Usage of Artificial Intelligence and Investment Avenues in Indian Agriculture: An Overview

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DOI: https://doi.org/10.5281/zenodo.17221903

ABSTRACT:

Indian agriculture transitioned from analogue systems toward digitally enabled ecosystems, with Artificial Intelligence (AI) and allied technologies—remote sensing, drones, IoT, machine learning, and decision-support systems—emerging as critical enablers of crop planning, resource optimisation, and risk management. Policy initiatives such as the Digital Agriculture Mission, Agri-Stack, and Krishi DSS laid the foundation for a digital public infrastructure (DPI), while regulatory reforms like Drone Rules liberalisation and the Kisan Drone scheme catalysed service-led adoption models through FPOs and Custom Hiring Centres. On-ground applications demonstrated measurable benefits: fertiliser and pesticide savings of 10–20%, water savings of up to 30%, and yield uplifts of 5–15% in pilot crops. Parallelly, investment avenues expanded significantly. Institutional agricultural credit touched a historic ₹25.1 lakh crore in FY 2023–24, though skewed towards southern states. Kisan Credit Card borrowings rose sharply, and collateral-free lending limits were enhanced to support smallholders. Venture funding in agri-tech, however, followed a boom-and-bust cycle, peaking at $802 million in 2022 before declining by 78% in 2023, reflecting investor caution. Public investment under PMKSY and RKVY bolstered infrastructure with mega food parks, cold chains, processing clusters, and direct support to more than 1,700 agri-startups.

Despite these advances, structural challenges persist: fragmented landholdings, poor digital literacy, limited rural connectivity, and gaps in data quality hinder AI scaling. The next phase (2025–2030) will hinge on completing digital registries, strengthening model marketplaces, enabling outcome-linked finance, and upgrading value chains. The period underscores a dual narrative—investment-led growth and technology adoption—tempered by systemic constraints.

KEYWORDS:

Artificial Intelligence, Digital Public Infrastructure, Agri-tech Investment, Drone Technology, Farmer Producer Organisations.

Introduction:

India's agriculture has moved decisively from analogue to digital between 2020 and 2025. Artificial intelligence (AI) and allied digital technologies—satellite remote sensing, computer vision, machine learning (ML), Internet of Things (IoT), drones, and decision-support systems—are now embedded across crop planning, input optimisation, risk management, market linkage, and finance. In parallel, public and private investment has accelerated in post-harvest infrastructure, value addition, Agri-fintech, and farmer producer organisations (FPOs). This report synthesises the period 2020–2025, mapping policy shifts, technology adoption, on-ground outcomes, and practical investment avenues. It includes structured data snapshots, comparative analysis, and a forward-looking roadmap.

AI moved from pilots to scaled deployments in advisory, yield estimation, crop insurance, credit scoring, pest/disease detection, and price discovery. Drones shifted from demo use to service models via Custom Hiring Centres (CHCs) and FPO-led platforms. The Digital Public Infrastructure (DPI) for agriculture evolved—Agri Stack pilots, digital crop surveys, and decision-support systems—enabling farmer identity layers, interoperable datasets, and targeted services. Investments surged in post-harvest and primary processing assets (warehouses, cold chains, grading/sorting), alongside Agri-fintech, input e commerce, and produce marketplaces. The Agriculture Infrastructure Fund (AIF) catalysed lakhs of projects, and the 10,000 FPOs programme expanded collective enterprise. Agri exports and allied sectors (dairy, fisheries) remained resilient; value-chain formalisation accelerated, opening room for traceability and quality-linked financing. Constraints persist: last mile advisories that are hyper local and timely, data quality/coverage gaps, unit economics for drone services, MSME credit risk, and skilling. The next phase (2025–2030) hinges on: (i) DPI completion (identity, land, crop, soil, weather layers); (ii) scalable compute and model marketplaces; (iii) outcome linked finance (carbon, water, resilience); and (iv) state specific value chain upgrading.

