon dependence, extreme land fragmentation, and reliance on low-margin food grain production makes many AgTech solutions economically unviable.

In response to these structural barriers, startups that have adopted phygital models—an adept blend of scalable digital platforms with a strong on-ground presence—have managed to overcome foundational constraints such as low digital literacy, infrastructural gaps, and, most importantly, a deep trust deficit, thereby creating tangible impact. By leveraging local village-level entrepreneurs (VLEs), agri-retailers, and FPOs as last-mile partners, these models deliver tangible value to farmers through higher price realisation and significant input cost savings.

To effectively bridge the farm-tech divide and scale innovations nationally, the paper proposes a multi-stakeholder strategy that serves as a roadmap to pivot from isolated pilots to a self-reinforcing cycle of innovation, validation, and inclusive value creation, thereby unlocking the sector's innate potential. This strategy could redefine how decisions are made across different stakeholder groups. For instance, the role of policymakers could shift from being direct providers to becoming market orchestrators, creating pull factors for private-sector innovation through interventions such as digital agri vouchers (DAVs) to convert passive subsidies into a demand-driven marketplace, and establishing national hubs for AgTech validation and commercialisation. For AgTech organisations and agribusinesses, focus can be redirected from pilots to full-stack, farmer-centric models such as strategic enabler for technology uptake framework, and to standardising communications acting as the universal indicator of trust and ROI. For investors, it expands the thesis from backing technologies alone to backing the delivery architecture, farmer trust levels, and digital literacy improvements that determine real-world impact, as well as co-investing alongside public capital such as the AgriSURE fund. FPOs and local entrepreneurs are kept at the centre of the diffusion story by making them digital-native, bankable enterprises that anchor technology adoption and create reliable, efficient pathways to market for tech-enhanced production.

We are proud to collaborate with FICCI for developing this paper which serves as a roadmap for scaling AgTech's adoption and shaping the future of the agriculture sector of India. We hope that the paper will enable new conversations, partnerships, and forms of investment, so that the success of Indian AgTech can measured not only by the strength of its innovation pipeline but by the scale and depth of its impact on the farmers.



Shashi Kant Singh
Partner, Agri-Food-Agribusiness
PwC India

5 India Brand Equity Foundation, "Agritech landscape in India," blog post, accessed 11 December, 2025
6 Economic Times, India needs unified agri-tech ecosystem to reach 86% of farmers left behind, 2025



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Executive summary

The Indian agricultural sector, a cornerstone of the national economy valued at over **$600 billion**[1,2] and the primary source of livelihood for more than half its population, stands at a pivotal inflection point. The convergence of digital technologies and agricultural science referred to as AgTech could unlock a new wave of agricultural revolution, one defined not merely by yield, but by resilience, profitability, and sustainability. This burgeoning digital agriculture market is projected to surge to **$34 billion by 2027.**[3] However, this immense potential is impacted by the farm-tech divide—the gap between technologies developed within a dynamic ecosystem of over 3,000 startups and their actual adoption on the ground. The stark reality is that AgTech solutions currently reach **less than 15% of India's 146 million farmers,**[4] with overall market penetration lingering at a nascent **1%.**[5] This report provides a comprehensive understanding of this divide and presents a strategic, multistakeholder roadmap to bridge the gap.

Our research discusses the root causes of this divide, which stem from deep-seated systemic inefficiencies that AgTech is uniquely positioned to solve. These inefficiencies including **persistent productivity gaps** when compared to global benchmarks, **unsustainable resource** use that degrades soil health, **fragmented value chains** that prevent farmers from realising a fair share of market value, and **critical infrastructure deficits in post-harvest logistics and storage,** which results in immense value loss between farm and consumer. These compounding challenges create a cycle of value destruction and reinforce the profound risk aversion of India's farming community, overwhelmingly comprised of small and marginal landholders with precarious livelihoods. This economic reality dictates adoption behaviour, forcing a rational preference for low-cost, operational expenditure models over capital-intensive investments—a critical insight for designing viable AgTech solutions. Understanding how and where such viable solutions are succeeding is therefore key.

The level of AgTech adoption varies significantly across different regions of India. This paper identifies the emergence of distinct **efficiency-driven markets in agriculturally advanced regions, such as the irrigated northern plains and the commercial horticulture belts of the peninsula.** Here, more favourable unit economics—driven by larger farm sizes and high-value horticultural crops—create a fertile ground for technologies that enhance efficiency and price realisation. These markets are contrasted sharply with **vast resilience-focused markets characteristic of regions like the eastern Gangetic plains, and extending across India's central and north-eastern belts.** Here, a combination of structural challenges—including high dependency on monsoon rainfall, extreme land fragmentation, and a reliance on low-margin food grain production—renders many AgTech solutions economically unviable. It is within the efficiency-driven markets that a clear and dominant operational paradigm has emerged—**the phygital model.** The convergence of a user-friendly app with a network of on-ground personnel, demonstration farms, and last-mile logistics is the definitive strategic response to overcome the foundational barriers of low digital literacy, infrastructural gaps, and, most importantly, building the deep trust required for a smallholder farmer to invest in a new technology.

The success of this phygital model is quantifiable. Market linkage platforms adopting this approach are positioned to enhance farmers' price realiation through improved transparency and demand alignment, while tech-enabled input marketplaces create opportunities for cost optimisation across the supply chain. This model is operationalised through a diverse range of market actors, validating the indispensable role of farmer producer organisations (FPOs), digitally enabled agri-retailers, and village-level entrepreneurs (VLEs). These actors are catalysts for technology adoption, service delivery, and trust-building within their farmer communities. To transition these pockets of success into a nationwide

1 Press Information Bureau, 22 July 2024
2 Press Information Bureau, 31 January 2025.
3 India Brand Equity Foundation, "Agritech landscape in India," blog post, accessed 11 December, 2025
4 Economic Times, India needs unified agri-tech ecosystem to reach 86% of farmers left behind, 2025
5 IBEF, AgriTech Landscape in India, 2024

phenomenon, this report highlights **a framework** which is a set of interconnected strategic imperatives designed to systematically bridge the farm-tech divide.

The framework begins with **strategic ecosystem and enablers development (SEED)** which details the government's pivotal shift from a direct technology provider to a **market orchestrator and integrator.** The core strategy is to attract private innovation by fostering a vibrant market that demands and rewards new technology, rather than by building the technology ourselves. This can be achieved by deploying demand-driving **digital agri-vouchers (DAVs)** via the e-RUPI platform, a transformative move that converts subsidies into a demand-driven marketplace, empowering farmers with choice over quality-assured services. In parallel, existing agricultural research sites should be upgraded into **national hubs for AgTech validation and commercialisation.** These hubs could provide a trusted, standardised 'seal of quality' and economic impact assessment for AgTech solutions—a single source of truth that simultaneously builds essential farmer trust and gives financial institutions the verifiable data needed to shift from asset-based to performance-based lending.

Building on this foundation, the **collaborative and user-centric technology innovation (CULTIVATE)** pillar calls for industry and academia to build an **adoption-first innovation model.** To combat farmers' skepticism fueled by confusing ROI claims, they should co-create a standardised, open-source **farmer value framework** that establishes a universal standard for calculating and reporting impact, turning the adoption decision from a leap of faith into a confident, evidence-based business choice. To scale proven solutions, the framework proposes a catalytic platform, **strategic enabler for technology uptake framework,** which can act as a service aggregator and diffusion engine. By bundling solutions (tech, finance, inputs) and deploying catalytic cavpital like first loss guarantees, this platform can de-risk entire implementation models for all partners. This can crucially enable financial institutions to directly **link lower-cost credit and insurance to the adoption of national hub certified technologies,** creating a powerful market-based incentive that rewards farmers for de-risking their operations.

The framework culminates with the **hyper-scalable adoption and real-world value enhancement services (HARVEST)** pillar, which focuses on operationalising viable, data-driven business models up to the last mile. This requires large agribusinesses to evolve from transactional procurement to **strategic sourcing,** embedding technology adoption (e.g. IOT sensors, traceability) into their supply contracts to create a powerful commercial 'pull' for proven solutions. Concurrently, farmer producer organisations (FPOs) should evolve from subsidised collectives into **bankable business enterprises** by adopting a full suite of digital management tools. This creates the immutable, auditable track record necessary to solve the 'trust deficit' for formal lenders and positions FPOs as 'anchor clients for the AgTech ecosystem. Finally, the framework emphasises the importance of a phygital **network of village-level entrepreneurs** and training them as last-mile orchestrators who can guide farmers through the entire adoption journey, from building awareness and de-risking the purchase decision to ensuring successful implementation and connecting produce to better markets.

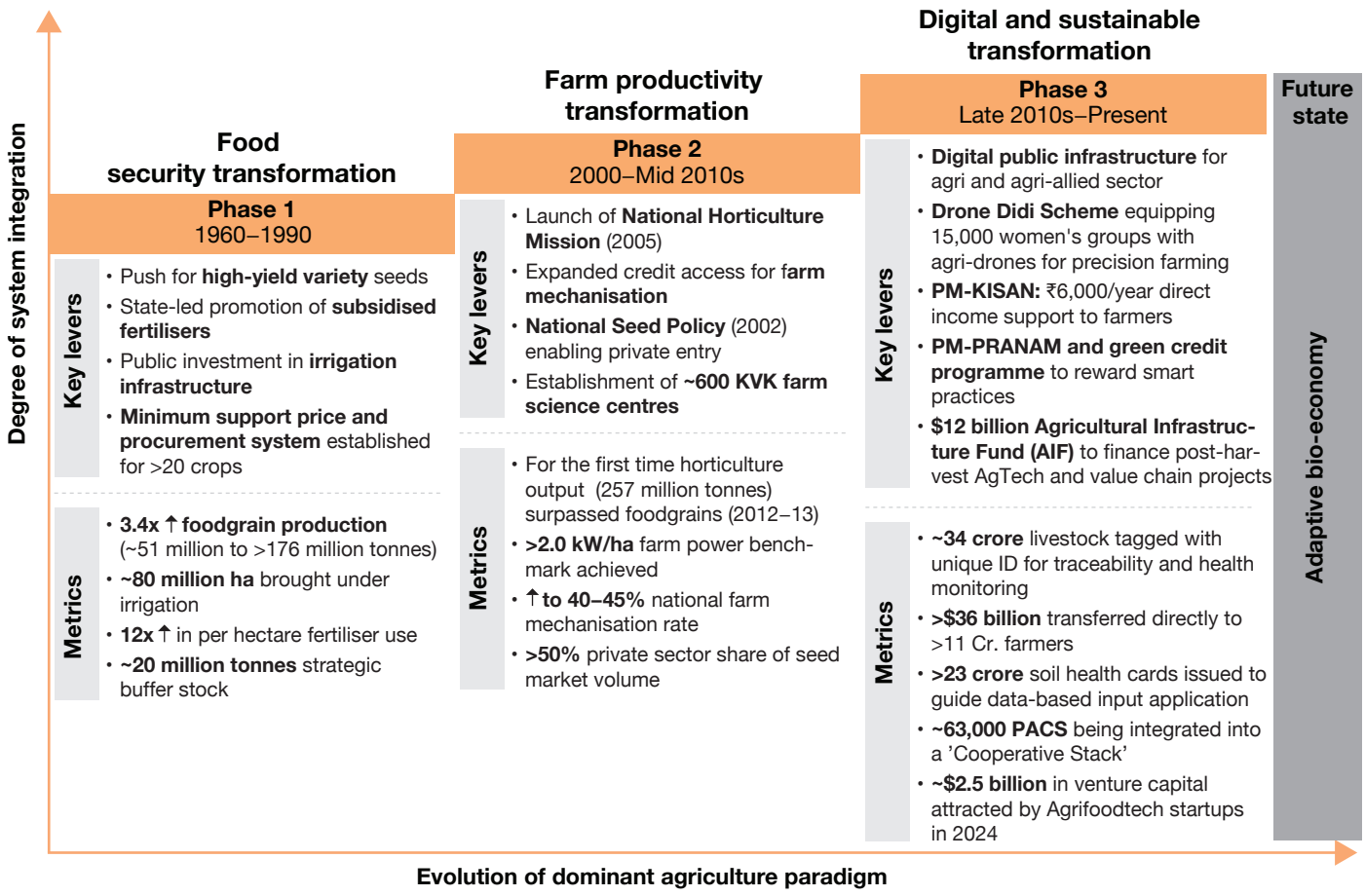
By implementing these interconnected strategies, India can create a self-reinforcing cycle of innovation, validation, and inclusive value creation. The proposed framework could be a blueprint for building resilience in the agri sector, food security, and shared prosperity while meeting the envisioned targets against key indicators for achieving Viksit Bharat 2047. The concerted action of all stakeholders today can unlock the sector's immense potential and reinforce India's position as a major force in the global AgTech landscape.

01
Introduction

1a. From food security to value creation

Indian agriculture is undergoing a major evolutionary journey, progressing from a singular focus on production during the Green Revolution to a more holistic, farm-centric approach that boosted mechanisation and diversification. Each phase was characterised by specific strategic drivers—from high-yielding seeds to mechanisation—addressing the predominant challenge of its era.

Figure 1: Evolution of agriculture in India (1960—Present)



Source: Reserve Bank of India, Handbook of Statistics on Indian Economy;
Union Budget 1998–99, Chapter 85 ;
NABARD Operating Circular 4/OC%204.pdf;
Subramanian, Anandi. "Crossing the Rubicon: Towards a Pareto Efficient Indian Agricultural Market";
Buragohain, Tarujyoti. "Bearing Fruit: India's Growing Horticulture Edge" – Financial Express, September 10, 2020;
Standing Committee on Agriculture, Animal Husbandry and Food Processing, 64th Report (2022–23);
The Indian Journal of Agricultural Sciences – ICAR peer-reviewed journal;
SeedNet India Portal: "Indian Seed Sector" – Overview of policy, production, and certification;
Press Information Bureau. "Namo Drone Didi: Empowering Women Self-Help Groups with Advanced Agricultural Technology";
Press Information Bureau, PRID 2191651;
Press Information Bureau, PRID 2101845;
Department of Animal Husbandry & Dairying. Annual Report 2024–25;
Press Information Bureau, PRID 1932398;
Press Information Bureau, PRID 1881468;
India's agrifoodtech startups raised $2.5 bn in 2024, 3X rise from 2023 | Industry News - Business Standard;

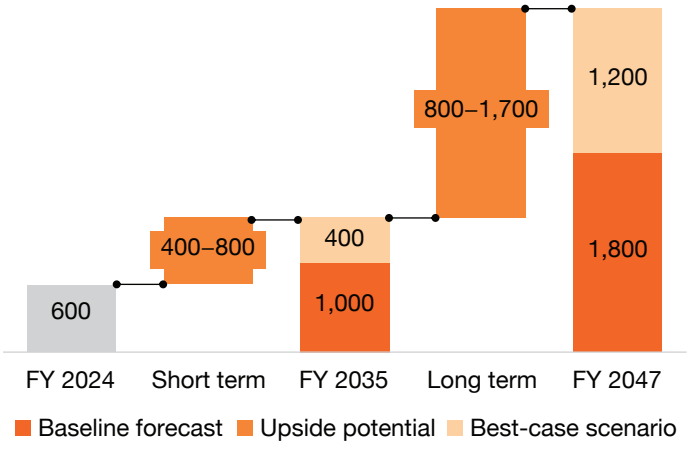
Today, India's agriculture sector's focus has shifted towards **digital and sustainable transformation.** As Figure 1 illustrates, the key levers of transformation are no longer just physical inputs but are increasingly digital, institutional, and transformational. A dynamic ecosystem of over 3,000 AgTech startups is now at the forefront of innovation,[6] underpinned by a revolution in rural connectivity where smartphone penetration has now surpassed 59%,[7] creating a massive addressable market for digital farm solutions. This has catalysed a burgeoning digital agriculture market, with the sector's gross merchandise value (GMV) projected to surge to **$34 billion by 2027,**[8] signalling a monumental opportunity for value creation. This **digital-first approach** is enabling new models for service delivery and market access at an unprecedented scale.

The Indian agriculture sector, the bedrock of the nation's economy and the primary source of livelihood for over 55% of the population,[9] stands at a pivotal strategic inflection point. Valued at **$600 billion,**[10,11] the sector is at a strategic juncture where a combination of external tailwinds and internal momentum driven by factors ranging from structural reforms to digital innovation has propelled it to become one of the world's powerhouses of agricultural economies. As supply chains become increasingly interconnected, India's position as a critical producer and exporter presents a transformative opportunity for agribusinesses to capture value and shape global markets.

Realising this potential is contingent to accelerating the sector's current growth trajectory. In the past six years, India's agricultural sector has grown an impressive **5% per annum**[12] due to structural reforms, government investments, and increased formalisation enabled by wider credit availability.

