AgroSpectrum
Envisaging Future | Updating Present
www.agrospectrumindia.com
Volume 6 ▪ Issue 11 ▪ January 2026 ▪ ₹150
An MM ACTIV Publication
Sci-Tech Communications
Media | Events | Partnering | Advisory
52 pages including cover

UNION BUDGET 2026 EXPECTATIONS:

Resilience, Efficiency & Prosperity

DESIGNED BY MEDTECH. POWERED BY AI.

MedTech Spectrum
EMPOWERING MEDTECH ECOSYSTEM

Meet Medina, Our Ai host

Bringing you the latest from the world of medical technology - crisp, consistent, and captivating.
Medina is the face of MedTech Spectrum, delivering breakthrough stories, product launches, and innovation trends in a dynamic video-first format.

Explore More

Powered by MM Activ's AI Newsroom

We've redefined biotech & health media with intelligent, platform-specific AI anchors - ***Realistic. Reliable. Ready.***

Meet Our Entire AI Hostline:

Maria

BioSpectrum Asia

Daily health & pharma updates from across Asia-Pacific.

Sana

BioSpectrum India

Covers India's biotech, pharma, and regulatory landscape.

Arin

NUFFOODS Spectrum

Focused on food tech, nutrition, and functional health.

Daniel

AgroSpectrum India

Your voice for agri innovation, sustainability & policy.

Contact for more details: ankit.kankar@mmactiv.com | sakshi.kulkarni@mmactiv.com

FINOLEX
PIPES & FITTINGS

PLUMBING | SANITATION | AGRICULTURE

1800 200 3466

finolexpipes.com

AgroSpectrum
Envisaging Future | Updating Present
www.agrospectrumindia.com

Volume 06 | Issue 11 | January 2026

Printed and published by
Ravindra Boratkar on behalf of MM Activ Sci-Tech Communications Pvt Ltd
Printed at AKRUTI PRINT SOLUTIONS PRIVATE LIMITED, 31 B, Parvati Industrial Estate, Pune-Satara Road, Pune-411009.
Published from Ashirwad, 36/A/2, S.No. 270, Pallod Farms, Near Bank of Baroda, Baner Road, Pune- 411045. Tel. No: +91 20 2729 1769
www.agrospectrumindia.com
Reprinted for private Circulation

AgroSpectrum
Envisaging Future | Updating Present
www.agrospectrumindia.com

TOP STORIES

Scan the QR Code — Fushi Tech and PlayMade bet on CRM-led growth in Southeast Asia's competitive tea market

Scan the QR Code — World Bank approves new grant to boost climate-resilient farming and food security in Morocco

Scan the QR Code — Husqvarna Group unveils AI vision–powered robotic lawnmowers for 2026

Scan the QR Code — String Bio and CLRRI complete the first successful field trial of CleanRise® in Vietnam

www.agrospectrumindia.com

Letter from Publisher

Ravindra Boratkar
Publisher &
Managing Editor,
MD, MM Activ Sci-Tech
Communications Pvt. Ltd.

Dear Readers,

We are grateful to our readers, partners, advertisers, and stakeholders for joining us on this adventure as we greet 2026. Our dedication to reliable information, insightful discussion, and top-notch business journalism is fuelled by your interaction and trust.

As Finance Minister Nirmala Sitharaman prepares to present the Union Budget 2026 on February 1, 2026, we examine what this pivotal Budget could mean for agriculture and allied industries. There is growing recognition among economists, policymakers, and industry leaders that incremental policy changes are no longer sufficient. Stagnant productivity, pressure on soil and water resources, climate risks, and uneven farm incomes call for deeper structural reforms. Experts, including senior voices from NITI Aayog, have consistently advocated moving from blanket input subsidies to outcome-linked, digitally verifiable support that rewards efficient resource use, crop diversification, and climate-smart practices.

Against this backdrop, our lead story brings together expectations from across the agriculture value chain and explores whether Union Budget 2026 can serve as a true launchpad for the Viksit Bharat 2047—placing farmers at the centre of growth and positioning Indian agriculture as a high-income, climate-resilient, and globally competitive sector.

India's dairy sector is shifting from a volume-driven model to a technology-led, science-backed industry. Digital systems, automation, and improved infrastructure—supported by the Revised National Programme for Dairy Development (NPDD) —are enhancing productivity and quality. However, high costs and limited access still restrict adoption among marginal farmers. Our coverage highlights the urgent need to bridge this digital and financial divide to ensure inclusive and sustainable sectoral growth.

This edition also examines a major policy reset in crop nutrition—the ban on animal protein–based biostimulants—which is reshaping a Rs 7,000–8,000 crore industry. Far from a routine regulatory action, the move signals a transition from informal and opaque formulations toward science-led, traceable, and accountable biological solutions. While animal-derived products delivered agronomic benefits, inconsistent composition undermined credibility. The reform is accelerating the adoption of cleaner alternatives such as algal extracts, plant-based hydrolysates, and microbial consortia, where compliance and validation have become competitive advantages. Our analysis explores how the success of this shift will depend on translating scientific innovation into farm-level practice through digital agronomy.