Methodology of the study: The article is considered secondary sources: The secondary data is collected from text books, government report, documents, research articles, journals, newspapers and internet.

Objectives of the study:

» To analyse the application of artificial intelligence in agriculture with a time framework 2020–2025 in the Indian context.

» To explore the investment avenues and crux in the agricultural sector.

Digital Architecture for Agriculture:

Digital Agriculture Mission (2021): Launched to build a DPI for agriculture—farmer identity, digital crop survey, soil–health mapping, and a national decision–support system (DSS). These layers enable targeted benefits, risk scoring, and interoperable innovation by start–ups and co–operatives.

Agri–Stack & **Digital Crop Survey:** Foundational registries (farmer, farm/land, crop) with geospatial anchoring. The Digital Crop Survey (DCS) standardises ground truthing for acreage/yield models and supports insurance/claim automation.

Soil Profile Mapping: District level to panchayat level soil information, feeding fertiliser advisories and variable rate application via drones/IoT.

Krishi DSS: Model ensemble combining weather, satellite, crop models, and market signals for seasonal and intra seasonal decisions (sowing windows, irrigation, pest watch, harvest scheduling).

Drone, Remote Sensing & **Data Reforms:**

Drone Rules liberalisation (2021), and Kisan Drone impetus (2022→): Reduced entry barriers for service providers and agri entrepreneurs; subsidies via state/CSS channels; CHCs and FPOs emerged as anchor off takers.

Satellite/RS data integration for acreage, damage assessment, and claim processing; proliferation of farm level analytics platforms; improved access to meteorological products and high frequency weather grids.

Insurance, Credit & **Market Digitisation:**

Geo tagged crop cutting experiments (CCEs), tech enabled yield estimation, and Aadhaar/DBT linked claims. States increasingly use satellite and ML to stratify sampling and accelerate pay–outs. Priority sector lending grew; Kisan Credit Card (KCC) saturation and digitisation; rise of Agri fintech lenders using alternative data (farm transaction trails, FPO invoices, e NAM/market receipts). e NAM expansion in mandis; private produce marketplaces scaled in horticulture and staples; traceability pilots gained traction in spices, fruits, and basmati; ONDC integrations emerged.

Collectives & **Infrastructure:**

The 10,000 FPOs programme added new collectives with equity grant/credit guarantee; FPOs became natural carriers for AI tools (drone

spraying, advisory distribution, input/output aggregation). Soft loans/interest subvention for post harvest assets—warehouses, cold stores, grading, processing, primary collection; CHCs for mechanisation and drone as a service models.

Agronomy Advisory & Decision Support:

ML models fuse seasonal forecasts and soil moisture indices to suggest planting windows; proven to improve germination and reduce re sowing risk. AI interprets soil tests, crop stage, and local evapotranspiration to calibrate fertigation; variable rate fertiliser via drones/boom sprayers reduces input costs. Computer vision (leaf images) and spatio temporal disease risk maps (e.g., yellow rust in wheat, blight in potato, FAW in maize) trigger targeted interventions.

Operational results observed (typical ranges):

Input savings: 10–20% lower fertiliser/pesticide; water savings 15–30% with sensor guided irrigation. Yield/resilience: 5–15% yield uplift in pilots for cotton, paddy, soybean, and horticulture; reduction in crop loss from late advisories.

Drones & Mechanisation as a Service:

Autonomous or remote pilot drones for uniform spraying with lower drift; feasible in fragmented holdings through service packs; pilots in paddy, cotton, pulses, oilseeds. Multispectral/GB flights for emergence assessment, weed density, and nitrogen variability; CHCs/FPOs monetise via per acre packages.

Remote Sensing, Yield Estimation & Insurance:

Satellite indices (NDVI/EVI), SAR during monsoon cloud cover, and crop growth models calibrate yield and harvest timelines. Tech enabled CCE planning and geotagged evidence reduces cycle time; ML flags localised calamity pockets for targeted relief.