Analysis shows the potential to aim higher and set an aspiration for an additional one to two percentage points of growth. Achieving this requires unlocking greater momentum across key performance markers, including improving crop yields by an estimated 15–40% through better inputs and practices; expanding downstream processing for greater value-addition, such as leveraging feedstock for higher-value biochemicals; and significantly increasing agricultural exports in line with government targets. If leveraged to their full potential, these drivers could accelerate the sector's **growth to an estimated $1.4 trillion by 2035 and $3.1 trillion by 2047.**[13]

Figure 2: Projected growth for India's agricultural economy (in $ billion)



Source: Press Information Bureau, January 31, 2025; Financial Express: Structural gains may take India's agriculture to $1.4 trillion by 2035

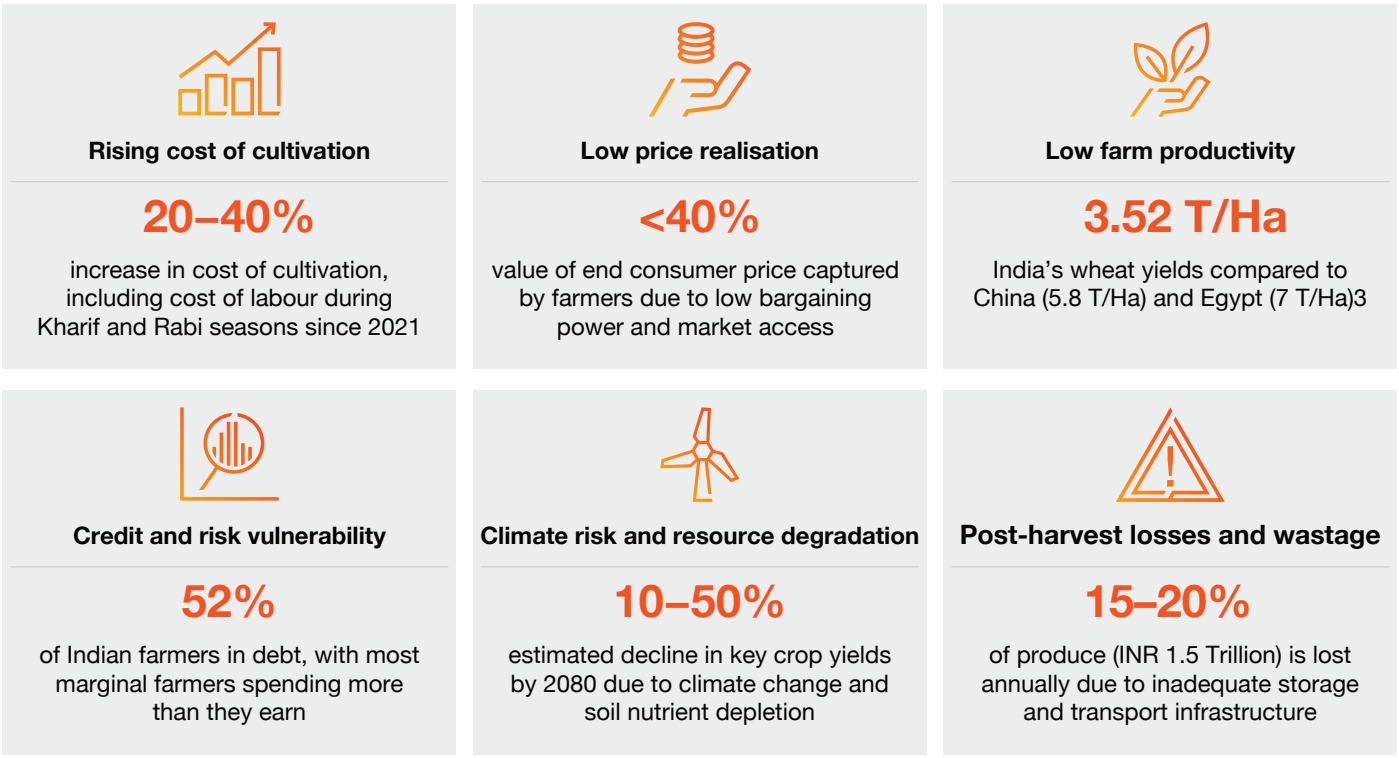
6 Emerging landscape of agri-startups in India, JAEM-National Institute of Agricultural Extension Management (MANAGE), 2025.
7 Economic Time Insight, Why rural India will lead the next smartphone revolution, 2025
8 India Brand Equity Foundation, "Agritech landscape in India," blog post, accessed 11 December, 2025
9 India Brand Equity Foundation, "Agriculture in India: Information About Indian Agriculture & Its Importance", August, 2025
10 Press Information Bureau, 22 July 2024
11 Press Information Bureau, 31 January 2025
12 Press Information Bureau, January 2025
13 Financial Express, "Structural gains may take India's agriculture to $1.4 trillion by 2035," 2024.

It is at the intersection of these growth levers that AgTech moves decisively from the periphery to the core of the sector as enables efficiency, sustainability, and profitability. Improving crop yields is directly addressed by precision agriculture and biotechnology platforms; expanding downstream processing relies on tech-enabled supply chains that ensure quality and traceability; and increasing exports is underpinned by digital systems that meet global standards.

However, the existence of these powerful tools does not guarantee their impact. The main challenge of the current phase of implementing AgTech is not just the creation of technology but its effective and equitable **distribution to smallholder farmers.** The urgency for this transition is underscored by a persistent productivity gap. For instance, India's average rice yields still lag **30–40% below the global average,** highlighting a significant opportunity for improvement through emerging, yet simple and scalable, yet affordable technology.[14]

This productivity gap, however, is a complex web of deep-rooted, structural challenges that confront Indian smallholder farmers regularly. From rising cultivation costs and poor price realisation to climate vulnerability and significant post-harvest losses, these interconnected barriers trap farmers in a cycle of low profitability and high risk, underscoring the critical need for targeted, scalable solutions.

Figure 3: Structural challenges in Indian agriculture



Source: Reimagining Agriculture: Roadmap for Frontier Technology-Led Transformation. New Delhi: NITI Aayog, 2024.

14 FAOSTAT database, FAO

How AgTech can provide targeted solutions and create significant impact across the entire value chain is illustrated in Table 1.

Table 1: Mapping key challenges to AgTech solutions across India's agricultural value chain

	Key levers	Key challenges in the Indian context	AgTech solutions and evolving impact scenarios
Pre-production	**Soil and input intelligence**	• **Over 53% of Indian soils are deficient** in essential micronutrients, directly limiting yield potential from the very beginning of the agricultural process.[15]	• **Significant reduction in fertiliser usage** is being achieved with sensor-based, variable-rate nutrient application, while maintaining yield.
		• **A skewed 7.7:3.1:1 N:P:K consumption ratio** (vs. an ideal 4:2:1) is degrading national soil health and causing nutrient runoff.[16]	• **A ~50% reduction in overall urea consumption** per application is possible through drone application of new-age liquid fertilisers like Nano Urea.[17]
		• Counterfeit and substandard seeds, fertilisers and pesticides are eroding farmer trust and investment returns.[18]	• **Savings on input costs** are being enabled by direct-to-farmer (D2F) platforms through bulk procurement and disintermediation.
Production	**Precision farm management**	• **Nearly 90% of freshwater withdrawal** is driven by agriculture, with inefficient flood irrigation keeping on-farm efficiency below 40%.[19]	• **A 30–50% improvement in water use efficiency** is being delivered by IoT-automated micro-irrigation systems, directly combating water scarcity.[20]
		• **Between 20–26% of annual yield is lost** to pests and diseases due to reactive and labour-intensive monitoring methods.[21]	• **Over 95% accuracy** in identifying pests and diseases is now achieved by AI-powered diagnostic tools, enabling timely and effective treatment.[22]
	Asset-light farming models	• **A ~45% overall mechanisation rate lags** global peers, as high ownership costs remain a key barrier for India's 85% smallholder farmers.[23]	• Pay-per-use farm-as-a-service (PaaS) models are emerging as a mechanism to optimise operational efficiency for smallholders, offering an alternative to traditional equipment rental or ownership structures.

15 Centre for Science and Environment, October 2025, Indian soils severely deficient in key nutrients
16 NITI Aayog & Fertiliser Statistics, 2024, Fertiliser Use and Imbalance in India
17 Economic Times, "Nano urea can enhance yields, save up to 50% nitrogen: Mansukh Mandaviya," 2021.
18 "Present status of usage of Nano urea and Nano DAP in agriculture sector," 2025.
19 World Bank AQUASTAT, 2021, Annual freshwater withdrawals, agriculture
20 IJISRT, Application of IoT in Boosting Irrigation Efficiency for Sustainable Agriculture
21 National Centre for Organic and Natural Farming
22 AgriTech Insights, 2025, India's AI Breakthrough: Rapid, Accurate Pest Detection
23 FICCI-PwC Report, 2024, Farm Mechanization: A Catalyst for Sustainable Agricultural Growth



	Key levers	Key challenges in the Indian context	AgTech solutions and evolving impact scenarios
Post-production	**Harvesting and storage**	• **Only ~36 MMT of cold storage capacity** exists against a requirement of over 70 MMT, creating a critical infrastructure gap for perishables.[24]	• **Over a 75% reduction in post-harvest losses** of perishables has been proven through the implementation of end-to-end cold chain solutions.[25]
	Market linkage and value realisation	• **Less than 10% of India's total food output is processed** (vs. >65% in developed economies), leading to high wastage and lost value.[26]	• Traceability systems for high-value crops, such as grapes and organic spices, are increasingly viewed as mechanisms that can strengthen market confidence and support differentiated pricing in export channels.
		• **Only 1/3rd of the final consumer price** on an average reaches to fruit and vegetable farmers due to perishability, post harvest losses, seasonality, andpresence of multiple intermediaries.[27]	• E-commerce platforms that connect farmers to broader buyer networks are increasingly positioned as catalysts for improved price realisation, leveraging direct market access and reduced intermediation.

Bridging the gap between this technological potential, as illustrated in the table, and on-ground practice is integral to achieve the wide-scale adoption of AgTech.

24 MoFPI, 2024, Rajya Sabha Unstarred Question No. 2954-Integrated Cold Chain Infrastructure
25 NCCD, 2025, Energy Transition in Cold Chain Infrastructure
26 RBI Bulletin, 2020
27 Indian Express, "Farmers get only a third of what consumer pays for vegetables, fruits: RBI study," 2024

02

Current state of AgTech adoption in India

2a. Evolution of Indian AgTech: From information to intelligence

The adoption of AgTech in India has transformed the agriculture sector from a traditional, analogue sector to a sophisticated, data-driven ecosystem.

Figure 4 provides an overview of the evolution of AgriTech in India and highlights how the sector matured from providing simple information to building intelligent, full-stack platforms that are reshaping Indian agriculture from the ground up.

Figure 4: Evolution of Indian AgTech

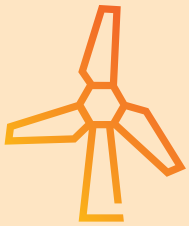
Ignition phase (2017–21) 	• **Market reality:** The COVID-19 pandemic exposed supply chain fragility, accelerating digital adoption. • **Technological focus:** Phygital (physical+digital) models that combined on-ground presence with tech platforms became the standard. • **Ecosystem and startups:** Grew rapidly to 1,000+ startups which were trying to solve challenges across the value chain. • **Investment landscape:** Gained significant momentum, with total funding in the sector crossing $2.1 billion in 2020 alone. • **The government:** Promoted digital markets via e-National Agriculture Markets (e-NAM) and encouraged farmer collectivisation through farmer producer organisation (FPO) schemes.
Hyper growth peak (2021–2022) 	• **Market reality:** Intense competition for market share as well-funded platforms scaled aggressively nationwide. • **Technological focus:** Building integrated platforms covering inputs, financing, advisory, and output linkages. • **Ecosystem and startups:** Major consolidation began as leaders used capital to acquire smaller, niche players. • **Investment landscape:** Funding increased to a record peak of over $3.6 billion in 2021, marking the high point of the investment frenzy.

Path to profitability (2023–25)



- **Market reality:** Despite funding slowdown, opportunity remains vast, with AgTech penetration at 1% of its potential market.
- **Technological focus:** Optimising unit economics and monetising existing user bases, with embedded FinTech (credit and insurance).
- **Ecosystem and startups:** A 'flight to quality' as investors back companies with strong fundamentals and a clear path to initial public offering.
- **Investment landscape:** Funding moderates but remains robust for proven models. Sector is projected to reach a market value of USD 24 billion by 2025.
- **The government's role:** Creating regulatory sandboxes for agri FinTech and supporting FPO-startup partnerships.

Climate-tech's era (2026–30)



- **Market reality:** A clear performance gap will emerge between tech-enabled, data-driven farms and traditional ones.
- **Technological focus:** Dominated by precision tech: drones, soil sensors, satellite imagery and platforms for carbon credit markets.
- **Ecosystem and startups:** A new wave of climate-tech startups will emerge to address sustainability and resource efficiency.
- **Investment landscape:** Will attract significant capital from global climate-tech funds; impact investors focused on ESG outcomes.
- **The government's role:** Shifts to regulating advanced tech (drone usage, data privacy) and creating a national framework for agricultural carbon trading.

Source

Business Standard. "Over 1,000 Tech Startups Added in 2017: NASSCOM";
Times of India. "Investments in Agri-Food Tech Start-Ups Jump 97% in FY21 to $2.1 Billion: Report";
Funding In Indian Agrifoodtech Startups Falls 33% To $2.4 Billion In 2022: Report;
Invest India Blog. "Growth of Agritech in India"

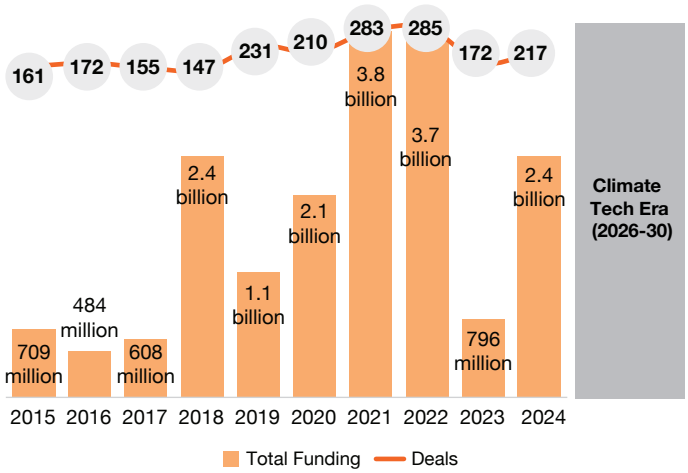
Tracing this path reveals a clear evolutionary logic: from one-way information to transactional platforms, and now towards predictive intelligence. The journey underscores a fundamental truth of the Indian market-technology is an enabler, but trust is the final currency. Even as the focus shifts to sophisticated deep-tech, the 'phygital' model remains the cornerstone of success, proving that a human-centric approach is non-negotiable. Moving forward, although the initial investment intensity has subsided, the opportunity remains immense. With market penetration still in single digits, true growth in this sector remains to be seen. The next chapter for Indian AgTech will be defined by its ability to leverage AI and climate-smart solutions not just for profit, but to build a resilient, sustainable, and prosperous future for millions of farmers.

(i) The investment landscape: A tale of momentum and maturation

The strategic importance of AgTech can be observed in the sector's investment trajectory. In the last decade, the market that has moved from a nascent experimental phase to a mature asset class, attracting significant domestic and international capital. This investment momentum, however, is not consistent and conveys the trends related to changing investor confidence, market priorities, and emerging opportunities. As per our analysis, the overall health and dynamism of the sector are captured in Figure 5, which details its funding and deal flow. After a period of steady growth, the Indian AgTech ecosystem witnessed an unprecedented surge in 2021 and 2022, attracting a staggering $3.8 billion and $3.7 billion in funding, respectively. This peak was driven by a confluence of factors: a global abundance of venture capital, a post-pandemic acceleration of digitisation, and the maturation of early AgTech leaders who demonstrated scalable business models.

The subsequent decline, as depicted in the graph for 2023, constituted a fundamental market correction. This rationalisation intensified through 2024 as investor scrutiny shifted decisively from topline revenue growth to profitability and a clear path to achieving it. As highlighted in market analyses from the period, persistent concerns over high rates of capital consumption and unclear paths to profitability led to a sharp contraction in available capital.

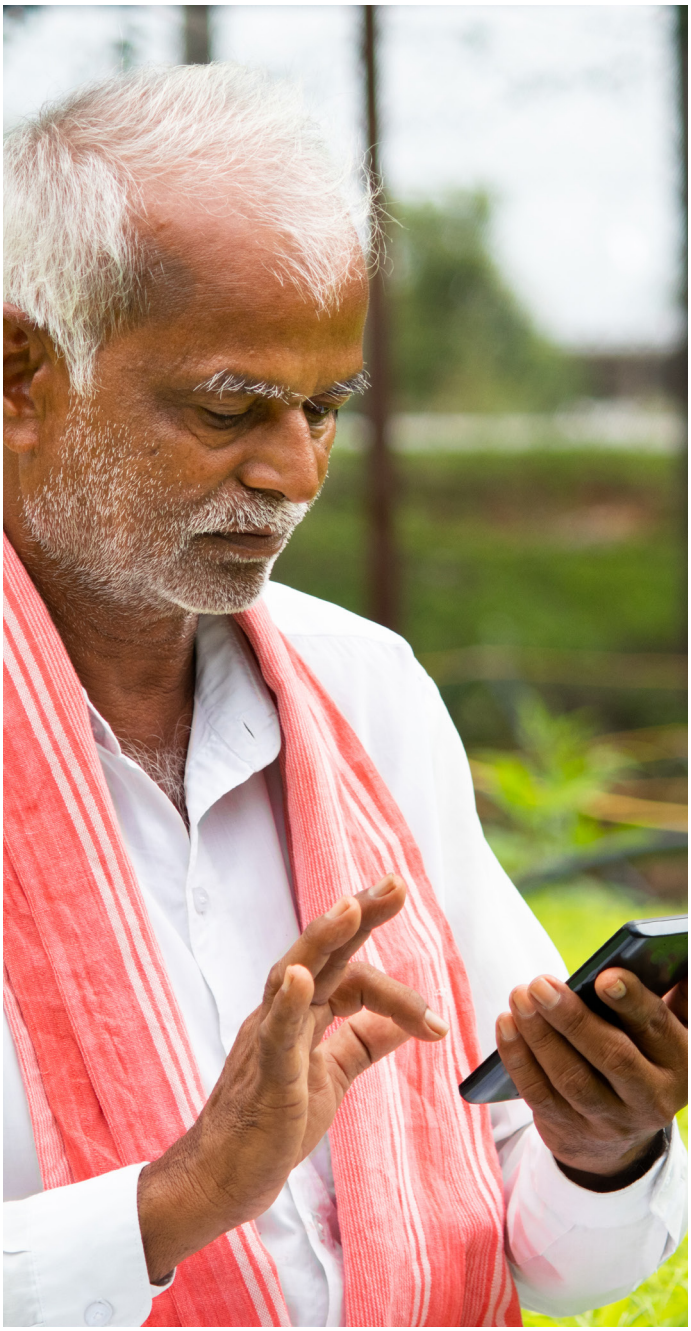
Figure 5: India's AgTech investment landscape



Phase 1: Ignition phase (accessing markets, inputs, credit, insurance, data & advisory)
Phase 2: Hyper growth peak (crop life cycle management, convergence of Agri-fintech)
Phase 3: Path to profitability (increased adoption, consolidation, collaborations)
Phase 4: Climate Tech Era (farm size specific offerings, climate techs)

Source: PwC analysis

After touching record highs in 2021 and 2022, **capital inflows have slowed by more than 50% in 2025, raising only $182.19 million.**[28] The current landscape in 2025 represents a new equilibrium defined by strategic selectivity. While the market contraction has stabilised, the investment climate remains cautious. Capital is now being directed toward enterprises that can demonstrate a clear and credible path to sustainable profitability, supported by robust unit economics and operational efficiency. There is a marked preference for business models that are not reliant on heavy subsidies, with a significant premium placed on innovations that incorporate a strong climate-tech and sustainability component. This has established an unequivocal imperative for AgTech ventures that the future growth of the sector must be synonymous with sustainable profitability.