We also take a close look at the Draft Seeds Bill, 2025, released by the Department of Agriculture & Farmers Welfare, which seeks to modernise India's seed regulatory framework by replacing the Seeds Act, 1966 and the Seeds (Control) Order, 1983. The proposed legislation aims to improve seed quality and availability, promote innovation, enhance transparency, protect farmers' interests, and improve ease of doing business. As experts point out, the draft has elicited mixed responses from industry, farmers' organisations, and other stakeholders—reflecting both the opportunities and concerns inherent in the proposed reforms.

Additionally, this issue features comprehensive coverage of the 16th edition of Agrovision, India's premier international agricultural summit, held from November 21–24, 2025, at the RTMNU Campus, Nagpur. Organised by the Agrovision Foundation and MM Activ Sci-Tech Communications in collaboration with key partners, the summit —centred on the theme "Transforming Agriculture, Empowering Farmers," the summit brought together farmers, agri-innovators, policymakers, industry leaders, and global experts. Spread across 25,000 square metres with participation from over 450 organisations, Agrovision 2025 showcased focused pavilions on agri incubation, start-ups, MSMEs, animal husbandry, and self-help groups, emerging as a vital platform for collaboration and innovation across the agri-value chain.

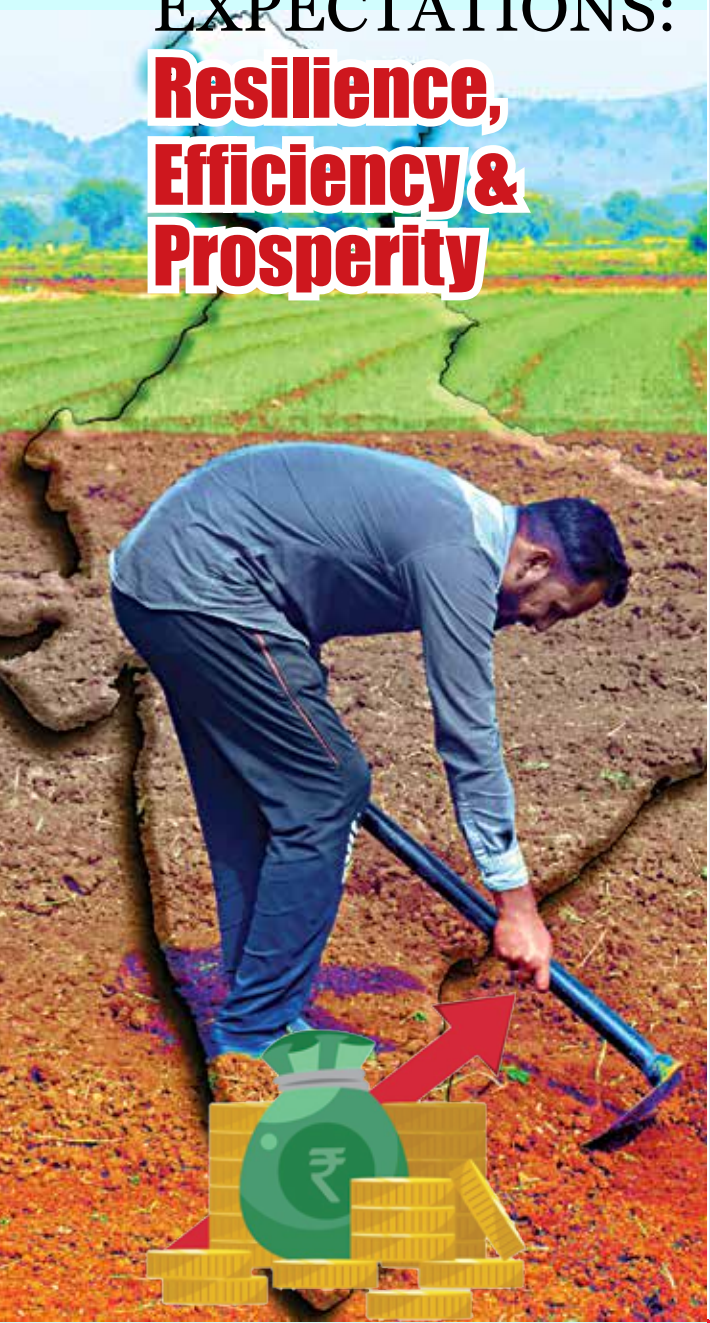
Wishing you a successful, resilient, and impactful year ahead.

I am sure you will find this edition a great read.