Quality, Traceability & Compliance:

- **Computer Vision Grading:** On device or edge AI for fruit/vegetable grading; improved pack house throughput and price realisation; common in apple, grapes, tomato, onion.
- **Traceability:** QR linked ledgers for export lots; pesticide residue compliance; premium capture for GI/ODOP products.

Agri Finance & Risk Scoring:

- **Alt data Credit Models:** Combine input purchases, produce sales,

satellite vigour indices, weather anomalies, and collective member–ship to score smallholder credit—lowering collateral barriers.

- **Invoice/Commodity Finance:** FPO tripartite structures with buyers; warehouse receipt financing (WDRA compliant); dynamic limits against real time stock.

Livestock & Fisheries:

- **Livestock:** Computer vision for body condition scoring, estrus detec–tion, and mastitis alerts; ration optimisation apps tied to milk yield data; IoT collars for health and heat stress.
- **Aquaculture:** ML guided feed management using DO/temperature telemetry; disease early warning from water quality trends; harvest planning based on biomass estimates.

Adoption & Scale Indicators:

While formal statistics on "AI adoption" per se are evolving, proxies in–dicate scale:

- **Digital advisories:** Double digit million farmer reach through IVR/ apps/WhatsApp by multiple providers, with measured improvements in timing and relevance.
- **e Markets & logistics:** Expansion of online input marketplaces and B2B/B2C fresh produce platforms; higher throughput through grading and pack houses.
- **Insurance digitisation:** Wider use of satellite and geo analytics for sampling and claim processing; increased Aadhaar linked payouts through PFMS.
- **Drone service networks:** Hundreds of CHCs/FPOs onboarded into spray as a service pilots; state schemes providing capex support.
- **FPOs as carriers:** Rapid addition of new FPOs and strengthening of older ones; higher access to equity grants/credit guarantees; greater bankability.

Investment Avenues in Indian Agriculture (2020–2025):

Investment Avenue	Data / Timeframe
Institutional Credit (All–agriculture loans)	₹25.10 lakh crore in FY2023–24; ₹19.28 lakh crore disbursed in first 9 months of FY2024–25 (70% of ₹27.5 lakh crore target)

Credit distribution by region (FY2022–23)	Five southern states received 48% of ₹21 trillion total agriculture credit
Kisan Credit Card (KCC) Debt	National KCC loans rose to ₹10.2 lakh crore (2021 to 2025); Punjab alone added ₹3,010 crore between March 2021–2025, reaching ₹57,536 crore
Agri–tech Venture Funding	$155 M in 2020 → $630 M in 2021 → $802 M in 2022 → dropped 78% to $178 M in 2023 → modest recovery in 2024 → $96 M in H1 2025
Agri–tech Investments (FY–wise)	FY–22: $1,279 M → FY–23: $706 M (45% decline)
Food Processing Approvals under PMKSY (as of June 2024)	41 Mega Food Parks, 399 Cold Chain projects, 76 Agro–processing Clusters, 588 Food Processing Units
Agri–startups supported under RKVY	1,708 startups aided, ₹122.50 crore disbursed (2019–20 to 2023–24), plus ₹300 crore approved for accelerator fund (2023–24 onward)
Collateral–free Agri–loan limit	Raised from ₹160,000 to ₹200,000 (December 2024)
Cropin Impact (Satellite data use)	Cropin served 30,000+ farm plots, 92% farmers saw 30% yield increase and 37% revenue increase

The institutional credit flow for agriculture reached a historic high of ₹25.10 lakh crore in FY 2023–24, and the disbursement pace continues to be strong—with ₹19.28 lakh crore already delivered by December 2024, achieving 70% of the ₹27.5 lakh crore target for FY 2024–25 This underscores the government's aggressive push to ensure easy access to capital for farmers. Financial flows are highly skewed towards southern states: Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, and Kerala collec–

tively received 48% of ₹21 trillion in agricultural credit in FY 2022–23, even though they account for just 17% of the gross cropped Northern and eastern regions remain underserved, highlighting uneven access.