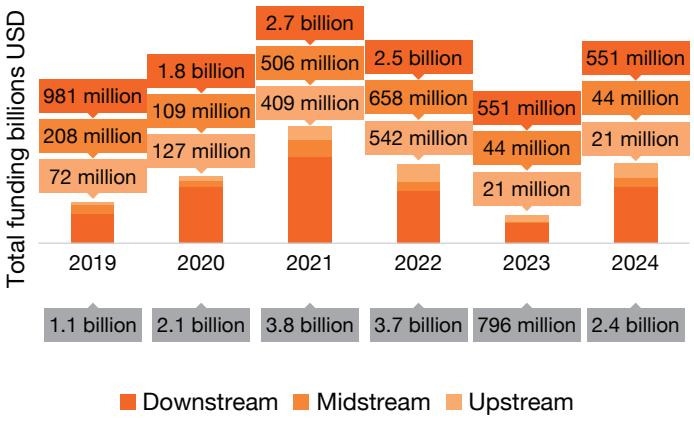
28 Financial Express: Agritech funding plunges over profitability concerns, 2025

Figure 6 highlights the distribution of investment capital reveals a pronounced concentration in downstream activities, which captured $2.7 billion of the $3.6 billion total funding in the peak year of 2021 alone. This focus is primarily attributable to the business models prevalent in this segment. Market linkage and supply chain platforms offer a clear, transaction-based path to monetisation. Furthermore, their operational requirements which include the development of physical infrastructure such as collection centres and logistics networks, as well as the provision of working capital and trade credit are inherently capital-intensive. Consequently, the consistent funding dominance of downstream[29] solutions reflect a rational investor preference for scalable, transaction-led revenue models that can absorb substantial growth-stage investment.

The capital-intensive profile of downstream enterprises contrasts sharply with the financial characteristics of many upstream[30] and midstream[31] innovations. Technologies such as biotechnology research, precision farming SaaS, and farm management software, while fundamental to enhancing farm-level productivity, are typically characterised by asset-light, research-and-development-focused models that require comparatively less capital during their initial stages. This disparity in capital allocation, however, provides an incomplete view of the sector's innovative landscape. A comprehensive understanding necessitates juxtaposing aggregate funding values with deal volume. This comparison reveals a distinct and critical trend regarding the distribution of entrepreneurial activity across the value chain.

In stark contrast to evaluated funding figures, the number of deals is far more balanced across the value chain. As seen in Figure 7, a significant amount of innovation and entrepreneurial activity happening at the farm level (upstream) and in the post-harvest space (midstream). In 2024, for instance, the number of deals in the upstream and midstream segments combined was 143, far exceeding the 62 deals seen in the downstream segment. This indicates that a vibrant pipeline of earlier-stage, less capital-intensive

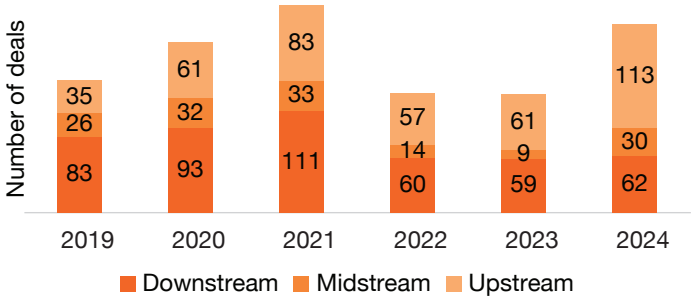
Figure 6: Funding trend by supply chain



Source: PwC analysis

companies is addressing fundamental challenges in farm productivity and efficiency. This analysis of the investment landscape highlights that while capital markets have validated the AgTech opportunity, the concentration of funding in downstream solutions underlines the farm-tech divide. The following sections will explore the on-ground barriers that make scaling upstream and midstream solutions more challenging and outline the strategies required to unlock the full potential of innovation across the entire agricultural value chain.

Figure 7: Deals trend by supply chain



Source: PwC analysis

29 Downstream AgTech: Consumer-facing platforms, including eGrocery, food delivery, retail tech, and home cooking innovations
30 Upstream AgTech: Startups operating closest to farm or food production, including inputs, farm management software, sensing, IoT, and novel farming systems
31 Midstream AgTech: Solutions focused on processing, storage, logistics, and distribution between farm and consumer, such as cold chain, supply chain optimisation, and food safety technologies

(ii) mpact investing and AgTech's adoption

Impact investing plays a pivotal role in facilitating AgTech adoption, with prominent investors guiding their portfolios with a clear focus on enhancing farmer livelihoods and aligning with global standards like the Sustainable Development Goals (SDGs). These investors meticulously select parameters such as climate action, small holder farmer (SHF) profitability, and gender impact, ensuring their initiatives yield extensive, long-lasting benefits.

Figure 8: Key parameters and focus areas for impact investors

Focus of investors and their impact investor framework for AgTech investments	
Key levers	**Key challenges in the Indian context**
Impact indicators	Increasing SHF profitability, their resilience, agricultural sustainability, climate action
Global impact investment framework followed	Impact Reporting and Investment Standards (IRIS), Principles for Responsible Investment (PRI), Impact Management Project (IMP), Sustainable Development Goals (SGDs)
Indicators of impact investment adopted/ customised for each investment majorly covers	• What: SDG alignment, outcome level in period, importance of outcome to stakeholder • Who: stakeholder and its characterisation, geography • How much: number of stakeholders experienced the outcome, at what degree and how long they experienced • Contribution: What would happen to the stakeholders if the company did not exist? • Risk: Likelihood that impact will be different that expected
Additional factors considered	Climate action, catalytic capital, employment generation, ESG impact and risk
Factors of AgTech adoption covered	03 04

01 Adoption: level and usage
02 Delivery channel: Stakeholders in support
03 Policy framework: Incentives, affordability, other infra and policy support by government.
04 Farmer outreach: Depth and scale in duration

Source: PwC analysis

However, an analysis of prevailing investment frameworks reveals a strategic gap. While these frameworks excel at defining and measuring the ultimate outcomes of technology, they place insufficient emphasis on the critical enablers of technology diffusion. The journey from piloting an innovation to achieving widespread adoption is determined by the strength of its **delivery channels**, the supportiveness of the **stakeholder ecosystem**, and its ability to navigate deep-seated **farmer adoption barriers**.

At present, these crucial 'how' factors are not treated as primary investment parameters. The focus remains on the technology's potential impact rather than the operational robustness of its adoption pathway. This creates a paradox where even well-funded, high-potential technologies fail to achieve scale because the ecosystem for their delivery—phygital networks, local support, and trust-building mechanisms (such as hands-on demonstrations, model farms and capacity building)—remains under-capitalised.

To unlock the next phase of growth, AgTech needs to integrate metrics that explicitly measure and finance the development of these delivery channels and stakeholder support systems, ensuring that capital is deployed not just for innovation but for ensuring that innovative products reach the farmers.

2b. Adoption rates and trends

(i) Analysis of current statistics on AgTech adoption: Potential vs. penetration

The Indian AgTech landscape presents a stark contrast. From a global investment perspective, India has firmly cemented its position as one of the **top four hubs for agri food tech funding.** Even amidst a global venture capital slowdown, the sector demonstrated remarkable resilience, with evaluated investments holding steady at **$2.4 billion in 2024.**[32] This stability, however, was accompanied by a decline in deal volume, indicating a significant market maturation. Investors have shifted from speculative, early-stage bets to a 'flight to quality', consolidating capital into proven business models. This maturation signals that the era of hype is over; the focus is now on building durable, scalable enterprises. The scale of the opportunity remains staggering: industry analysis projects the addressable market for farm-centric AgTech in India to exceed **$34 billion by 2027,**[33] yet current penetration is estimated to be just over **1%,**[34] highlighting the immense chasm between market potential and on-ground reality.

While our estimations says India's startups ecosystem of over **3,000 startups**[35] is constantly innovating, AgTech solutions have only reached less than **15% of India's 146 million farmers.**[36] This low aggregate figure, however, conceals a highly differentiated and rapidly evolving landscape across various technology sub-sectors. A detailed examination of adoption across these categories is necessary to reveal where these solutions are successfully implemented and where significant barriers persist.



(ii) The digital adoption chasm: Smartphone ownership vs meaningful use

The foundational layer for most AgTech services is digital connectivity. On this metric, the macro-picture is encouraging. Rural tele-density has surged, and as of 2024, approximately **59% of the rural population owns a smartphone.**[37] This high rate of device ownership, however, presents a misleading impression of digital readiness. The critical metric is not device ownership, but active, engaged usage for agricultural purposes. Only **35% of the rural population uses the internet on a daily basis**, with a significant portion of this usage dedicated to communication and entertainment rather than productivity applications.[38] This gap between device access and meaningful use represents the digital adoption chasm. Despite the growing penetration of smartphones in rural areas, sustained engagement with agricultural apps remains limited, indicating that while the hardware is in place, the software and behavioural transition is still in its early stages.

32 India's agrifoodtech startups raised $2.5 bn in 2024, 3x rise from 2023." Business Standard, 16 April 2025
33 The Hindu, Indian agritech sector to address $34 billion market by 2027, 2022
34 IBEF, AgriTech Landscape in India, 2024
35 PwC Analysis/estimations basis industry consultations
36 Agriculture Census, Department of Agriculture & Farmers Welfare
37 Economic Time Insight Why rural India will lead the next smartphone revolution, 2025
38 Business Standard, Will Union Budget 2025 focus on enhancing rural internet accessibility?, 2025

(iii) Dissecting adoption by AgTech vertical

A deeper understanding of AgTech adoption emerges when the aggregate rate is disaggregated by specific technology verticals. Table 2, "Analysis of diffusion channels and policy enablers driving AgTech adoption" breaks down how each segment is shaped by unique adoption dynamics, diffusion channels (the 'how'), and policy enablers (the 'why').

Table 2: Analysis of diffusion channels and policy enablers driving AgTech adoption

	AgTech vertical	Adoption dynamics	Diffusion channel (the 'how')	Policy and ecosystem enabler (the 'why')
Upstream	**Remote sensing and advisory**	**~42 million farmers annually** are covered by crop insurance schemes, making this a mature, institutionalised B2B2C vertical.[39]	**Mandated institutional push:** Diffused via government tenders and B2B contracts where insurers/ banks are the primary client; farmers are indirect beneficiaries	**~More than $3.5 billion annual premium market**[40] created by PMFBY mandates the use of satellite and tech-based data for yield estimation and loss assessment at scale.
	Precision farming and automation (Drones, FaaS)	**>15,000 'Kisan drones'** are targeted for deployment via SHGs, driving adoption via an asset-light service model, not hardware ownership.[41]	**Hyperlocal service model:** A classic 'uberisation' of farm services, where local entrepreneurs leverage platforms to offer on-demand spraying.	**An 80% subsidy (up to ₹8 lakh)** offered via the 'Drone Didi' scheme is creating a new class of 15,000 women-led rural service entrepreneurs.[42]
	Digital input marketplaces	**5–15% cost savings** are realised by farmers on these platforms, which directly impact the **~25% counterfeit pesticide market.**[43]	**Assisted commerce (phygital):** A hybrid model using VLEs to onboard and transact for farmers, thereby bridging the last-mile trust and literacy gap.	**A targeted ₹20,000 crore subsidy reduction under PM-PRANAM** is creating a massive market for efficient inputs, delivered through a **national network of >2,30,000 digitised retail outlets.**[44]
	Agri-FinTech	**>77 million farmers** are now covered under the digitised KCC scheme, with FinTechs targeting the remaining $200 billion credit gap.[45]	**Embedded finance flywheel:** Primarily scaled by integrating into full-stack platforms, using the platform's proprietary cash-flow data for low-cost underwriting.	**Over 12 billion monthly UPI transactions and 1.3 billion Aadhaar IDs** form the digital rails (India Stack) that enables low-cost eKYC and rural lending at scale.[46]

39 Financial Express, 2024, Performance of Crop Insurance Scheme
40 India Brand Equity Foundation (IBEF). "Pradhan Mantri Fasal Bima Yojana."
41 PIB, 2024, Implementation of Drone Didi Scheme
42 PIB, 2024, Implementation of Drone Didi Scheme
43 ET times newsarticle Sept'2025, Shortage to scam: Fake fertilisers, pesticides flood farms - how much is China to blame?
44 Department of Fertilizers, 2024, PM-PRANAM Scheme Guidelines
45 NABARD, 2024, Adoption of Kisan Credit Card Scheme
46 NPCI, 2025, UPI Product Statistics



	AgTech vertical	Adoption dynamics	Diffusion channel (the 'how')	Policy and ecosystem enabler (the 'why')
Downstream	**Market linkage and full-stack platforms**	**Increase in price realisation by farmers** on these platforms by connecting with institutional buyers, better market information dissemination and fewer intermediaries. due .	**Phygital aggregation network:** A capital-intensive model building physical collection centers as anchor points, managed by a central digital logistics and trading platform.	**$900 million fund** under the FPO Promotion Scheme is creating **10,000 organised FPOs,** providing a readymade supply base.[47]
	Agri-logistics and supply chain tech	**>75% reduction in post-harvest loss** of perishables is proven by tech-enabled cold chains, directly addressing the **~40 million MT capacity gap.**[48]	**Enterprise B2B integration:** Solutions are sold directly to large food processors and organised retailers who require auditable quality control and traceability.	**$1.4 billion PLI Scheme** for food processing creates a massive demand-side pull for high-quality, traceable produce, forcing investment in modern logistics.[49]

AgTech sector is undergoing significant maturation, defined by a pronounced 'flight to quality' in both investment and business models. The initial phase of speculative, single-point solutions is giving way to a more disciplined market where integrated, full-stack platforms with demonstrable unit economics are becoming the dominant, viable model.

Consequently, the strategic imperative for the sector's next phase of growth is to bridge the divide from the current base of early adopters to the vast mass market of smallholder farmers. The central challenge has evolved from mere technology creation to the more complex task of devising scalable and economically viable distribution and service models. The ultimate success of India's agricultural transformation will be measured not by the sophistication of its technology, but by its ability to deliver tangible value to this mass-market majority.

47 PIB, 2024, Formation and Promotion of 10,000 FPOs
48 NCCD, 2025, Energy Transition in Cold Chain Infrastructure
49 MoFPI, 2024, PLI Scheme for Food Processing Industry

(iv) Status of adoption rates across different regions

The national average for AgTech adoption reveals vast regional disparities driven by agro-climatic and socio-economic conditions. Consequently, the diffusion of technology is creating two distinct market archetypes, differentiated by their primary path to improved profitability. The **first** is the **efficiency-driven market,** where the strategic priority is to enhance unit economics through precision, optimisation, and greater value chain integration. The **second** is the **resilience-focused market,** where the immediate priority is to secure foundational stability by mitigating risk and improving access to reliable inputs and information. Table 3 provides a detailed comparison of these two profiles. Recognising these different strategic priorities is essential for designing context-specific scaling strategies to bridge the farm-tech divide.

Table 3: Analysis of diffusion channels and policy enablers driving AgTech adoption

Dimensions	Efficiency-driven markets	Resilience-focused markets
Exemplar states*	**Indo-Gangetic and Deccan Semi-Arid Belt**	**Eastern Humid–Sub-Humid Belt (Gangetic–Plateau–NE)**
Structural profile (the 'why')	• **Farm size (Average holding):** >1.5 ha • **Irrigation coverage:** >80% • **Mechanisation level:** >2.5 kW/ha • **Horticulture share (of agri GVO):** >35% • **Average per capita farmer income:** ~₹19,000	• **Farm size (Average holding):** <0.5 ha • **Irrigation coverage:** <50% • **Mechanisation level:** <1.5 kW/ha • **Horticulture share (of agri GVO):** <20% • **Average per capita farmer income:** ~₹9,000
Farmer archetype	**Transitioning farmers:** Early stages of adoption, seeking relevant solutions	**Aspiring farmers:** Low adoption, need to build access and confidence in technology
Dominant AgTech playbook (the 'what')	**Focus on efficiency and value-chain integration:** the primary driver is optimising profitability. Adoption is high for solutions that: • Increase input efficiency (precision agri) • Enhance price realisation (market linkage) • Provide access to credit (FinTech)	**Focus on access and risk mitigation:** the primary driver is securing basic needs. Adoption is highest for solutions that: • Provide access to authentic inputs (marketplaces) • Deliver timely, basic advisory (interactive voice response, apps) • Mitigate climate risk (insurance, forecasting).
Primary adoption inhibitors (the 'blockers')	• **Problem saturation:** Basic problems are largely solved; startups must demonstrate clear, rapid ROI on advanced technologies. • **High farmer expectations:** Farmers are digitally aware and demand sophisticated, reliable service delivery.	• **Affordability:** Low disposable income makes even small upfront costs a significant barrier. • **Infrastructure deficit:** Gaps in rural power, logistics, and digital connectivity render many tech solutions unviable. • **Low digital literacy:** Requires high touch, assisted models.

Dimensions	Efficiency-driven markets	Resilience-focused markets
Diffusion model (the 'how')	• **Platform-led, B2B and B2C integration:** The winning model is a digitally led, full-stack platform that captures value across the chain or a specialised, ROI-focused service targeting FPOs and large farms.	• **Hyperlocal assisted commerce (phygital):** The only scalable model is asset-light for the user, relying on a dense physical network of trusted village-level micro-entrepreneurs who onboard, assist, and transact for farmers.

*__Note:__ The listed regions are representative exemplars, not a comprehensive enumeration. They are chosen to provide empirical context for the analytical framework, having been selected for their strong alignment with the defining economic structures and adoption patterns of each market archetype, despite acknowledged intra-state variations.

This regional analysis provides a comprehensive overview which can help governing bodies to develop a clear framework for scaling AgTech by identifying the **key factors that accelerate or impede AgTech adoption.** Strategies must be tailored to a specific regional context and a one-size-fits-all solution may not be beneficial in such a scenario. In high-adoption corridors, the focus can be on deploying more advanced, capital-intensive technologies and fostering deeper innovation. In low-adoption belts, the strategic priority must be on building foundational infrastructure, promoting low-cost and asset-light solutions, and scaling phygital models that are designed to overcome the deep-seated barriers of trust, affordability, and digital literacy.

2c.. Challenges in adoption at the grassroots level

While the promise of AgTech is immense, its translation into widespread on-farm impact is impeded by a complex web of barriers at the grassroots level. These challenges are not singular issues but a cycle of interconnected obstacles operating on two fronts. The first are the tangible, widely recognised challenges: a foundational **infrastructure deficit** in rural connectivity and power; an acute **affordability gap** that places modern tools financially out of reach for the average farmer; and widespread **institutional fragmentation** that creates a confusing and unsupportive policy environment.

Yet, beneath these issues lies a more profound set of behavioural barriers. Chief among them is a critical **yield impact communication gap:** the failure to translate a technology's potential into a believable, context-specific promise of value for the farmer. This gap fuels a deep-seated **farmer resistance,** where even available and affordable tools are met with hesitation due to a lack of trust, low digital literacy, inherent risk aversion, and socio-cultural constraints. These human-centred factors form an invisible layer of resistance that technology rollouts frequently miss. The following analysis explores each of these four barriers in detail, revealing how the tangible and the behavioural combine to stifle progress and what it will take to drive real, inclusive adoption up to the last mile.

