

India's agriculture crossroads:

sustainability,
innovation and the
future of farming

April 2025

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Introduction

Agriculture is the lifeblood of the Indian economy, sustaining nearly half its workforce and contributing 15% to GDP. But the sector today stands at a critical juncture. Decades of unsustainable agricultural practices have severely depleted its groundwater, eroded its soil and left behind toxic residue. Climate change, meanwhile, is reshaping the agricultural landscape, with erratic monsoons and extreme heat waves combining with soil depletion to threaten long-term food security. To feed a growing population while protecting India's biodiversity, a shift towards sustainable agriculture is no longer optional, but an urgent necessity. Cropping patterns will need to change, and technology will have to occupy centre-stage. The required path forward is clear – one that hinges on innovation and receives strong policy support. This paper explores how India's agrochemical sector is evolving—embracing sustainability, adopting cutting-edge technologies and overcoming challenges—to secure a resilient and food-secure future.



The environmental cost of agriculture

Over 120 million hectares (ha) of Indian farmland — more than a third of the total — is now degraded, and 83 million ha of land suffers from water erosion. India has only ~4% of the world's freshwater but an estimated ~87% of this is used for agriculture, mainly because huge volume of it is used to grow water-intensive crops in unsuitable regions. Rice, wheat and sugarcane — accounting for over 75% of the country's agricultural water use — are primarily cultivated in water-stressed states. Rice and wheat dominate in Punjab and Haryana, where groundwater is depleting at an alarming rate (Punjab extracts 1.6x its annual recharge rate.) Meanwhile, Maharashtra, with limited water resources, devotes over 40% of its irrigated land to sugarcane. Cotton, which requires up to 22,500 litres of water per kg, is widely grown in arid regions, worsening drought conditions.

At the same time, India's fertiliser use remains highly imbalanced, skewed heavily towards urea, which is heavily subsidised. Although urea is cheap to procure, its misuse extracts long-term costs: depleted soil, which demands ever-more fertiliser, reducing both profitability and crop resilience. Inadequate soil testing and low levels of awareness worsen this imbalance. Poor fertiliser-use practices have led to rampant soil degradation, nutrient depletion and declining productivity. At the same time, excess nitrogen runoff pollutes water bodies, with nitrate levels in Punjab, Haryana and Uttar Pradesh far exceeding the WHO safety limits. Inefficient fertiliser use is also a major climate threat. Furthermore, the fertiliser industry accounts for about 1% of total global emissions).

India is also one of the world's biggest insecticide consumers, with cotton, rice and vegetables receiving heavy doses. Indiscriminate insecticide use causes soil toxicity, pollinator decline and pesticide resistance, trapping farmers in a cycle of chemical dependency. Punjab's Malwa region, which accounts for 75% of the state's pesticide consumption, suffers from highly contaminated soil and water, earning it the label of 'India's cancer capital'.



The shift to sustainable farming

On a more hopeful note, change is afoot, in terms of cropping choices and the use of chemicals. Across large swathes of the country, supported by government schemes, farmers are shifting to climate-smart, water-efficient crops like millets, pulses and various high-value crops from the traditional, water-and-chemical intensive staples like rice & wheat. States like Karnataka, Rajasthan and Maharashtra are turning to drought-resistant crops like ragi and jowar, while Maharashtra, Andhra Pradesh (AP) and Gujarat are promoting fruits and vegetables under the Mission for Integrated Development of Horticulture (MIDH). Organic farming is booming: Sikkim is now fully organic, and AP's Zero Budget Natural Farming (ZBNF) initiative aims to make 6 million farmers chemical-free by 2030.

Biopesticides, biofertilisers and nano fertilisers are potential game-changers. Currently valued at ~USD 78 million, the biopesticides market, is projected to touch USD 130 million by 2029. Although it will remain a fraction of the overall market — which is projected to surpass USD 4 billion in 2029 — it is growing considerably faster than the rest of the industry. The change is most visible in organic and export-focused farming. Companies like BASF (with its Xemium biofungicide) and Coromandel International (neem-based biopesticides) are helping farmers reduce their reliance on harsh chemicals while improving soil health. Meanwhile, nano fertilisers are revolutionising the seeding stages. IFFCO's Nano Urea, which cuts traditional urea use by 50% while increasing crop yields by 8%, is helping to reduce costs, environmental damage and nutrient loss. As these innovations scale, they are set to transform Indian agriculture into a more sustainable, climate-resilient system.