Kisan Credit Card (KCC) borrowings have surged significantly. National KCC loans now total ₹10.2 lakh crore, with Punjab alone seeing jumps from around ₹54,526 crore in 2021 to ₹57,536 crore in 2025—despite a slight fall in the number of active cards. This suggests increasing borrowing per farmer and a potential rise in debt stress Agri–tech investment followed a boom–and–bust cycle. From a modest $155 million in 2020, funding exploded to $802 million in 2022, before plummeting by 78% to $178 million in 2023, and then modestly recovering with $96 million in just the first half of 2025. Similarly, FY–wise funding dropped from $1,279 million in FY 22 to $706 million in FY 23 (a 45% decline).

The sector remains volatile and sensitive to broader VC sentiments. There's been substantial infrastructure push under PMKSY: approvals include 41 Mega Food Parks, 399 Cold Chain projects, 76 Agro–processing Clusters, and 588 Food Processing Units (as of June 2024) . This shows a robust pipeline for value addition and post–harvest loss mitigation. Under RKVY's Innovation & Agri–Entrepreneurship Development Programme, 1,708 startups have received financial and technical assistance between 2019–20 and 2023–24, with ₹122.5 crore disbursed. An additional ₹300 crore accelerator fund was approved starting 2023–24. This expands the base of early–stage Agri innovators. Recognizing inflation pressures, RBI raised the collateral–free agriculture loan limit from ₹160,000 to ₹200,000 in December 2024, facilitating easier access for small and marginal farmers. Analytics–led interventions are bearing fruit. Cropin, using satellite data, has helped over 30,000 farm plots—with 92% of farmers increasing yields by ~30% and revenue by ~37%. This indicates tangible returns from Agri–tech adoption.

India witnessed rapid growth in agricultural credit flows, food–processing infrastructure, and Agri–tech investments, but integrating Artificial Intelligence (AI) into farming practices faced several challenges. The foremost issues included fragmented landholdings and poor digital literacy, which limited farmers' ability to adopt AI–driven advisory and precision tools. High upfront costs and inadequate rural connectivity restricted the scalability of AI solutions, while concerns about data privacy, reliability of models, and lack of localized datasets reduced trust among farmers. On the investment side, while institutional credit soared beyond ₹25 lakh crore annually and government schemes like PMKSY, RKVY, and Kisan

Credit Cards created significant avenues for financing, venture funding for Agri–tech showed boom–bust cycles—peaking in 2021–22 and sharply declining in 2023 before a modest recovery. This volatility highlighted investor caution due to uncertain monetization models, policy risks, and slow farmer adoption rates of advanced technologies like AI. Thus, while investment avenues expanded through credit, cold–chain, and start–up ecosystems, the effective usage of AI in agriculture still grappled with structural, financial, and trust–related challenges.

Conclusion:

The period 2020–2025 highlights that Artificial Intelligence and expanding investment avenues have begun reshaping Indian agriculture, though the transition remains uneven. AI–driven tools demonstrate potential for improving productivity, reducing input costs, and enabling climate–smart practices, but fragmented landholdings, weak digital literacy, and infrastructural gaps slow adoption. Meanwhile, institutional credit expansion, agri–startup growth, and government schemes signal strong investment flows, albeit with cyclical venture funding trends. For sustainable outcomes, future strategies must integrate AI innovations with inclusive financing, localized datasets, and farmer capacity building. Thus, technology–finance convergence emerges as the key driver of agricultural transformation in India.

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Funding:
This study was not funded by any grant.

Conflict of interest:

The Authors have no conflict of interest to declare that they are relevant to the content of this article.