Figure 9: Challenges in adoption at the grassroots level

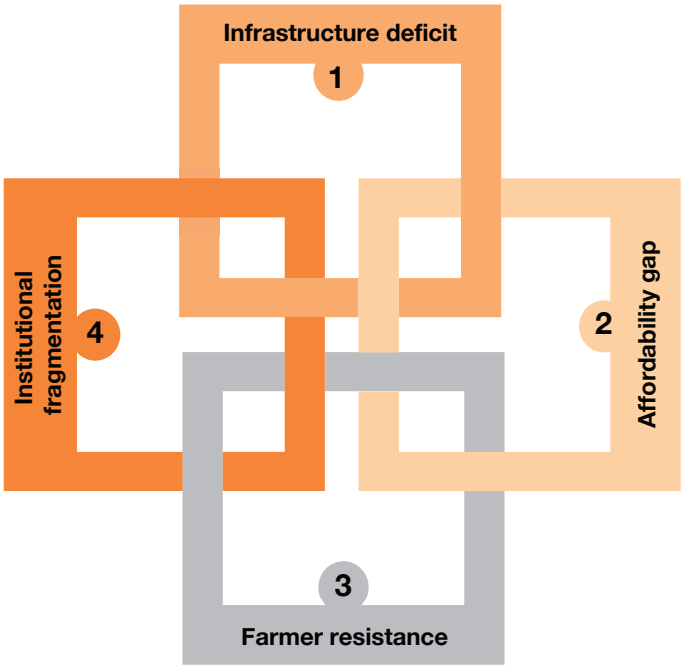


Figure 10: Challenges in adoption at grassroots level



Connectivity gap: While there are >480 million rural internet users, India's mobile broadband speeds lag the global average, hindering data-intensive AgTech applications.

Critical gaps in cold chain facility: Post-harvest losses for agriculture and allied sectors exceed ~₹1.5 lakh crores annually, driven by a massive deficit in refrigerated storage and transport infrastructure.

Local support: >5 lakh common service centres (CSCs) exist but lack specialised agri digital support for farmers.



Trust deficit: Majority of smallholders trust app-based advice over trusted local human networks (dealers, peers).

Digital literacy gap: ~70% rural smartphone penetration clashes with just 25% of the rural households being digitally literate and able to use the internet effectively.

The gender divide: Agriculture employs about 80% of rural women, yet 51% of rural women don't own a mobile phone, creating a deep digital divide.



Prohibitive cost: Average farmer income is just ₹10,218/month, making technologies like drones (₹2–3 lakh) impossible to afford.

Low investment and credit: Over 60% of farmer do not have access to formal credit, and most are unwilling to risk investing over ₹1,000 in new tech.



Fragmented governance: Over 27 different government bodies influence AgTech policy, creating confusion and slowing down cohesive implementation.

Shortcomings in land record integration: >94% of village land records are computerised but lack real-time integration with maps creates major hurdles for FinTech and land-based services.

Sources:

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Lok Sabha Annexure AU839;
CSC Portal. "Common Services Centres Official Website" ;
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The Hindu Business Line. "Addressing Credit Challenges Faced by Indian Farmers";
New Indian Express. "Number of Smartphones Doubled in Rural India from Pre-COVID Era: ASER".;
CBWE Digital Literacy Report. "Digital Literacy in India: Status and Challenges".;
NITI Aayog Blog. "Rural Women: Key to New India's Agrarian Revolution";
Business Standard. "Digital India Divide: NSO Report Highlights Rural Women Mobile Phone Ownership Gap";
Press Information Bureau, PRID 2068408;

Case study 1

Delayed adoption of sensor-based irrigation

The initiative

Across many states in India, numerous pilot projects have introduced IOT-based soil moisture sensors to promote data-driven irrigation.

The goal: In controlled trials, this technology consistently shows the potential for significant water savings.

Core challenges

Technology and infrastructure gaps: Erratic power supply and inconsistent mobile connectivity in remote areas rendered the sensors and data transmitters unreliable, undermining the technology's core value.

Economic and behavioural barriers: Farmers perceived the recurring subscription and maintenance costs as a new, uncertain financial risk, preferring the known (though inefficient) cost of running their pumps.

Outcome and key takeaway

Post-subsidy adoption rates remained exceptionally low. This demonstrates that without robust rural infrastructure and risk-free business models, even proven hardware fails to achieve scale.



The theoretical framework of barriers to adoption becomes tangible when examined through on-the-ground applications. The following examples,[50] synthesised from field studies and impact assessments, representative archetypes of the challenges facing the AgTech sector. By deconstructing the performance of hardware-centric, service-based, and platform-driven models, we can identify recurring patterns of friction between technological promise and operational reality, thereby distilling critical lessons for future strategy and investment.

A clear, unifying thread runs through these case studies and highlights that technology, in isolation, is insufficient to drive adoption. Whether it is hardware requiring a supportive physical infrastructure, a service model dependent on local human capital, or a digital platform that must overcome deep-seated behavioural norms, the shortcomings are usually at the intersection of the digital solution and the complex realities of the rural ecosystem. This persistent gap between promise and reality underscores a critical conclusion that the last mile cannot be bridged by technology alone. It requires a human intervention with trusted local actors who can translate digital information, de-risk new practices, and embed innovation within the community's existing social and economic fabric. It is these intermediaries—the retailers, FPO leaders, and local champions—who represent the most critical and often overlooked lever for unlocking the true potential of AgriTech at the grassroots level.

(i) Strategies to overcome grassroots challenges: The power of intermediaries

Most smallholder farmers do not engage with AgriTech platforms in isolation; their decisions are shaped by the people and networks they trust. This is where intermediaries play a critical role not just as delivery agents, but as enablers, translators, and trust-builders. The following actors are crucial for bridging the last-mile gap.

Retailers: Input retailers are the most trusted and accessible advisors for smallholder farmers. Unlike overstretched government extension agents, retailers offer year-round support and informal credit, making them ideal AgriTech influencers. Startups are empowering digitally trained retailers to deliver advisory services and manage tech-driven inventories. However, challenges remain as only 18% have stable internet, and over 40% lack the credit to stock advanced products. Investing in retailer training, digital infrastructure, and financial inclusion is critical to unlocking their potential.

50 Powering Agriculture in India, 2021; Smart Irrigation System Using IoT

Case study 2

The challenging unit economics of Drone-as-a-Service (DaaS)

The initiative

An AgTech model where startups provide on-demand drone services for pesticide and nutrient spraying.

The goal: To deliver precision spraying with unparalleled speed, solving labour shortages and reducing farmers' chemical exposure.

Core challenges

Technology and infrastructure gaps: A shortage of trained and certified local drone pilots, coupled with a lack of rural repair and maintenance ecosystems, leads to significant operational downtime. Operating in small, irregularly shaped plots further complicates logistics.

Economic and behavioural barriers: The per-acre service fee is often perceived as higher than the cost of manual labour, especially for smallholder farmers. Strong farmer skepticism about spray efficacy, coverage uniformity, and potential crop damage leads to a reluctance to pay for the first use.

Outcomes and key takeaways

The inherent challenges of DaaS—high capex, low asset utilisation, and fragmented demand—make it commercially unviable for most startups targeting smallholders. The government's 'Drone Didi' programe is a direct policy response to this market failure. By subsidising drones for women's SHGs, it creates a community-owned service model that solves for both demand aggregation and the local support ecosystem. The key takeaway is that DaaS in India is not evolving as a typical B2C or B2B service, but as a government-enabled, community-operated (B2G2C) model to ensure scalability and impact.

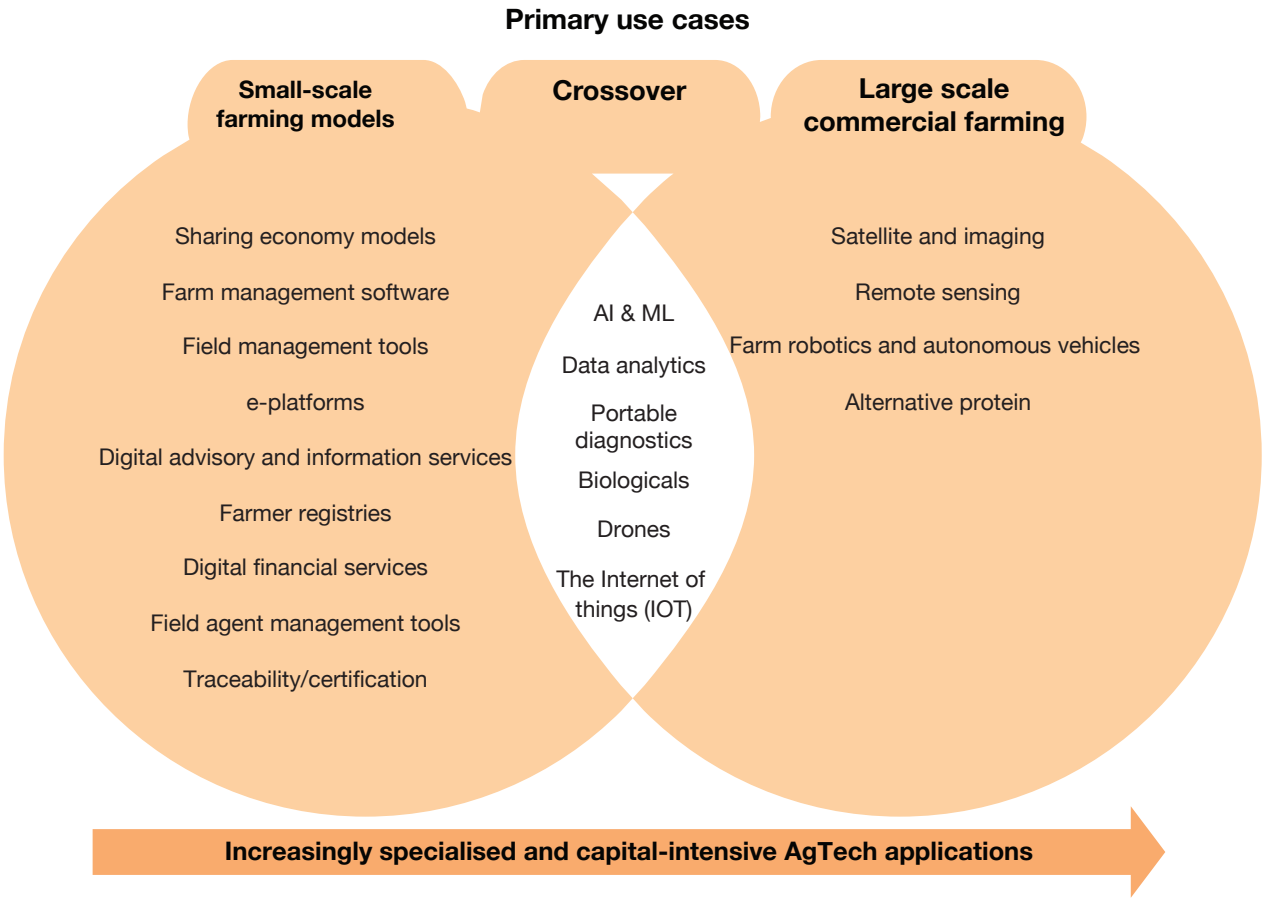
FPOs and cooperatives: FPOs aggregate land, reduce transaction costs, and enable shared technology adoption. Farmers affiliated with FPOs are **more likely to adopt AgriTech;** however, only **half of India's FPOs are digitally active.** Models such as Andhra Pradesh's Rythu Bharosa Kendras and Maharashtra's MahaFPO illustrate how well-supported FPOs can integrate drone services and digital agronomy, strengthening farmer access to technology and enhancing yields . Empowering FPOs through capacity-building and tailored credit is essential to make them central to scaling AgriTech.[51]

Informal networks: For most smallholders, peer advice drives technology use more than platforms. Evidence suggests that peer influence plays a critical role in technology adoption among farmers, with first-time adopters often motivated by observing successful outcomes within their community. Peer-led demonstrations tend to outperform formal campaigns in driving engagement Initiative like UNDP's **Agri Mitras**[52] in Bihar prove that local champions, especially women, dramatically improve tech retention and trust. To scale meaningfully, policy must treat these informal networks as core delivery infrastructure, backing them with incentives and support systems that embed local champions into mainstream extension models.

2d. Key technologies used in AgTech

The contemporary AgTech landscape is a multi-layered stack of technologies addressing systemic inefficiencies across the value chain. This ecosystem can be divided into two distinct categories based on their **maturity, scale, and primary function:** the foundational digital infrastructure that defines the current market, and the emerging deep-tech innovations poised to re-engineer the sector's physical and biological frontiers.

Figure 11: Key technologies used in AgTech



51 NABARD, Handholding (Capacity Building and Facilitation) of FPOs: Framework to Implementation, 2022
52 UNDP India, "Sunlit Future: Harnessing Solar Power to Help Women Farmers Combat Climate Change," 2024

Foundational technologies at scale

The established pillars of Indian AgTech are foundational technologies that have achieved significant adoption by creating digital efficiencies and market linkages, as summarised in Table 4. These technologies are the established pillars of Indian AgTech, characterised **by significant adoption, proven business models, and a primary focus on digital efficiency and market linkage** and form the core infrastructure upon which the entire ecosystem is built.

Table 4: Analysis of foundational AgTech, core problems addressed, and scalable impact

Technology	Core problem addressed (the 'why')	Potential impact and scale ('why it wins')
Digital platforms full-stack marketplaces	• A 15–20% lower price realisation is the norm for farmers due to fragmented supply chains with multiple intermediaries.[53] • Over ~$12 billion in value is lost annually to post-harvest inefficiencies.[54]	• Enhanced agricultural productivity. • ~10% savings on input costs through direct sourcing.[55]
Precision AgriTech and remote sensing	• A skewed 7.7:3.1:1 N:P:K consumption ratio (vs. an ideal 4:2:1) is degrading national soil health and increasing input costs.[56] • Nearly 90% of India's freshwater withdrawal is for agriculture, with on-farm efficiency often below 40%.[57]	• Significant improvement in water use efficiency via IoT. • Very high accuracy in AI-powered pest/disease identification. • Services the very large crop insurance (PMFBY) market with institutional risk analytics at scale.
Agri FinTech and embedded services	• A $200 billion annual credit gap persists for the agricultural sector.[58] • Over 50% of India's smallholder farmers lack access to formal credit, forcing reliance on high-cost informal lenders.[59]	• De-risks lending using proprietary farm data, reducing cost-to-serve faced by traditional banks.

Emerging technologies shaping the next frontier

The future of Indian agriculture is being shaped by a new wave of deep-tech and biotech innovations that build upon the existing foundational platforms. These emerging technologies, profiled in Table 5, are designed to solve complex challenges related to automation, climate resilience, and sustainability. Although adoption is nascent, their potential impact makes them critical to the sector's long-term evolution.

Table 5: The next frontier: Emerging technologies which are shaping India's agriculture sector

Technology	Core problem addressed (the 'why')	Potential impact and scale ('why it wins')
Farming-as-a-Service (FaaS)	• ~45% mechanisation rate lags behind global peers as high ownership cost is a barrier for 86% small and marginal farmers.[60]	• Significant reduction in farm operational costs for smallholders. • Converts high CapEx into affordable, pay-per-use OpEx, unlocking a massive latent market.
Traceability, blockchain, and food safety	• A significant share of potential export opportunities may be compromised when products fail to align with international quality and compliance standards.	• Integrating QR-code based traceability into high-value crop supply chains can act as a strategic enabler for differentiated pricing, signaling transparency and

53 Growth of Agri Marketplaces in India's Rural Economy-StarAgri, 2024
54 NABCONS, Addressing Post-Harvest Losses in India: A Silent Crisis in Agriculture
55 FAIFA, Indian Agriculture Outlook, 2025
56 NITI Aayog & Fertiliser Statistics, 2024, Fertiliser Use and Imbalance in India
57 World Bank AQUASTAT, 2021, Annual freshwater withdrawals, agriculture
58 NABARD, 2024, Adoption of Kisan Credit Card Scheme
59 The Hindu BusinessLine, 2024, Addressing Credit Challenges Faced by Indian Farmers, 2024
60 FICCI-PwC Report, 2024, Farm Mechanization: A Catalyst for Sustainable Agricultural Growth

Technology	Core problem addressed (the 'why')	Potential impact and scale ('why it wins')
		compliance that global buyers increasingly prioritise. • Addresses the 25.5% CAGR in domestic demand for verified and organic food.[61]
Advanced biotechnology and genomics	• Projected 10–40% crop yield reduction by 2050 due to climate change.[62] • Large-scale land degradation across diverse regions highlights persistent challenges in maintaining soil health and ecological balance.	• Potential to develop climate-resilient traits better yields under stress conditions. • Cuts new variety R&D cycles significantly using genomic selection and advanced techniques (e.g. clustered regularly interspaced short palindromic repeats (CRISPR).
Robotics and on-farm automation	• Declining agricultural workforce (from >54% to <45%) which causes severe labour shortages.[63] • Consistently rising real agricultural wages, pressuring farm profitability.	• Potential to reduce high labour costs (e.g. precision spraying) in horticulture.
Next-gen biological inputs	• 59% of Indian soil is deficient in organic carbon, a key marker of poor soil health.[64] • Widespread and imbalanced use of chemical fertilisers leading to declining crop response.	• Seeks to transform the conventional fertiliser and pesticide market by introducing sustainable, next-generation alternatives that challenge conventional practices. • Helps reduce reliance on synthetic fertilisers, contributing to lower greenhouse gas emissions and mitigating nutrient runoff risks.

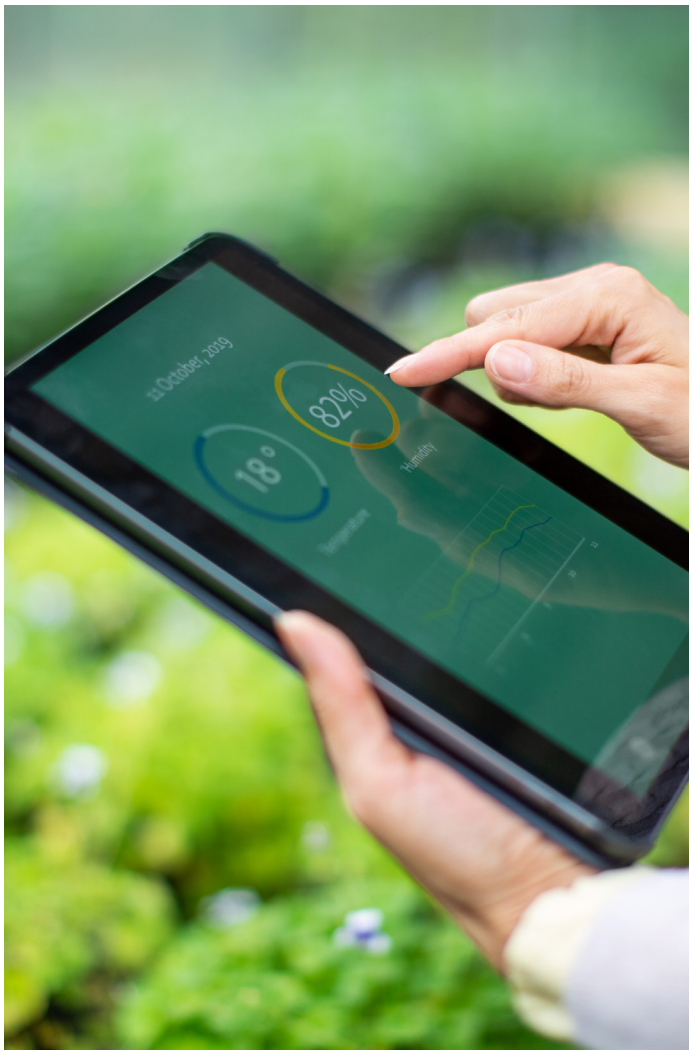
Collectively, these emerging technologies illustrate a clear trajectory away from simply managing farm operations to fundamentally re-engineering them. From FaaS democratising mechanisation to robotics addressing labour crises and gene editing promising climate-proof crops, the focus is on creating systemic resilience. However, the path from niche innovation to mainstream adoption is fraught with challenges, including high capital costs, the need for new regulatory frameworks (particularly for biotechnology), and the critical task of building farmer trust in unfamiliar solutions. Unlocking the immense potential of this next frontier will therefore depend not only on the ingenuity of startups but also on a concerted effort from policymakers, investors, and research institutions to create an ecosystem that nurtures these deep-tech solutions from the lab to the land.