Tech adoption: leading the charge

To make Indian agriculture more efficient and climate resilient, the farm revolution will have to extend beyond cropping, fertiliser and pesticide choices, into technology-driven solutions. Precision-farming techniques can help mitigate issues around water scarcity and climate change while boosting productivity. Equally, by leveraging AI, IoT, drones and satellite-based monitoring, farmers can optimise resource use, minimise waste and boost yields while ensuring sustainability and cost efficiency. Challenges remain, including the high cost of adoption, but scaling innovation will be key to driving sustainability, increasing yields and optimising resource use. At the same time, as several successful examples demonstrate, partnerships spanning the agrochemical and technology sectors will prove decisive.



Smarter water management: drip irrigation and direct seeding of rice (DSR)

Precision irrigation is helping farmers conserve scarce water resources. Drip and sprinkler systems, particularly in Maharashtra, Tamil Nadu and Rajasthan, are replacing water-intensive flood irrigation, improving efficiency levels by up to 50% with IoT-powered moisture monitoring. In Punjab and Haryana, where excessive paddy cultivation has severely reduced groundwater levels, direct seeding of rice (DSR) has emerged as a breakthrough. By eliminating standing water, DSR reduces water use by 30-40% and lowers labour costs. However, the associated need for intensive weed management and access to specialised equipment remain barriers to widespread adoption.

VRT: optimising input use

Variable rate technology (VRT) is revolutionising the application of agrochemicals, allowing farmers to use real-time data from soil sensors, drones and satellite images to distribute fertilisers, pesticides and water with added precision. This reduces both waste and environmental damage. BASF has integrated IoT-based weather stations and soil sensors with its Xarvio platform, and has partnered with Microsoft on predictive analytics. UPL's Smart Agriculture Platform provides site-specific solutions, cutting agrochemical use by upto 25% while optimising pest control and crop health.

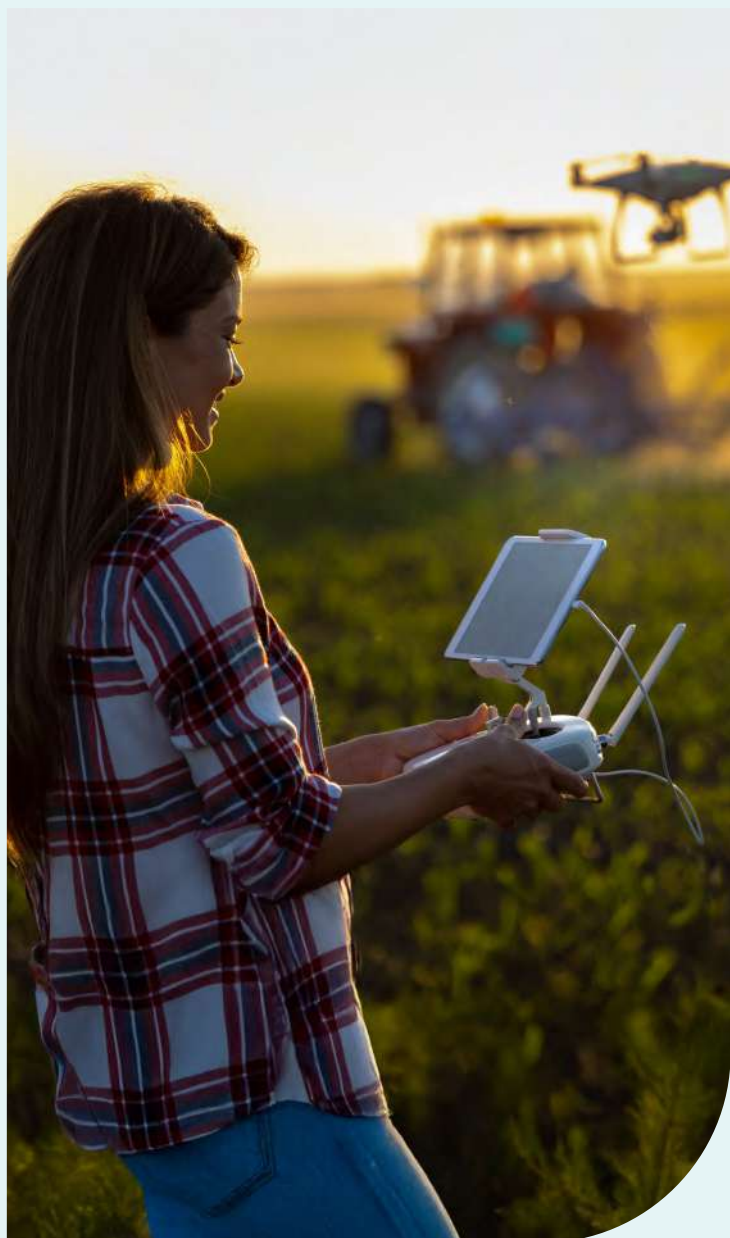
Integrating AI, IoT and satellite imagery...