61 Demand and Consumption of Organic Farming Products, PIB, Feb 2023
62 Climate Change Puts India's Rice and Wheat Output at Risk, 2025
63 PIB, Reverse Migration to Agriculture-PLFS Data, 2025
64 CSE Assessment Finds Indian Soils Severely in Key Nutrients, 2025

2e. Channels of diffusion

The diffusion of agricultural innovation is not a passive process; it requires the deliberate activation of specific channels that can carry information, build trust, and facilitate access to technology. Understanding these pathways is critical to moving AgTech from niche pilots to mainstream impact. This section analyses the three primary drivers of AgTech's distribution in India: the top-down influence of large-scale government programmes, the agile and market-driven ecosystem of private sector and non-profit actors, and the rapidly emerging, bottom-up power of digital and social platforms. Each channel possesses distinct strengths, limitations, and spheres of influence that determine its role in the broader ecosystem.

1. Government initiatives and International Development Agency's programmes: The government remains the most significant channel for distribution due to its scale, regulatory authority, and ability to make long-term infrastructural investments. Its initiatives are best suited to address the most capital-intensive barriers identified earlier.



The foundation for scaling AgTech

Addressing the infrastructure and affordability gaps: Through programmes like BharatNet and the Deen Dayal Upadhyaya Gram Jyoti Yojana, the government directly addresses the foundational infrastructure deficit in connectivity and power. Furthermore, it is the primary actor for tackling the affordability gap at scale through subsidies. Policies like the 40–100% subsidy on agricultural drones under Sub-Mission on Agricultural Mechanization (SMAM) and the Drone Didi Yojana or financial assistance under the Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM-KUSUM) scheme for solar pumps are designed to de-risk the initial purchase of high-cost technology for farmers and service providers.

Tackling institutional fragmentation: Initiatives like the India Digital Ecosystem of Agriculture (IDEA), or Agri Stack, represent a top-down effort to create the unified digital architecture needed to overcome the systemic fragmentation that plagues the sector. By attempting to standardise data and create interoperable systems, the government aims to build the digital highways upon which private innovation can move seamlessly.

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2. Private sector and NGOs: Where government initiatives provide scale, the private and non-profit sectors provide the necessary agility, trust, and customer-centricity to bridge the gap between technology providers and the farmer. These actors excel at creating models that directly respond to the behavioural and economic realities on the ground.

The engines of last-mile innovation

Overcoming farmer resistance: Startups and non-government organisations (NGOs) have pioneered the phygital model, directly countering the trust deficit. Rather than replacing trusted local actors, successful startups in Farming as a Service (FaaS) segment empower existing input retailers with technology. NGOs leverage the deep trust vested in self-help groups (SHGs) to disseminate information through community-led video screenings, effectively bypassing both literacy and trust barriers.

Innovating around affordability: The private sector's most significant contribution has been the creation of asset-light, pay-per-use business models. As seen in the Drone-as-a-Service (DaaS) example, this shifts the financial burden from the individual farmer to the service provider, converting a prohibitive capital expenditure into a manageable operational expense. This directly solves the affordability challenge for precision technologies.

3. Social media and digital platforms: A rapidly emerging and disruptive channel for diffusion operates outside formal institutional structures with digital peer-to-peer networks. This channel leverages social proof at an unprecedented scale.

The new frontier of peer-to-peer diffusion

Knowledge and demonstration: Video streaming platforms have emerged as a de facto agricultural extension platform. Agri-influencers—progressive farmers who create video content in regional languages—command audiences of millions. Their channels demonstrate everything from low-cost micro-irrigation techniques to reviews of new seed varieties. This visual, peer-to-peer format is highly effective at bypassing both text literacy and trust barriers, as farmers are more likely to adopt a practice demonstrated successfully by a peer.

Real-time problem solving: Instant messaging app groups, often organised by crop or geography have become indispensable tools. Farmers share photos of pest infestations or nutrient deficiencies and receive instant, crowdsourced diagnoses and advice from hundreds of fellow farmers. This creates a real-time, hyper-local support system that formal channels cannot replicate. Even government bodies like Krishi Vigyan Kendras (KVKs) are now creating their own social media to disseminate alerts and advisories more efficiently.

Sources: https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=1985470&reg=3&lang=2

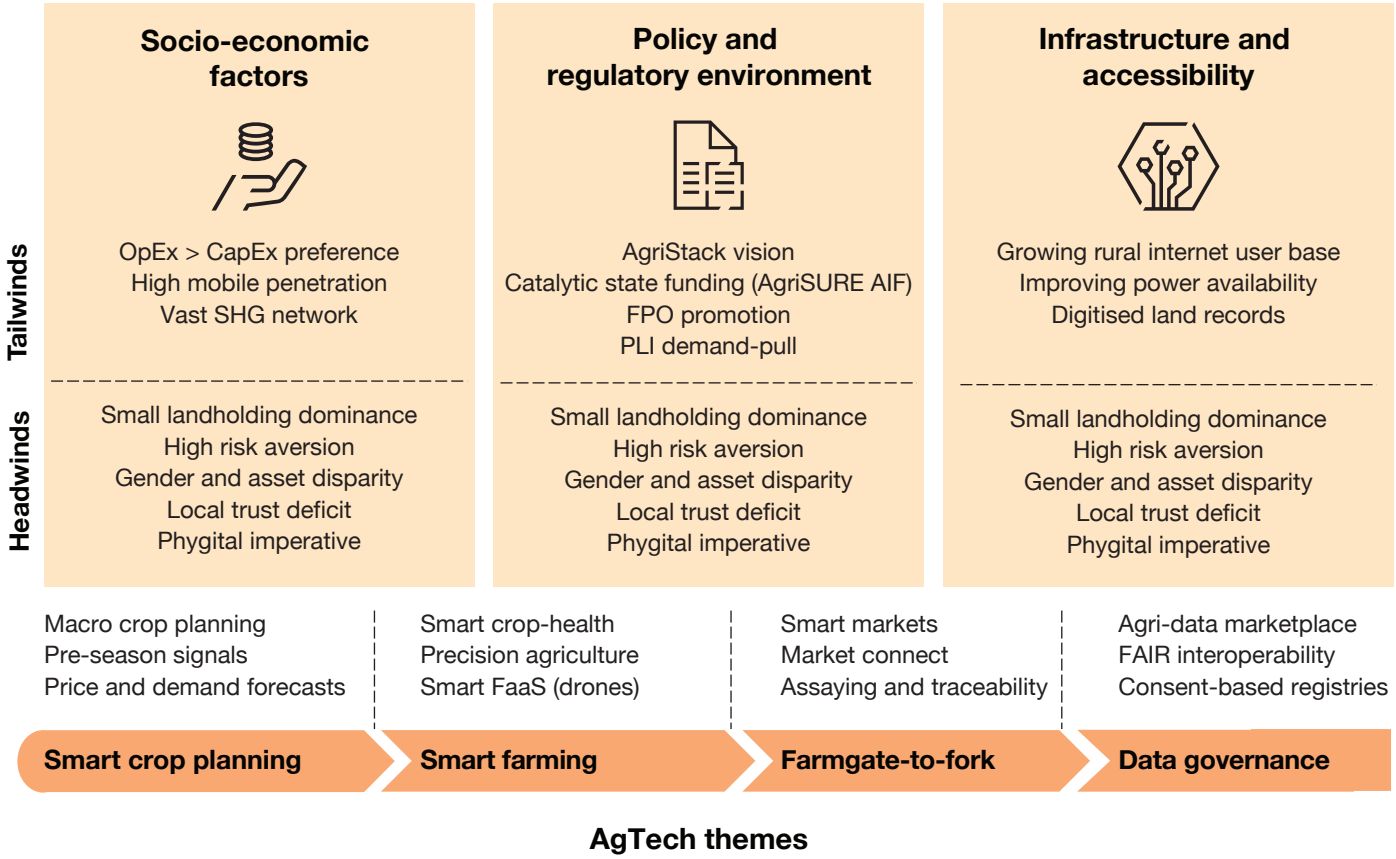


03

Factors influencing AgTech's diffusion

The pace and pattern of AgTech adoption in India are impacted by the complex interplay between deeply rooted structural factors. The dissemination of innovation within a system as vast, fragmented, and heterogeneous as Indian agriculture is governed by a set of powerful enabling forces (tailwinds) and significant frictional touchpoints (headwinds). This section provides an analysis of the intricate web of determinants that could impact farm-centric innovations.

Figure 12: Key technologies used in AgTech



Source: PwC analysis

3a. Socio-economic factors

The decision of a farmer to adopt new technology is profoundly influenced by their immediate socio-economic context. These factors often outweigh the standalone technical merits of innovation.

1. Income, landholding, and risk appetite: This remains the most formidable determinant of technology adoption. India's agriculture is dominated by small and marginal farmers, who constitute over 86% of all landholders and cultivate approximately 47% of the operated area,[65] with an average landholding size that has shrunk to a mere 1.08 hectares.[66] This structural reality creates a condition of profound risk aversion. For a farmer whose net income may be precarious, any expenditure on a new technology is not an investment but a high-stakes wager. The potential loss from a failed experiment such as a malfunctioning sensor or an ineffective bio-input can threaten their livelihood for an entire season.

Consequently, farmers apply an extremely high **risk-discounting factor** to promised future gains, prioritising the avoidance of immediate loss. This economic psychology explains the market's overwhelming preference for operational expenditure models over capital expenditure models. Therefore, a technology's success is determined less by its overall, long-term ROI and more by its immediate impact on cash flow and its ability to show a clear, tangible profit or benefit within a single crop cycle.

2. Education, digital literacy, and the phygital imperative: The success of the current wave of digital AgTech solutions is dependent on the user's ability to engage with them. While India's rural tele-density is high, there is a significant difference between device ownership and effective digital literacy. As of 2025, rural internet penetration stood at approximately 53%,[67] however, effective usage and the ability to confidently navigate complex applications remain a challenge. Gender also plays a significant role in this gap with studies indicating that only 57% of women in India have ever used the internet, compared to 75% of men.[68]

To bridge this gap, the market has adopted a phygital strategy. This is not merely a supplementary service but a core, strategic necessity. This model combines a scalable digital platform with a network of on-ground field agents, agri-preneurs, or FPO staff who serve as a last-mile human interface. They provide crucial services like onboarding, training, troubleshooting, and translating digital outputs into locally relevant, actionable advice. This human element builds the trust that a digital interface cannot, mitigating the barriers of both literacy and inherent skepticism.

3. Role of gender in technology access and design: The feminisation of Indian agriculture is a well-documented phenomenon. An estimated 73.2% of all rural women are engaged in agriculture, performing the majority of on-farm labour. However, this contribution is set against a backdrop of deep structural inequality: women own less than 14% of operational landholdings in India.[69] This creates a critical disjuncture for AgTech adoption: the primary user of a technology (the woman performing the labour) is often not the primary decision-maker or the owner of the enabling asset (the land and often, the smartphone).

This asymmetry necessitates a deliberate, gender-inclusive approach to technology design. Solutions must be built for this reality, incorporating features like voice-based commands to overcome literacy barriers, icon-heavy interfaces for intuitive use, and content tailored to the specific tasks predominantly handled by women (e.g. seeding, weeding, and post-harvest processing). Furthermore, leveraging self-help groups (SHGs), which have a vast and trusted network among rural women, is emerging as a highly effective channel for disseminating technology and financial services directly to this user base.

65 Standing committee on agriculture, animal husbandry and food processing, 2022-23
66 Press Information Bureau, "Decrease in Agricultural Holdings," Ministry of Agriculture & Farmers Welfare, 3 March 2020
67 News article, MEDIANAMA, January 2025, Rising rural adoption, AI integration—How India used Internet in 2024
68 National Family Health Survey (NFHS-5), 2019–21, reported in Times Now Digital, "Only 33% Of Women In India Use Internet, Men Account 57%,"18 December 2023
69 73.2% of rural women workers are farmers, but own only 12.8% land holdings." Business Standard, 9 September 2019

3b. Policy and regulatory environment

The government, at both the central and state levels, functions as the primary system architect for the agricultural economy. Its policies and regulatory frameworks acts as a powerful dual-edged sword that can either catalyse and accelerate innovation or curb it through ambiguity, complexity, and inertia. For AgTech startups and investors, navigating this environment is not a secondary concern but a primary strategic imperative. A nuanced understanding of the prevailing policy tailwinds and regulatory headwinds is therefore essential for assessing risk and identifying scalable opportunities.

(i) Enabling policies and catalytic initiatives

In recent years, policy momentum to foster a more technology-driven agricultural sector is developing to create foundational layers that innovators can build upon.

1. Rise of digital public infrastructure (DPI): India's pioneering approach to DPI is the most significant tailwind, creating a low-cost, high-trust environment for innovation.

- **Leveraging foundational DPI:** AgTechs are building on the core India Stack- Aadhaar for farmer KYC, UPI for low-cost payments, and DigiLocker for secure document management.
- **The AgriStack and India Digital Ecosystem of Agriculture (IDEA) as sector-specific DPI:** The vision for the IDEA is to create a comprehensive DPI by federating successful state initiatives like **Karnataka's Farmer Registration and Unified Beneficiary Information System (FRUITS), Telangana's Dharani portal, and Maharashtra's e-Peek Pahani** into a national framework. This architecture will also integrate the operational **'Pashu Aadhaar'** system, which assigns a unique digital ID to livestock. By linking the Farmer ID to both federated farm data and these individual asset records, the vision aims to create the foundational 'digital soil' for new generation of farm solutions. For AgTechs, this shift is monumental. It de-risks the ecosystem by providing verified identity and asset data, dramatically lowers the cost of farmer onboarding, and enables the development of sophisticated, data-driven financial and advisory products at a scale that is currently impossible.
- **Open Network for Digital Commerce (ONDC):** This emerging DPI aims to unbundle e-commerce. For AgTech, this presents a monumental opportunity for market-linkage startups to help FPOs and small traders gain access to a nationwide pool of buyers, fostering a decentralised market ecosystem as envisioned by policy architects.

2. Direct startup ecosystem support and demand creation:

- **AgriSURE fund:** This initiative is an ₹750 crore blended-capital alternative investment fund (AIF) designed to make **equity investments** in high-impact AgTech startups, directly addressing the venture funding gap for scaling innovations in frontier areas like AI, IoT, and biotechnology.
- **Production linked incentive (PLI) for food processing and exports:** The PLI scheme for food processing and a focus on boosting agri exports create a powerful **demand-pull** for quality and traceability. This incentivises large firms to partner with AgTechs specialising in precision farming, quality assaying, and **blockchain-enabled supply** chains to ensure consistent, traceable produce.
- **Rashtriya Krishi Vikas Yojana - Remunerative Approaches for Agriculture and Allied Sector Rejuvenation (RKVY-RAFTAAR) and Agri-Grand:** These programmes provide crucial, **early-stage grant funding** and incubation, acting as a vital pipeline that prepares startups for venture funding from AIFs like AgriSURE.



(ii) Regulatory barriers and ambiguities

Despite these positive developments, the regulatory landscape remains a complex maze that can create significant friction and uncertainty.

1. **Regulatory lag for frontier technologies and inputs:** While drone rules are liberalised, a significant area which needs to be addressed is the absence of an **anticipatory regulatory framework** for other frontier technologies. This includes:
   - **Lack of regulatory sandboxes:** The absence of regulatory sandboxes for AgTech slows down the testing of innovations where rules are undefined (e.g. liability for AI-based advisory, data standards for IoT devices, commercial use of gene-edited crops).
   - **Slow-moving agri-input regulations:** The regulatory pathway for frontier inputs like biologicals, bio-stimulants, and new genetic technologies remains slow and ill-suited for the rapid pace of biotech innovation, stifling the introduction of climate-resilient solutions.
2. **Fragmented agricultural markets:** Because agriculture is a state subject under the Indian constitution, the laws governing the marketing of agricultural produce (Agricultural Produce Market Committee Acts) vary significantly from one state to another. This legal fragmentation poses a major operational hurdle for market-linkage platforms that aim to create a seamless national marketplace. It creates compliance complexities and can limit the ability to enforce contracts or ensure smooth interstate trade, hindering the creation of a truly unified agricultural market.
3. **Data governance and interoperability challenges:** Despite the DPDP Act 2023, there's a lack of granular, sector-specific rules on data ownership, consent management, and crucially, inter-departmental data sharing protocols. The absence of standardised data formats across different government bodies creates digital silos, hindering the creation of a truly seamless AgriStack.
4. **Talent and digital literacy gap:** The success of frontier AgTech depends on a dual-sided talent pool: a critical mass of digitally literate farmers who can adopt new tools, and a domestic supply of experts in AI, remote sensing, and biotechnology focused on agriculture. Both remain significant bottlenecks.
5. **Slow-moving input regulations:** The path to market for innovative agricultural inputs, particularly in the biologics space (e.g. bio-fertilisers, bio-pesticides, bio-stimulants), can be slow and arduous. Products must navigate a complex regulatory pathway, such as the fertiliser (inorganic, organic or mixed) (control) Order, 1985, which was not originally designed for such novel products. The time and cost associated with generating efficacy data and gaining regulatory approval can be a significant barrier to entry, particularly for smaller startups, slowing the pace at which sustainable innovations reach the farm gate.

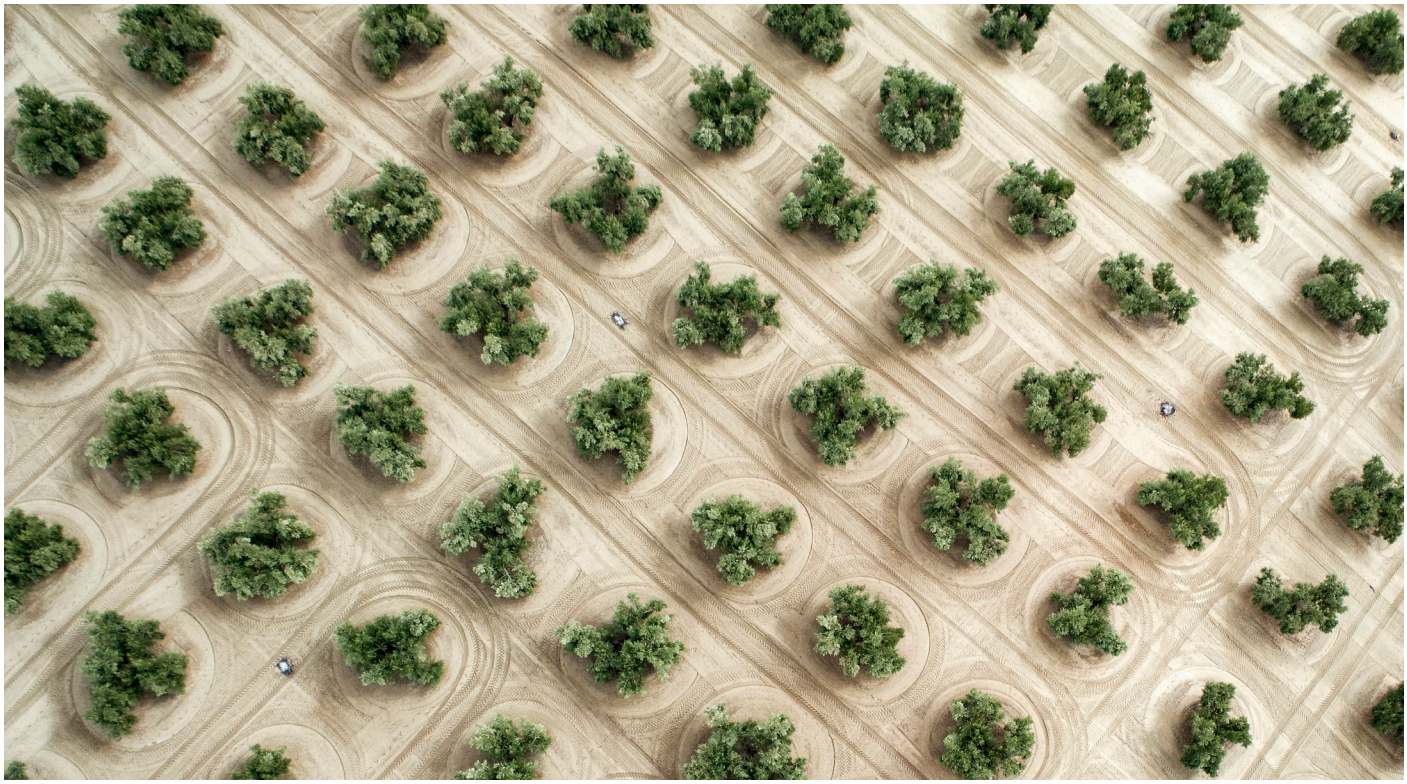
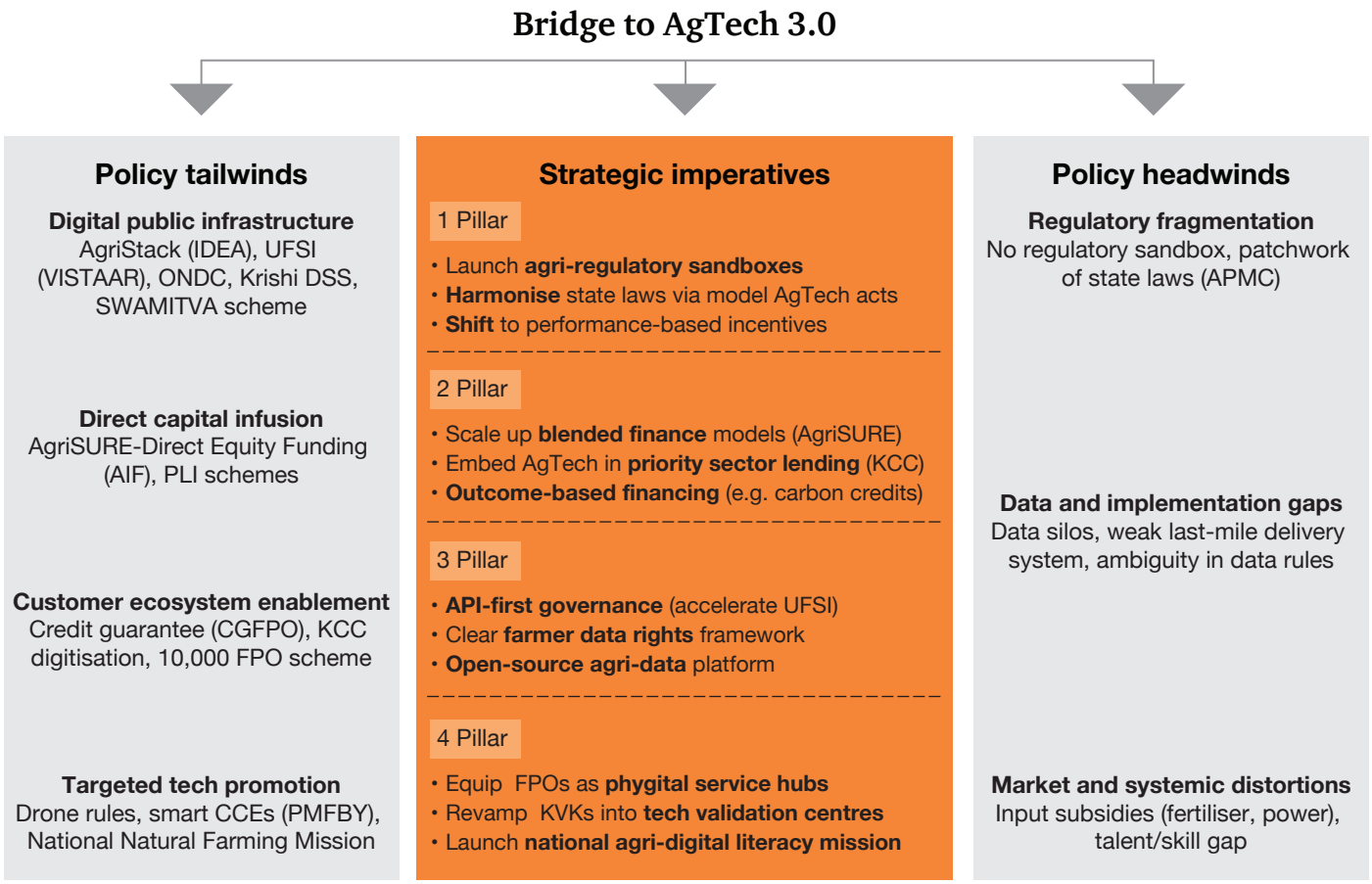


Figure 13: Policy and regulatory environment



Source: PwC analysis

Advancing Indian AgTech to its subsequent stage of development necessitates a fundamental re-architecting of its governing frameworks. This entails a transition from static regulations to agile, adaptive governance, characterised by the establishment of **agri-regulatory sandboxes** for frontier technologies and the promotion of national policy harmonisation to create a unified economic landscape. Concurrently, this new framework must be supported by capital strategies including the expansion of **blended finance models,** such as the AgriSURE fund, to mitigate risk for private investors; the development of **outcome-based financing mechanisms** like carbon credits; and the integration of technology adoption into mainstream credit through structured incentives within the Kisan Credit Card (KCC) scheme. The foundational layer for this structure is the **accelerated operationalisation of digital public infrastructure,** which requires mandating **API-first governance** to expand the utility of the Unified Farmer Service Interface (UFSI)/Virtually Integrated System to Access Agricultural Resources (VISTAAR) gateway and establishing a robust data governance framework that formally recognises farmer data ownership, thereby fostering the stakeholder confidence required for widespread adoption.

Systemic policy reforms, however, will prove ineffective without a corresponding strategy to address implementation challenges at the local level. Therefore, a second critical imperative is the strategic development of institutional and human capacity. This involves empowering **FPOs** to function as integrated physical-digital service hubs for technology demonstration, service delivery, and data aggregation, leveraging their enhanced access to institutional credit. Public extension services, such as **Krishi Vigyan Kendras (KVKs)**, must be re-envisioned as modern validation centres that can formally certify emerging technologies and train a new generation of local entrepreneurs. Ultimately, translating technological potential into tangible impact hinges on human capital. **A National Agri-Digital Literacy Mission** is, therefore, essential to enhance the digital competencies of farmers and to cultivate a professional unit of rural technology facilitators to ensure that modern agricultural tools are not merely available but are also accessible and effectively utilised at the farm gate.

3c. Infrastructure and accessibility: The physical and digital foundation

The most sophisticated AgTech solution is ultimately a theoretical construct until it can be reliably delivered and implemented within the physical reality of rural India. Infrastructure—both digital and physical—forms the fundamental rails upon which the entire AgTech ecosystem must operate. Deficiencies in this foundation do not merely slow down adoption; they dictate the very nature of viable business models, forcing companies into complex operational workarounds and hybrid strategies. A strategic analysis of infrastructure moves beyond simply noting its absence; it examines how these gaps create systemic friction and how successful AgTech models are architected to either navigate or directly monetise these deficiencies.

(i) The digital divide: A challenge of quality, not just quantity

While the narrative of a Digital India is compelling at a macro level, the reality at the last mile is defined by a paradox of pervasive access and qualitative deficiencies. This multi-layered challenge defines the practical boundaries of technological deployment.

1. **The last mile connectivity gap:** While rural tele-density reached 58.3% as of late 2024,[70] indicating widespread mobile signal availability, this top-line number masks a deep quality-of-service issue. A significant portion of rural India remains on slower 2G/3G networks, and even in areas with 4G coverage, inconsistent signal strength and low bandwidth are persistent problems. This has profound business model implications. According to a 2024 report, only 41%[71] of the rural population, or approximately 385 million people, are active internet users. This means that nearly 60% of the rural populace is still offline. For those who are online, low bandwidth makes data-intensive applications impractical. The strategic response from leading AgTech firms has been to engineer for this constraint by building 'offline-first' applications that can operate without a live connection and sync data opportunistically.
2. **The energy deficit:** The digital experience is contingent on a reliable power supply. However, the quality and duration of electricity in rural India remain highly variable. A comprehensive survey found that while 97% of households had an electricity connection, rural households in states like Uttar Pradesh received, on average, only 18 hours of supply per day,[72] with frequent voltage fluctuations. This energy deficit is a direct impediment to consistent device charging and, more critically, to the operation of hardware-based AgTech solutions. IoT gateways and automated farm equipment require 24x7 power, a reality that forces solution providers to integrate costly solar power and battery backup systems, fundamentally altering the unit economics of their offerings.
3. **Device heterogeneity as a product constraint:** The digital access point for the vast majority of farmers is a low-cost Android smartphone. The sub-$200 (~₹16,000) price segment accounts for over 58% of the Indian smartphone market.[73] This introduces the engineering challenge of extreme device heterogeneity. These entry-level devices are characterised by limited processing power, low RAM (often 2–4 GB), minimal internal storage, and older OS versions. An application that works seamlessly on a mid-range phone may crash or lag on the devices most farmers actually use. Successful AgTech companies recognise this not as a technical inconvenience but as a core product strategy constraint, investing heavily in building extremely light, memory-efficient applications that can perform reliably on this hardware base.

(ii) The physical infrastructure chasm: A source of both friction and opportunity

An analysis of India's rural physical infrastructure reveals critical deficiencies that span the complete agricultural value chain. These gaps, extending from the last-mile delivery of inputs to the first-mile procurement of produce, function as both formidable operational barriers and, for strategic innovators, as significant opportunities for value creation.

1. **Water and micro-irrigation infrastructure:** As agriculture consumes over 87% of India's annual extractable ground water resource,[74] water infrastructure is paramount. However, the penetration of modern micro-irrigation systems (MIS), such as drip and sprinkler, remains critically low—covering only about 17% of India's

70 Telecom Regulatory Authority of India. (2024, November)
71 News article, MEDIANAMA, January 2025, Rising rural adoption, AI integration—How India used Internet in 2024
72 Ministry of Power, Government of India. 24x7 Power for All. Ministry of Power, 2017.
73 IDC (2024, August)
74 Ministry of Jal shakti, Government of India. (March, 2023). Ensuring optimum utilisation of water in agriculture sector

estimated potential of 69.5 million hectares.[75] An AgTech solution offering precise irrigation scheduling via soil moisture sensors is rendered ineffective if the farmer lacks the physical infrastructure to control water application at a granular level. The value of precision irrigation technology is unlocked only in the presence of this foundational on-farm infrastructure.

2. **Agri-input logistics and storage:** The efficiency of the input supply chain is as critical as the output chain. The last mile is serviced by a highly fragmented network of agri-retailers, often with broken supply chains and limited quality assurance.[76] This creates two problems: lack of timely availability and the prevalence of counterfeit products, with estimates suggesting that spurious pesticides can account for up to 25–30% of the market by volume. This forces farmers into suboptimal choices and renders AgTech advisory platforms less effective if their recommendations cannot be acted upon with trusted products. It is this gap that is compelling many AgTech platforms to integrate vertically into input delivery, creating a full-stack model that combines advisory with an assured supply of quality inputs.

3. **Quality assessment and assay infrastructure:** The premise of precision agriculture and premium market linkages rests on verifiable data, yet the infrastructure for quality assessment is severely underdeveloped.

- **Soil testing:** While the Soil Health Card scheme is a commendable initiative, its operational effectiveness is hampered by a sparse network of static labs, leading to long turnaround times (often weeks) and generic recommendations. The lack of accessible, rapid, and affordable soil testing infrastructure at the village level dilutes the value proposition of any precision nutrient management platform.
- **Produce assaying:** At the market end, there is a lack of standardised, trusted, and scalable produce assaying infrastructure at the point of collection. This leads to subjective pricing based on visual inspection, perpetuating information asymmetry and value loss for the farmer. AgTech platforms aiming to facilitate quality-based pricing are often forced to invest in their own expensive assaying equipment at each collection centre—a significant capital expenditure that hinders scalability.
- **Post-harvest logistics and the cold chain:** India's cold chain is critically underdeveloped, with a 98% gap in required farm-gate pack-houses and a massive shortfall in refrigerated vehicles. These systemic inefficiencies result in annual post-harvest losses of fruits and vegetables estimated at ₹57,000 crore (approx. $8 billion). For downstream AgTech enterprises, this systemic friction constitutes the core commercial opportunity.[77]



The phygital model as a holistic strategic response

The convergence of this expanded set of digital and physical infrastructure deficits has established the 'phygital' model as the dominant and most resilient strategic paradigm. It is a market-driven response, marrying a scalable digital platform for data intelligence with a network of physical assets and personnel. This physical layer does not just provide last-mile digital connectivity—it provides input warehousing, facilitates quality assessment, acts as a logistics hub, and builds trust. It is an operationally intensive, but strategically necessary, approach to delivering tangible value within the complex realities of India's infrastructural landscape.

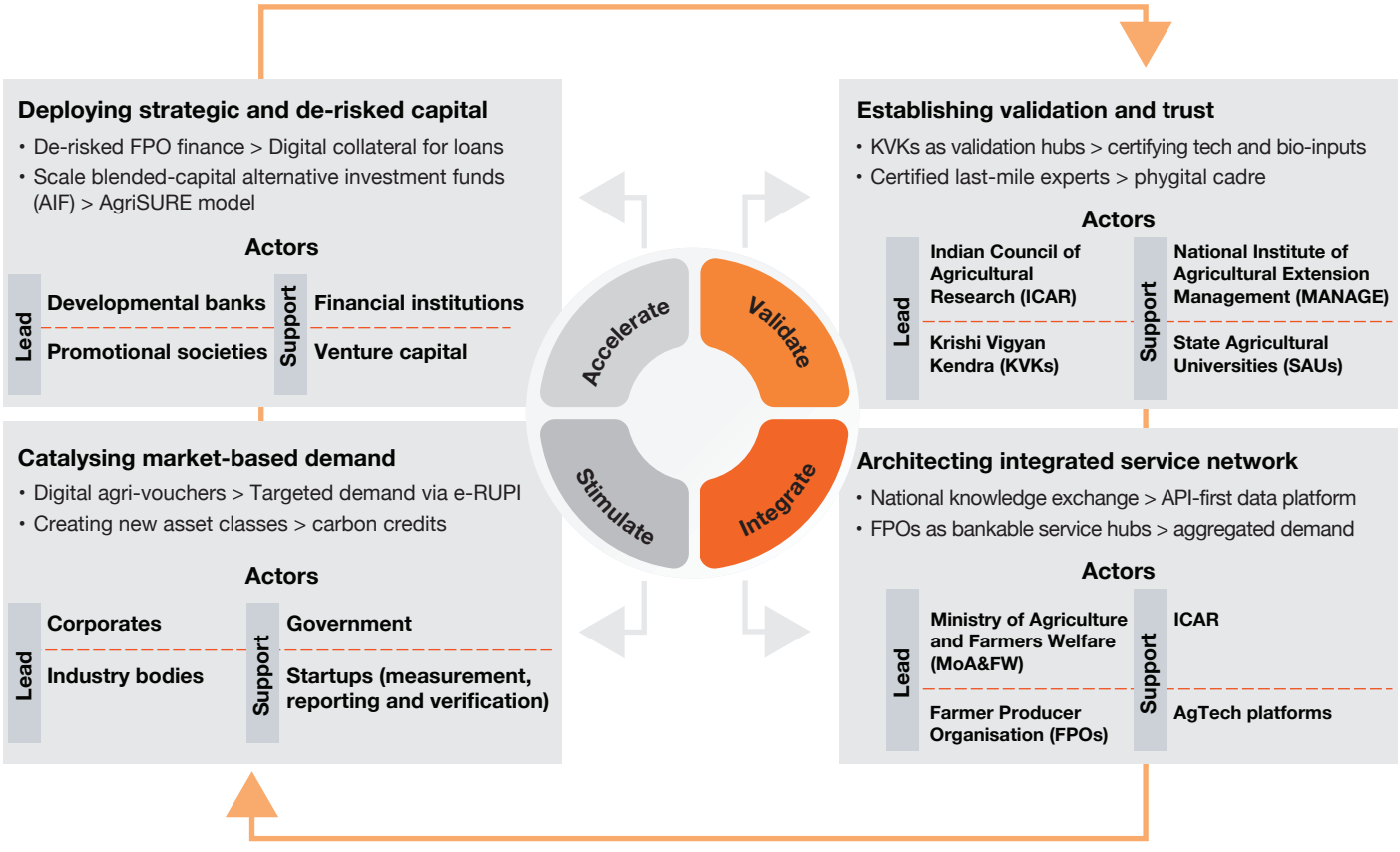
75 Ministry of Agriculture & Farmers Welfare, Government of India. (2024, April). Five-year action plan on micro irrigation through Per Drop More Crop Scheme
76 Forvis Mazars. (2025, April). Counterfeit fertilisers and pesticides flood farms. Economic Times
77 Ministry of Food Processing Industries (MoFPI), Rajya Sabha Reply (December 2024)

04

Strategies for enhancing AgTech diffusion

The successful diffusion of agricultural technology is the critical link between innovation and impact, requiring a move from isolated pilot projects to systemic, nationwide adoption. As established, this potential remains constrained by deep-seated structural and human capital barriers. The preceding analysis reveals that linear, top-down interventions are insufficient to bridge this gap, necessitating a fundamental strategic shift: a move from a fragmented 'push' of technology to the creation of a self-sustaining 'pull' from the market. To achieve this, we introduce the Agtech diffusion strategy, a deliberate national strategy designed as a dynamic, self-reinforcing engine for transformation. The logic of this framework dictates that momentum is built sequentially and cyclically: it begins with validating technology to build trust, then integrating these elements into a unified network, followed by stimulating market-based demand, and finally accelerating the entire cycle with strategic capital. the following infographic details this model, illustrating how each component builds momentum for the next, driving systemic and exponential AgTech diffusion.