At a high level, AI, IoT and satellite technologies are providing real-time insights on crop health, weather and soil conditions to boost productivity:

Syngenta's FarmShots platform processes drone imagery to detect early signs of disease and pest infestation, while its Cropwise platform provides digital tools for crop health monitoring and precision agrochemical application.

UPL is collaborating with an AI-focused start-up to enable real-time field monitoring, improving efficiency, cost savings and sustainability.

Bayer has worked with Microsoft to offer predictive insights on weather, soil nutrients and irrigation needs, catering to agribusinesses, researchers and policymakers in agricultural planning. Separately, its Climate FieldView, a farm-level precision agriculture platform, enables real time data-driven decision-making, field mapping and digital traceability, helping farmers optimise yields and resource use.



FarmERP, a Pune-based software company, supports over 13,000 farmers in agroforestry by leveraging AI, IoT, remote sensing and blockchain. It manages large-scale neem plantations and oversees 300,000 sandalwood trees through real-time farm monitoring, precision agriculture and AI-driven analytics. Using GIS mapping, predictive modelling and blockchain-powered traceability, FarmERP optimises tree growth, irrigation, pest control and market linkages, ensuring sustainable and profitable agroforestry management.

In Maharashtra and Gujarat, IoT-powered weather stations and soil moisture sensors are helping farmers fine-tune irrigation schedules, cutting costs and boosting sustainability.

Drones are transforming agrochemical spraying, ensuring targeted, uniform coverage while reducing chemical use and farmer exposure to toxins. **Garuda Aerospace** has more than 500 pilots operating over 400 drones providing agricultural spraying, infrastructure mapping, disaster management and surveillance services. **BharatRohan**, an agritech startup, provides drone advisory services to 6,000 farmers in Uttar Pradesh and Rajasthan. Meanwhile, the Indian Council of Agricultural Research (ICAR) has initiated large scale demonstrations to promote adoption through 100 Krishi Vigyan Kendras, 75 ICAR institutions and 25 State Agricultural Universities, making drone-based field monitoring more accessible.

Green(er) logistics

As elsewhere in the economy, agrochemical supply chains remain heavily dependent on fossil fuels, which power ~90% of all transportation. However, as the pressure to cut emissions and lower fuel costs mounts, companies are turning to electric, biofuel and rail-based logistics. The Indian government's FAME-II policy, offering subsidies for electric logistics, has paved the way for change, but adoption remains slow. However, some of the front runners are making progress: BASF has reduced its overall CO₂ emissions by 20% by integrating electric vehicles and optimising supply chains, while Corteva Agriscience has slashed its logistics footprint by 25% using biofuel-powered trucks and multimodal transport. Similarly, Novozymes, by prioritising rail and sea freight, cutting emissions by 30%; while Bayer has reduced its carbon footprint by 22% by deploying hybrid vehicles and AI-driven fleet management.

As companies continue to explore greener alternatives, shifting to rail and sea transport alone could cut CO₂ emissions by 25-30% compared to road freight. This makes sustainable logistics a key pillar of the industry's future. However, challenges persist, including limited charging infrastructure for electric trucks, high upfront costs and evolving regulations. Looking ahead, biofuels, hydrogen-powered logistics and autonomous electric freight are expected to drive the next phase of sustainable agrochemical supply chains.





Biodegradable packaging: the next frontier in sustainable agrochemicals?

With over 300 million tonnes of plastic waste generated globally each year, 40% of which comes from packaging alone, the agricultural supply chain — including producers of agrochemicals, seeds and other inputs — are under growing pressure to reduce its environmental footprint. Traditional plastic packaging, which takes over 400 years to degrade, contributes to soil and water pollution, and worldwide, just 9% of plastic waste is recycled. To tackle this, companies are shifting to biodegradable and recyclable materials. BASF aims to cut its plastic waste by 30% by 2030 by using plant-based alternatives. Henkel aims to achieve

recyclable or reusable packaging this year, targeting a 50% reduction in packaging-related emissions. Similarly, Dow is integrating 50% post-consumer recycled plastics to minimise its use of virgin plastic.

Industry estimates suggest that biodegradable agrochemical packaging can reduce waste by 60% and cut carbon emissions by up to 40%. However, costs, limited recycling infrastructure and regulatory challenges remain hurdles. As governments tighten packaging regulations and demand for eco-friendly solutions grows, sustainable packaging is set to become the new industry standard.

Clearing the hiccups along the way

Despite being a pillar of Indian agriculture, the agrochemical sector faces major regulatory road blocks. The Pesticide Management Bill, 2020, currently languishing in Parliament, seeks to replace the Insecticides Act of 1968, modernising safety standards and approvals. It proposes the establishment of a Central Pesticides Board to advise on scientific and technical matters, mandatory registration for importing or manufacturing pesticides and graded penalties for offenses to address issues like the sale of spurious pesticides. Introduced 5 years ago and reviewed by a Standing Committee in 2021, it has failed to find passage thus far. Meanwhile, the industry continues to be regulated by the outdated 1968 Act. As a result, approval timelines for new agrochemicals stretch to 3-4 years, far behind the EU (18 months) and US (2 years), limiting innovation and undercutting India's global competitiveness.

Moreover, the industry continues to depend on Chinese imports for over 50% of all 5 agrochemical intermediates, leaving it vulnerable to supply chain disruptions and rising costs. Boosting domestic production through duty reductions, contract manufacturing incentives and R&D tax benefits under Make in India could enhance self-sufficiency. Localised production would reduce transportation-related emissions, promote green manufacturing and create a more resilient, sustainable supply chain, aligning the sector with long-term environmental goals.

Safety issues are another concern: poor pesticide handling and weak compliance measures pose risks to both farmers and consumers. Strengthening training programmes, enforcing stricter safety norms and aligning with global standards like the EU Green Deal and US EPA could boost exports and attract foreign investment. Fast-tracking approvals, enhancing local manufacturing and ensuring safer practices will be critical to unlocking India's agrochemical potential.

A sustainable, food-secure future

Bold steps are needed for India to fully harness the potential of sustainable agrochemicals. This can include fast-tracking approvals for new agrochemicals, expanding the ambit of Production-Linked Incentive (PLI) schemes and aligning safety standards with global norms. Incentivising R&D investments through grants, tax incentives and public-private partnerships could help drive the development of new nano fertilisers, biopesticides and other sustainable agro-solutions. While circular economy initiatives like biodegradable packaging and low-emission transport are emerging, large-scale adoption remains limited due to cost constraints, supply chain challenges and inadequate infrastructure. Scaling these solutions through targeted policy interventions, financial incentives and technology partnerships will be key to ensuring wider implementation.

Lastly, farmer adoption of sustainable agricultural practices can be accelerated through training programmes, incentives for sustainable inputs and the promotion of precision farming to optimise resource use and maximise yields. Setting up demonstration farms (real-world test sites showcasing precision agriculture, nano fertilisers and biopesticides) can help farmers see the benefits of these innovations firsthand. Additionally, extension services led by government agencies, NGOs and agribusinesses can provide farmers with on-field training, expert guidance, and access to digital tools, ensuring they have the knowledge and resources to implement sustainable practices effectively.

The future of Indian agriculture depends on scaling sustainable practices and embracing eco-friendly technologies. From biopesticides and AI-driven precision farming to green logistics, innovation is reshaping the agrochemical sector, advancing both global food security and climate goals – though perhaps not fast enough. Policy reforms, faster regulatory approvals and incentives for R&D and domestic production will be crucial in accelerating this shift. Success will depend on collaboration between industry leaders, policy makers and farmers. By scaling innovation, driving policy action and fostering sustainable growth, India can fortify its agricultural resilience and secure its food systems for generations to come.

Green mobility at your doorstep


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(The company is listed on Compartment A of Euronext Paris (ISIN: FR0013258662; Ticker: ALD). Societe Generale Group is Ayvens' majority shareholder.)

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Ayvens in India



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