Figure 14: Suggested strategies for enhancing AgTech diffusion



This multi-pronged strategy addresses the ecosystem holistically rather than in silos. It rests on three foundational pillars:

- Modernising the trusted institution of extension services by integrating it into a hybrid phygital architecture
- Launching a comprehensive capacity-building mission to create the necessary absorptive capacity for technology across the entire agricultural value chain
- Actively engineering and de-risking the collaborations between stakeholders that are essential for creating a self-reinforcing innovation cycle.



4a. Strengthening extension services through a hybrid phygital model

India's traditional public extension system, anchored by the KVKs, possesses immense scientific credibility but has long been constrained by a low agent-to-farmer ratio, limiting its last-mile reach. Simultaneously, the private sector has deployed thousands of on-ground agents who possess reach but may lack scientific validation and a holistic service portfolio. The strategic imperative is not to choose between these two but to architect a hybrid model that combines the scale of private networks with the rigor of public institutions.

1. **Synthesising and elevating last-mile certification:** The first step is to consolidate and elevate the existing, fragmented certification landscape for agricultural professionals. While programmes like the Agriculture Skill Council of India (ASCI)'s various qualification packs (QPs) and the National Institute of Agricultural Extension Management (MANAGE)'s respected DAESI diploma provide a strong foundation, they are not tailored for the tech-centric, multi-disciplinary demands of the modern AgTech ecosystem. The imperative is to create a new, apex-level certification: Certified Agri-Service Entrepreneur. This programme, delivered via a network of CSCs and KVKs, would be transformative because it would:

- **Integrate a comprehensive curriculum:** It would synthesise essential modules from existing ASCI QPs (e.g. integrated pest management, soil and water sample analysis) while adding a mandatory and robust phygital core.
- **Incorporate a phygital core:** This new core curriculum, co-developed with leading AgTech companies, would focus on practical, operational skills: using market linkage and input commerce apps; operating FinTech platforms for loan facilitation and insurance claims; understanding the basics of drone data and IoT sensor readings; and leveraging digital tools for FPO management.
- **Establish clear industry recognition:** This certification should become a recognised standard of excellence. The Government should designate certified individuals as preferred partners for public schemes, while banks should be encouraged to recognise them for business correspondent (BC) roles. AgTech platforms would naturally prioritise them for premium partnerships, creating a virtuous cycle of professionalisation and trust.

2. **Creating an integrated, bi-directional knowledge platform:** The backbone of a successful hybrid model is the seamless, real-time flow of information. The Government, through the Indian Council of Agricultural Research (ICAR), should spearhead the creation of a unified, open-source, API-first digital knowledge platform. This platform would not be another farmer-facing app but a 'system of systems' that would:

- **Push validated advisories:** Enable scientists at KVKs and state agricultural universities to push validated, geo-specific advisories (e.g. pest outbreak alerts based on weather patterns, ideal sowing dates) via APIs directly to the mobile applications used by the entire network of certified private agents.
- **Pull field-level data:** Critically, it would facilitate a two-way information flow. AgTech platforms could, with farmer consent, channel anonymised field-level data (e.g. thousands of farmers reporting a specific pest via an app's photo feature) back to the ICAR's research bodies. This creates a powerful, real-time feedback loop, allowing for faster response to emerging agricultural challenges and validating research with on-ground data.

3. **Evolving the mandate of public extension bodies:** With private agents handling high-frequency, last-mile information dissemination, the role of public extension bodies like KVKs can be strategically repositioned for higher-value activities, ensuring their continued relevance and leadership. Their evolved mandate would include:

- **Becoming hubs for training the trainers:** KVKs would become the primary physical institutions for delivering practical, hands-on components of the new Certified Agri-Service Entrepreneur programme.
- **Serving as impartial AgTech validators:** KVKs would run unbiased, local trials for new technologies—be it a new biological input or a new software platform—and publish official AgTech validation reports. This would be an invaluable service, helping farmers and FPOs make informed adoption decisions and separating credible solutions from the marketing hype.
- **Functioning as Level 3 diagnostic centres:** They would serve as the apex of a tiered advisory system, handling complex agronomic and soil health issues escalated to them by the on-ground agents who manage day-to-day queries.

4b. Capacity building and training programmes for the entire ecosystem

The successful diffusion of technology is ultimately limited by the ecosystem's absorptive capacity—the ability of individuals and organisations to recognise, value, and effectively utilise new innovations. A national capacity-building mission is therefore not a peripheral activity but a core pre-requisite for scaling AgTech. This mission must be comprehensive, addressing the distinct needs of farmers, last-mile agents, and the professional talent pool.

1. For farmers—a tiered approach to digital and financial literacy: Training must be practical, vernacular, highly visual, and designed to build confidence in a stepwise manner. A national digital literacy mission for agriculture should be structured in three tiers:

- **Tier 1 (digital onboarding):** Focus on foundational skills delivered via assisted-mode training at CSCs and FPO meetings. This includes setting up and using UPI, scanning QR codes, using voice notes for communication, and understanding the basics of smartphone security.
- **Tier 2 (applied digital skills):** Focus on using specific applications to improve decision-making. This involves video-based, just-in-time modules on interpreting weather forecasts from an app, comparing prices on market linkage platforms, and understanding pest/disease alerts.
- **Tier 3 (farm-as-a-business):** Aimed at more progressive farmers and FPO leaders, this tier would focus on using simple digital tools for record-keeping, calculating profit and loss per crop cycle, and managing digital credit statements.

2. For agri-service entrepreneurs—building a holistic portfolio of competencies: The training for this critical cadre must create a 'generalist-specialist' capable of handling a wide array of on-ground tasks. The curriculum for the Certified Agri-Service Entrepreneur programme, developed in partnership with national agri-finance and development institutions and leading AgTech firms, must cover:

- **Technical and agronomic skills:** Advanced soil sample collection methods, principles of integrated nutrient management and integrated pest management, water quality testing, basic maintenance of IoT sensors, and regulatory protocols for drone facilitation.
- **Financial and FinTech skills:** Detailed understanding of PMFBY, KCC, and other credit schemes; hands-on training on agri-FinTech platforms for loan applications; facilitating the creation of electronic-negotiable warehouse receipts; and principles of risk assessment.
- **Commercial and managerial skills:** Business plan development for FPOs, group management and conflict resolution techniques, inventory management for agri-inputs, and effective use of CRM tools to manage farmer relationships.

3. For AgTech professionals—cultivating a phygital talent pool: To address the critical shortage of talent with expertise in both agriculture and technology, a strategic intervention is required to create a new generation of leaders.

- **Experiential learning:** This prestigious two-year fellowship would select top graduates from premier engineering, management, and agricultural universities. Fellows would undergo an intensive bootcamp co-

designed by institutions such as IIMs and ICAR, followed by deployment where they work directly within an FPO, a state agriculture department, or an early-stage AgTech startup. This would create a pipeline of future executives and policymakers with invaluable, ground-level experience.

- **Integrate curricula at the university level:** UGC and ICAR should mandate the integration of cross-disciplinary courses. Agricultural universities must have compulsory modules on data science, GIS, and business analytics, while engineering institutions should offer specialised streams and final-year projects focused on solving real-world agricultural challenges sourced from industry partners.

4c. Promoting collaborations between stakeholders

Value creation in a complex ecosystem occurs at the intersections between different stakeholders. Silos are the primary impediment to scale. Therefore, the Government must transition from being a simple funder to an active orchestrator of collaboration, creating environments where partnerships are not just possible but actively de-risked and incentivised.

1. Government as an orchestrator of innovation hubs: As proposed in earlier sections, the Government should actively engineer the 'triple helix' model. Using the framework of RKVY-RAFTAAR, designated Agri-Innovation Hubs should be established with a formal charter that mandates joint, time-bound projects. For example, a hub in Maharashtra could be chartered to create a shelf-stable tomato value chain, requiring joint R&D between a university (for a new variety), a food processing corporate (for offtake), an AgTech startup (for traceability tech), and the state government (for policy support).

2. De-risking the triad of startup-FPO-FinTech partnerships: This is arguably the most powerful combination for unlocking smallholder value. The Government, through its national agri-finance and development institutions, can act as a catalyst by designing a dedicated AgTech Partnership Fund. This fund would:

- **Act as a coordinator and due diligence partner:** Create a verified platform to connect high-potential AgTech startups with FPOs that require their specific solutions, reducing search costs for both.
- **Provide a first-loss default guarantee (FLDG):** The fund would provide an FLDG (e.g. covering the first 10% of losses) on a portfolio of loans extended by a financial institution (bank or NBFC) to an FPO, where the loan is used to adopt technology from the partner AgTech startup. This elegantly de-risks the proposition for the lender, encouraging them to finance technology adoption. The AgTech platform's data, in turn, acts as a form of digital collateral, improving underwriting.

3. Incentivising corporate-startup open innovation: Large agribusinesses and food companies possess scale, market access, and patient capital, while startups offer agility and disruptive technology. To bridge the cultural and operational gap between them, policy should actively promote open innovation through:

- **Structured 'grand challenges':** The government, in partnership with industry bodies, should launch high-profile 'agri-grand challenges'. These would offer significant prize money and, more importantly, guaranteed procurement contracts for startups that can solve specific, well-defined industry problems (e.g. an affordable, scalable solution for aflatoxin detection in maize).
- **Corporate venture and pilot programmes:** Policy can offer tax incentives or co-investment grants for large corporations that establish dedicated CVC arms focused on Indian AgTech or launch structured accelerator programmes to pilot technologies from multiple startups within their own supply chains.

By implementing these interconnected strategies for extension, capacity building, and collaboration, India can create the fertile, supportive ecosystem necessary for agricultural technology to transition from a promising niche to a transformative national force.

05

Future prospects and recommendations: Charting India's path to global AgTech leadership

India's AgTech sector stands at a pivotal inflection point. The journey thus far has successfully demonstrated proof of concept, creating tangible impacts on farmer livelihoods and building the foundational layers of a digital agricultural ecosystem. The challenge ahead is to transition from this phase of incremental progress to one of exponential, systemic transformation. This requires a dual focus: anticipating and harnessing the next wave of disruptive technologies, and simultaneously executing a bold policy agenda that removes structural barriers and aligns national priorities with technological adoption. This concluding section outlines the emerging frontiers of AgTech and distils our analysis into a set of core strategic recommendations designed to secure India's position as a global leader in building a resilient, profitable, and sustainable agricultural future.

(i) Bridging the farm-tech divide

To translate the promise of AgTech into a nationwide reality, India requires a set of bold, synergistic policy missions. These are not incremental adjustments, but strategic interventions designed to create powerful 'pull' factors for technology adoption and unlock private innovation at scale. Drawing from the analysis throughout this report, we recommend three interconnected national missions that are politically astute, operationally viable, and positioned for maximum impact.

A multi-stakeholder playbook for national transformation

The preceding analysis has established the immense potential of agricultural technology to catalyse a second green revolution in India. However, the paper's findings also reveal a critical farm-tech divide—a chasm between high-level investment and grassroots adoption, where less than 15% of India's 146 million farmers have been reached. This gap is not a technology problem—it is an ecosystem problem, rooted in fragmented policies, misaligned incentives, and a lack of trust at the last mile.

To bridge the farm-tech divide, the proposed framework suggests a moves from building strategic ecosystems and enablers to driving collaborative, user-centric innovation, and finally to hyper-scalable adoption with real-world value creation, a multi-stakeholder policy and action playbook designed to systematically cultivate a thriving and equitable AgTech ecosystem. This framework moves beyond a government-centric view to outline a set of interdependent actions for all key stakeholders. Furthermore, it provides a shared roadmap to transform a landscape of isolated pilots into a self-reinforcing cycle of innovation, validation, and inclusive value creation—capable of unlocking the sector's projected $34 billion addressable market.

Pillars of the framework

The three distinguishable streams of the framework assign clear roles and responsibilities, have a principal actor, and one or more supporting actors. The three streams will run in parallel, despite dependencies among them, as highlighted below:

a) **SEED (strategic ecosystem and enablers development):** This pillar details the foundational actions to be undertaken primarily by the Government and academia

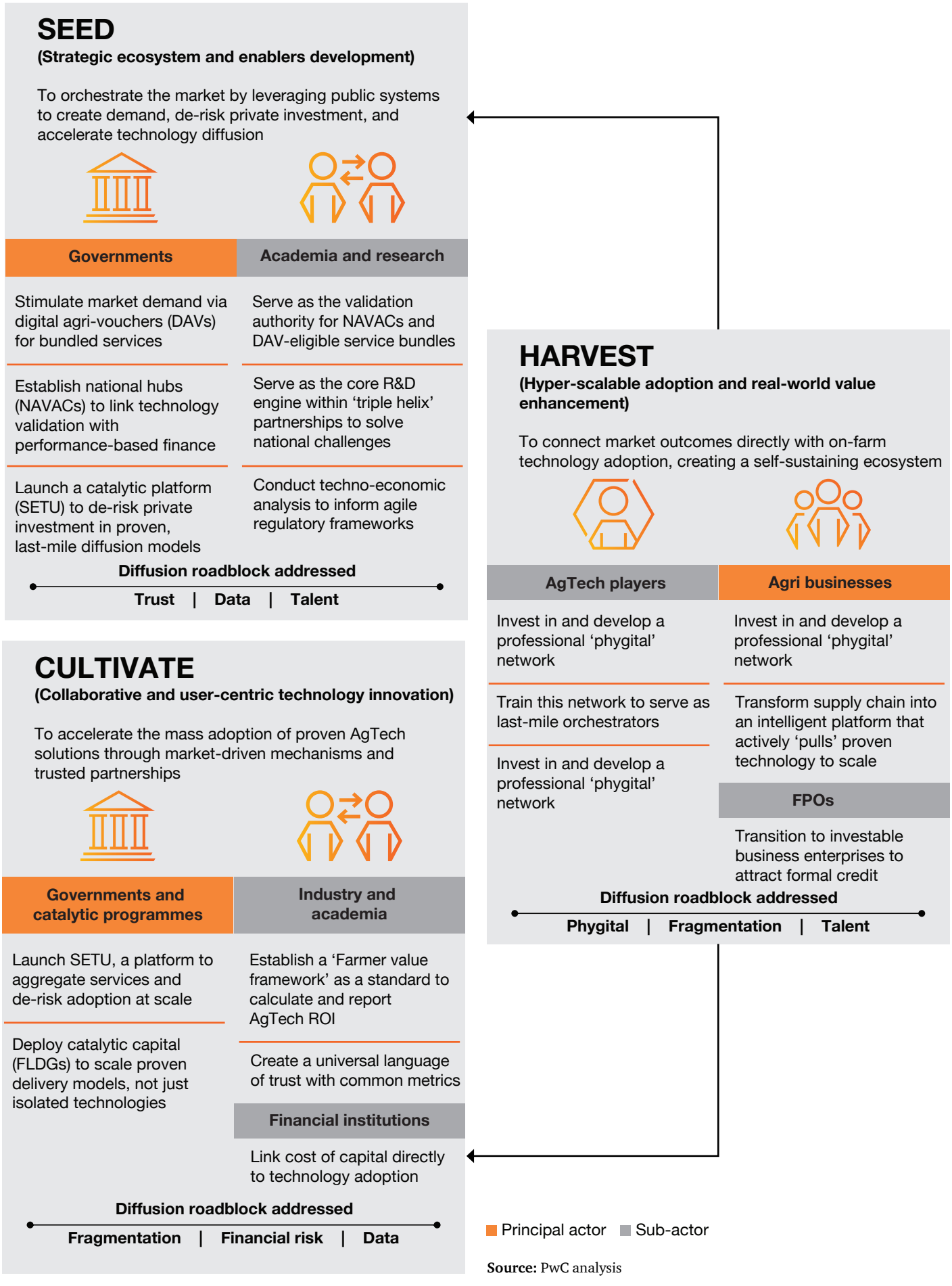


to engineer a de-risked and predictable operating environment by integrating existing solutions and innovations. It focuses on creating essential public goods, market-making policies, and collaborative innovation platforms that form the bedrock upon which private sector solutions can be built and scaled responsibly.

b) **CULTIVATE (collaborative and user-centric technology innovation):** This pillar is a call to action for technology firms, financial institutions, and academia—to innovate on both products and business models. It focuses on developing scalable, affordable solutions and the commercial mechanisms required to drive their adoption.

c) **HARVEST (hyper-scalable adoption and real-world value enhancement services):** This pillar focuses on the critical last-mile players—agribusinesses, FPOs, and on-ground entrepreneurs—who translate technology potential into tangible farm-gate value. It focuses on building viable, scalable business models that create powerful commercial 'pull' for technology, enhance the institutional capacity of farmer collectives, and professionalise the human support network required for a sustained, grassroot-level impact.

Figure 15: Pillars of multi-stakeholder playbook for national transformation



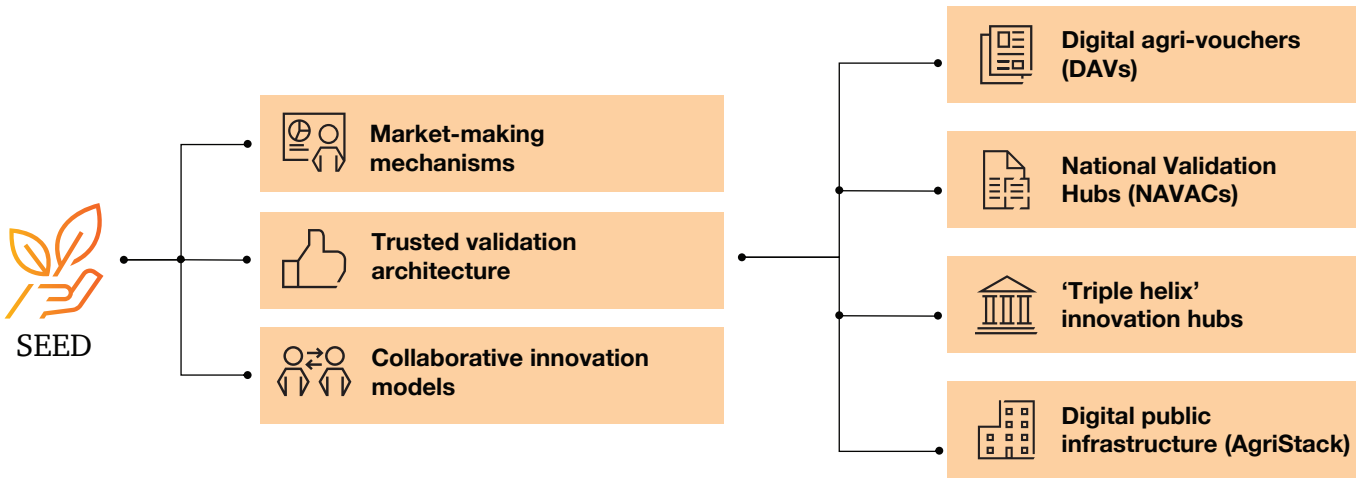
Source: PwC analysis

SEED: Actions for the Government and academia

1 Pillar

The **SEED** stream creates a predictable, enabling, and de-risked environment that attracts long-term investment and streamlines the adoption of responsible AgTech.

Figure 16: SEED: Actions for the government and academia



Source: PwC analysis

The Government's most powerful role is not that of a direct provider of technology, but as the **facilitator, orchestrator of the ecosystem, and integrator of existing solutions and innovations.**

a) Evolve from DPI development to market-making

With foundational DPI like **AgriStack** established, the Government can evolve the existing system to engineer a vibrant agri-services market. This can be achieved by deploying targeted **digital agri-vouchers (DAVs)**, leveraging the successful and leakage-proof precedent set by the **National Health Authority's use of the e-RUPI platform.** In this closed-loop system, farmers would use their vouchers to choose from a digital registry of providers—certified for quality by the ICAR/SAU network—and access them through a **phygital model** via apps or assisted at local CSCs/FPOs. The payment to providers would be contingent on verifiable service delivery, confirmed on AgriStack involving the provider, the farmer, and immutable digital evidence. This model has the potential to **transform subsidies into a genuine, demand-driven market** that empowers smallholder farmers, rewards AgTech players, and creates the powerful 'flywheel effect' needed for holistic solutions to achieve mass scale of diffusion. For farmers, this replaces scepticism with empowerment, allowing them to confidently choose a quality-assured service and directly overcoming the critical adoption roadblock of trust.

b) Establish national hubs for AgTech validation and commercialisation

It is important to strategically evolve existing AgTech **hubs**, operated with ICAR/SAUs/CoEs, to **move beyond testing to active market enablement.** Functioning as **solution validation sandboxes,** these hubs would **test and certify bundled solutions,** producing a standardised **solution efficacy and economic impact assessment.** This single, credible output can be the key to unlocking mass diffusion by providing the trusted seal of quality needed to build farmer trust, while simultaneously giving financial institutions the **data required to shift from asset- to performance-based underwriting** for technology adoption loans, thereby forging the **critical link between proven innovation and accessible capital.**

c) Forge 'triple helix' innovation hubs

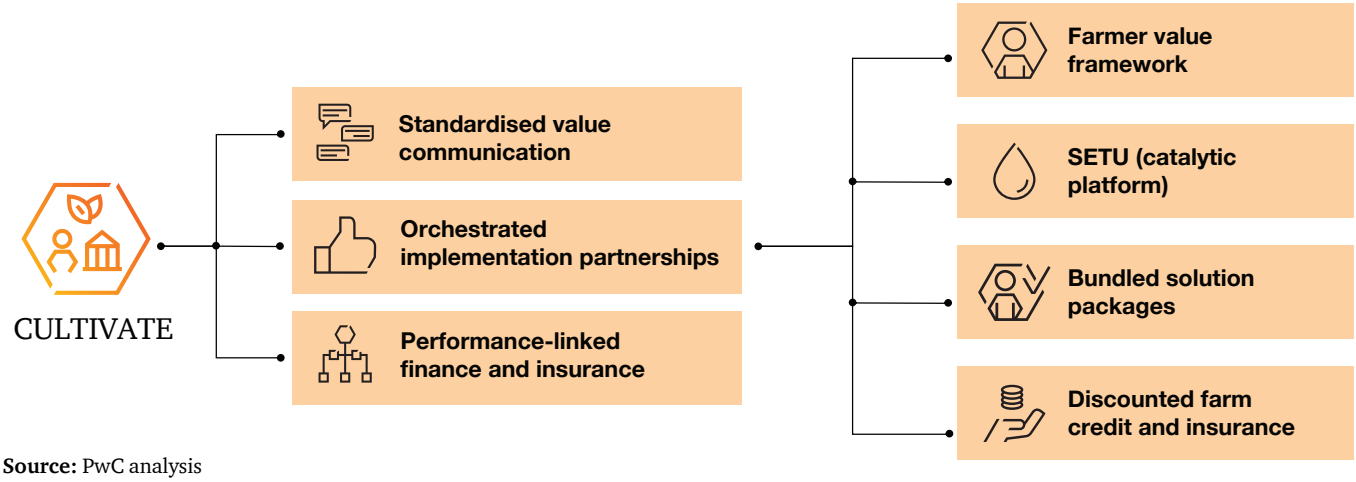
By emulating **Netherlands' Wageningen University,** where **government, industry, and academia co-develop** to solve critical challenges. India can operationalise this by establishing mission-oriented partnerships through platforms like **AgHub Telangana** or by creating new initiatives modelled on the **UK's AgriTech Catalyst.** A consortium of private companies, for instance, could partner with a designated **ICAR institute** to develop climate-resilient seed varieties, leveraging the immense scientific capacity of India's 104 ICAR institutes and 74 agricultural universities. This institutionalises a ground-up approach, transforming the innovation model from 'innovate, then sell' to 'co-create, then scale'. By aligning the nation's top scientific and commercial expertise, this model directly fosters the high-level talent required to solve agriculture's most complex challenges, ensuring the resulting innovations are born with inherent trust and market relevance.

CULTIVATE: Actions for the AgTech industry and academia

2 Pillar

The **CULTIVATE** stream drives the creation of affordable, scalable, and contextually relevant solutions by fostering deep collaboration and focusing on real-world farmer needs.

Figure 17: CULTIVATE: Actions for the AgTech industry and academia



Source: PwC analysis

The role of the private sector is to act as **innovators and scalers,** while academia serves as **knowledge anchors,** collectively shifting from isolated R&D to co-creating solutions designed for real-world adoption.

a) Standardise value communication to accelerate adoption

To overcome the primary barrier to adoption—farmer scepticism fuelled by a confusing array of competing ROI claim—academia and industry bodies must forge a standardised, open-source **Farmer Value Framework.** This framework would establish a common methodology and **a credible set of metrics** (e.g. net income gains per acre, reduction in key input costs) for calculating and reporting the impact by any AgTech player. Its purpose will be to create a universal language of trust, allowing farmers and FPOs to **compare different solution providers using consistent, objective criteria.** This will move the entire industry from a landscape of ambiguous marketing claims to one of verifiable impact, transforming the farmer's adoption decision from a leap of faith into a confident, evidence-based business choice. This directly counters the market's information fragmentation by creating a universal language for value, replacing ambiguous claims with the verifiable data farmers need to make confident, evidence-based adoption decisions.

b) Orchestrate high-impact implementation partnerships

Enabling partners such as the Government and development finance institutions can launch a multi-stakeholder catalytic platform, which would operate as a dynamic diffusion engine and a platform that acts as a **service aggregator,** de-risking partners/engagements. Platform's core function would be to first conduct data-driven **solutioning** to map high-impact AgTech solutions to priority value chains, and then to identify and back the most effective **delivery mechanisms.** It would bring together various private sector **partners** (in finance, technology, inputs, market linkage) and **bundle** their individual offerings into a **single, accessible package** for the farmers. To activate this ecosystem, this platform would deploy catalytic capital, like FLDG—not to fund technology in isolation, but to de-risk and scale the entire **proven diffusion model,** thereby bridging the critical gap between capital, technology, and sustainable mass adoption. This platform directly counters market fragmentation by aggregating services and mitigates financial risk for all partners through catalytic capital, enabling proven diffusion models to scale.

c) Link credit and insurance to technology adoption

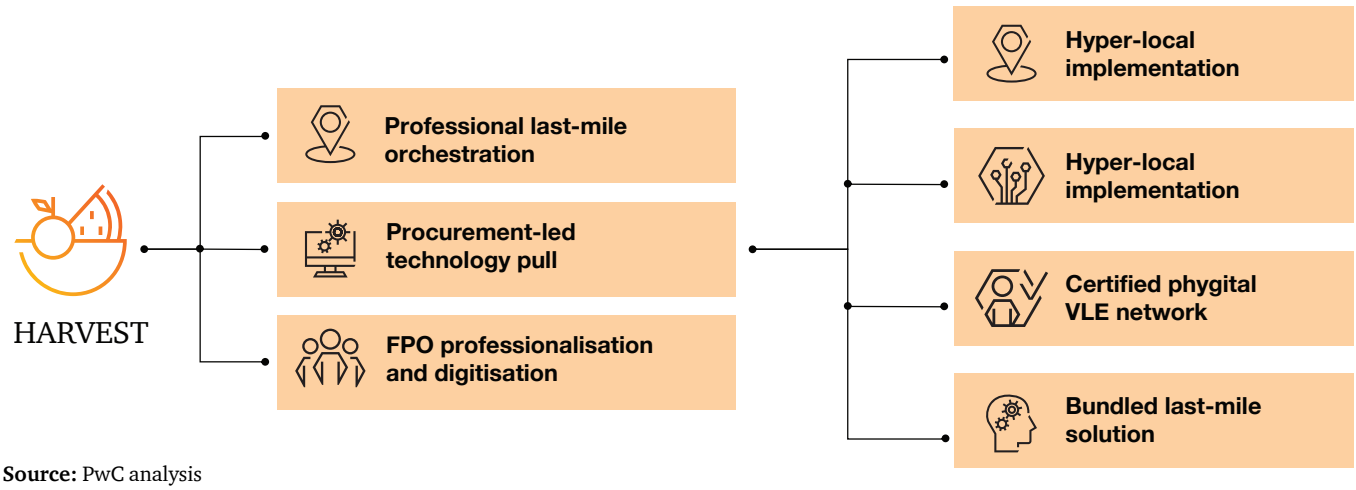
To create a powerful **market-based 'pull'** for proven technology, financial service providers need to adopt dynamic, performance-based models. Leveraging data from AgriStack and the trusted impact ratings from National hubs for AgTech Validation and Commercialisation, lenders can directly link the cost of capital to a farmer's adoption of certified risk-mitigating technologies. A farmer using an AAA-rated drip irrigation solution, for example, should automatically qualify for a **lower interest rate on their KCC.** Similarly, insurance providers can **design more accurate parametric products under PMFBY** that offer **premium discounts and faster payouts** for farmers adopting validated, climate-resilient practices, thereby directly rewarding them for de-risking their farm operations. This approach creates a powerful incentive that directly mitigates the financial risk of adoption, transforming the ecosystem's trusted data into tangible rewards and better protection for farmers.

HARVEST: Actions for the last-mile ecosystem and service providers

3 Pillar

The **HARVEST** stream aims to build viable, scalable business models that deliver tangible value to the farmer by integrating technology with essential financial, market, and advisory services.

Figure 18: HARVEST: Actions for the last-mile ecosystem and service providers



Source: PwC analysis

The role of the last-mile ecosystem is to act as the essential **connectors** and **enablers**, building viable business models that translate technology adoption into measurable farm-gate value.

a) Re-architect supply chains into platforms for technology pull

The most powerful lever large agribusinesses possess is their procurement power. These businesses should aim to transition from a transactional procurement model to a partnership-based value chain where technology adoption is a core component of sourcing agreements. Instead of simply buying produce, companies must actively shape how it is grown by embedding technology into their commercial relationships. For instance, a global food company sourcing processing-grade potatoes can mandate the use of certified IoT sensors to monitor soil moisture and storage conditions, making this a prerequisite for premium pricing. This **transforms the supply chain from a simple cost centre into an intelligent, de-risked asset,** and directly **'pulls'** proven technology into the ecosystem at scale. This procurement-led demand creates a powerful, unified market signal that directly counters ecosystem fragmentation, establishing a clear commercial pathway for proven technology to achieve scale.

b) Evolve from subsidised collectives to bankable business enterprises

FPOs should adopt a full suite of digital management tools for **governance, procurement, inventory, and finance.** This creates an immutable, auditable track record of commercial operations, solving the core 'trust deficit' that makes them un-bankable to formal lenders. FPOs must leverage the scale provided by the government's 10,000 FPOs scheme to act as sophisticated **'anchor clients'** for the AgTech ecosystem, offering start-ups a consolidated user base for pilots in exchange for preferential pricing. This digital transformation, supported by capacity-building from the **Government and development finance institutions,** will be the non-negotiable path to graduating from subsidised collectives to professional, investable enterprises. This digital transformation directly counters market fragmentation by enabling FPOs to serve as credible, large-scale anchor clients for both the AgTech ecosystem and formal financial institutions.

c) Professionalise the 'phygital' network of agri-entrepreneurs

To effectively scale, AgTech platforms must invest in **building and certifying a professional network of phygital village-level entrepreneurs (community representatives)**—comprising producer organisations, cooperatives, SHGs, and technical cadres like drone didis. This network must be trained to serve as sophisticated **last-mile orchestrators,** expertly guiding farmers through the **critical five-stage journey of technology adoption:**

- Building **awareness** and **persuasion** by establishing **local model demo farms** and showcasing tangible results
- De-risking the **decision** for farmers by acting as the single point of access for **bundled solutions** (tech, finance, inputs)
- Ensuring successful **implementation** by providing hands-on, data-driven advisory and troubleshooting support directly to the farmers

- Driving **confirmation** by connecting the farmers and FPO's aggregated produce to better markets and demonstrating a clear, collective increase in profitability

This initiative directly addresses the critical phygital gap by creating a trusted human interface for technology, while simultaneously building the skilled last-mile talent required to orchestrate services and drive adoption at scale.

d) The self-sustaining value loop

The entire system is powered by a continuous loop of contributions and motivation. Government provides legitimacy; private partners provide services; AEs provide trust; and crucially, farmers provide data, adopt practices, and repay for services. In return, the Government achieves its policy goals, private partners gain access to a de-risked and profitable customer base, AEs build a sustainable local business, and farmers achieve the ultimate goal: higher yields, lower costs, and a sustained increase in net income—thus completing self-sustained cycle and enriching the entire ecosystem for the next generation of innovation.



06

Conclusion

This report has established both the immense opportunity within India's AgTech sector and the critical farm-tech divide that constrains it. The analysis is complete—the imperative now is to act. However, moving from a landscape of isolated pilots to a systemic, inclusive growth requires a coordinated national effort.

The following is a playbook of core commitments for the key stakeholders who will collectively shape India's agricultural future.



For governments

- Evolve from regulator to sophisticated market-maker and system integrator by deploying DAVs to transform passive subsidies into a dynamic, demand-driven marketplace that empowers farmer choice.
- Act as the architect of a national trust infrastructure by establishing National hubs for AgTech Validation and Commercialisation as a neutral third party to provide a credible seal of quality for all AgTech solutions.
- Build and maintain the foundational digital rails for private innovation by ensuring Digital Public Infrastructure like AgriStack is open, interoperable, and fully operational.
- Champion a new model of co-creation over isolation by launching mission-oriented 'triple helix' hubs that bring government, industry, and academia together to solve systemic challenges.
- Invest in professionalising the last-mile phygital network by supporting capacity-building programmes for FPOs and the certification of phygital agri-entrepreneurs.



For AgTech industry and innovators

- Move beyond ambiguous claims to standardised value communication by actively co-creating and adopting the 'Farmer Value Framework' as a universal language of trust and ROI.
- Shift business models from selling isolated products to delivering bundled, outcome-based solutions through participation in catalytic platforms that de-risk adoption for farmers.
- Take ownership of the last mile by investing in, training, and certifying a professional phygital network of village-level entrepreneurs to act as trusted orchestrators of the adoption journey.
- Commit to building on open protocols and public infrastructure like AgriStack as a core business strategy to ensure interoperability, prevent proprietary silos, and accelerate scale.
- Forge deep, pre-competitive partnerships with academia and the government within triple helix hubs to co-create market-relevant solutions designed for scale from day one.



For investors

- Prioritise capital for the human-assisted delivery models, last-mile logistics, and support networks that are critical for technology diffusion, moving beyond funding only the core technology.
- Expand investment frameworks beyond measuring end-user outcomes (yield, income) to include critical diffusion metrics like the strength of delivery channels, farmer trust levels, and digital literacy improvements.
- Actively co-invest alongside public and philanthropic capital (like the AgriSURE fund) to de-risk early-stage investments in deep-tech and long-gestation business models.
- As a core part of investment strategy, champion the adoption of open protocols like AgriStack and ONDC within portfolio companies to prevent proprietary silos and foster a healthier, scalable ecosystem.



For academia and research institutions

- Serve as the unbiased scientific engine of the national validation architecture, taking the lead in operating the National hubs for AgTech Validation and Commercialisation and publishing standardised impact assessments.
- Provide the methodological rigor for the ecosystem by co-designing the 'Farmer Value Framework' and establishing credible metrics to measure the grassroot level impact of AgTech.
- Re-align research agendas to be mission-driven and commercially relevant, dedicating scientific capacity to solve critical agricultural challenges in direct partnership with industry.
- Act as the primary certifying body for the agri-services marketplace, ensuring all providers on the DAV platform meet a benchmark of quality and efficacy.



For last-mile ecosystem (FPOs, agribusinesses, and financial institutions)

- Drive the adoption of digital management tools to transform FPOs into bankable enterprises that can anchor local technology adoption.
- Use procurement power to embed technology adoption into commercial sourcing agreements, pulling innovation into the ecosystem at scale.
- Evolve underwriting models from static, asset-based collateral to dynamic, data-driven risk assessment, offering preferential terms for adopting certified technologies.
- Partner with catalytic platforms to deploy financial instruments, such as first-loss guarantees, that de-risk the scaling of entire proven diffusion models.
- Bridge the final gap between technology and farm-gate profit by creating reliable, efficient pathways to market for tech-enabled produce, completing the self-sustained cycle.



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