Thanks & Regards,

Ravindra Boratkar
Publisher & Managing Editor

CONTENT



Professor Paula Hammond,
Institute Professor and Executive Vice Provost at Massachusetts Institute of Technology (MIT) and Principal Investigator at SMART AMR,

Professor Mary Chan, NTU Singapore's School of Chemistry, Chemical Engineering and Biotechnology, and the Lee Kong Chian School of Medicine, as well as a Principal Investigator at SMART AMR

"Agriculture will become the primary source of income in many parts of the world by 2030"

Prashant Mishra,
CEO & Founder, AgriPilot.ai

AgroSpectrum
Envisaging Future | Updating Present
www.agrospectrumindia.com

Wishes its Readers, Contributors, Advertisers and Associates a Happy New Year...

TOP VIDEO

In an exclusive interview, Vilas Shinde, Chairman & Managing Director Sahyadri Farms shares his insights about the role of FPOs in increasing orange export.

Scan the QR Code ➤

Courtesy : ICAR

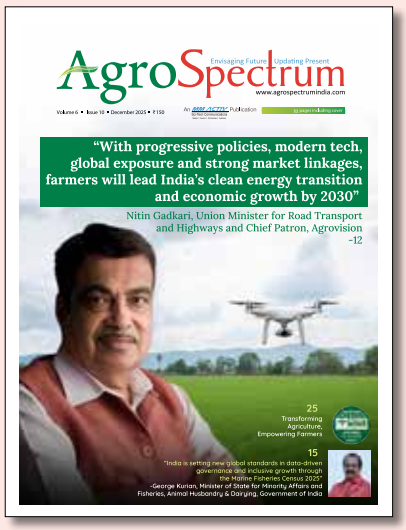
Sumit Bhatia, Vice President – Sales & Marketing Finolex Industries Ltd shares his thoughts about agriculture irrigation industry in India.

Scan the QR Code ➤

Courtesy : ICAR

Ajai Rana, Asia Pacific Business Head, RiceTec & CEO, Savannah Seeds Pvt Ltd sparks about the collaboration opportunities for India- Africa in the seed sector.

Scan the QR Code ➤



Feedback

Inspiring interview

The interview of Nitin Gadkari, Union Minister Road Transport and Highways published in AgroSpectrum December 2025 edition is very inspiring and interesting. His new initiatives such as biochar, sustainable fuel from agri-waste will definitely help the industry in making farming profitable.

Nakul Gorantiwar, Nagpur

Insightful article on seed industry

An article 'From genes to fields: A transformative seed tech revolution' by Raghavan Sampathkumar, Executive Director, FSII is very insightful and useful for seed industry for future strategy planning.

Deepanjali Chandran, Mumbai

Coverage of emerging agri businesses

AgroSpectrum should start publishing regular columns on new and emerging agri businesses in India and APAC region. It will help the new agripreneurs in getting funding and expanding their reach across the global markets.

Prabdeep Mukhopadhyay, Delhi

From AI to Orbit: Rewriting Indian Agriculture

Google, through its philanthropic arm, has committed $8 million to support four Centres of Excellence in Artificial Intelligence (AI) in India, one of which will focus on agriculture. The funding will be distributed among four institutions to strengthen India's AI ecosystem. Among them is annam.ai at IIT Ropar, which will work on agricultural development and farmers welfare by leveraging AI.

Agriculture is a uniquely Indian priority where AI can deliver measurable socio-economic impact. Google's recent funding commitment, aimed at leveraging AI for social and public good across key sectors including agriculture, signals a shift from purely commercial AI applications to applied, public-purpose AI. As India is in the process of building deep research and development capabilities in AI, such funding can help bridge gaps in talent, infrastructure, and high-impact research, considering India's need in areas crucial for improving India's global competitiveness in AI.

Although Google's commitment is modest compared to its global AI investments, it strengthens existing ties between Indian government research agendas and global technology platforms. A Google executive has placed it on record that Indian AI solutions built on Google models are already seeing global adoption. This funding is expected to promote deeper collaboration across academia, government, and industry. The government is already actively promoting AI-driven agricultural transformation. The Digital Agriculture Mission integrates AI tools into farming practices, and AI Centres of Excellence have been established to strengthen research and deployment. One such centre focused on agriculture is set to receive funding from Google. In addition to the Union government, states like Maharashtra have introduced dedicated AI-agriculture policies, with planned investments in crop monitoring, pest control, and farmer training.

AI is already being applied across several agricultural processes, including data analysis, pest surveillance, crop health monitoring, and providing recommendations to farmers on crop selection, sowing dates, and pricing trends for improved decision-making. While AI adoption in agriculture is expanding rapidly, it remains in the early to mid-stages, with a strong emphasis on pilot programmes, government incentives, and scalable tools.

However, challenges to widespread adoption persist. These include limited or event lack of access to the internet and smartphones for small and marginal farmers, digital illiteracy, high upfront costs, and most importantly incomplete or outdated agricultural data. Increased funding flowing in for research and adoption can help address at least some of these issues. Alongside AI, drones are also being deployed at scale in agriculture. Nevertheless, larger systemic investments in infrastructure, talent cultivation, and long-term research funding will be necessary for India to compete with global leaders such as the United States and China.

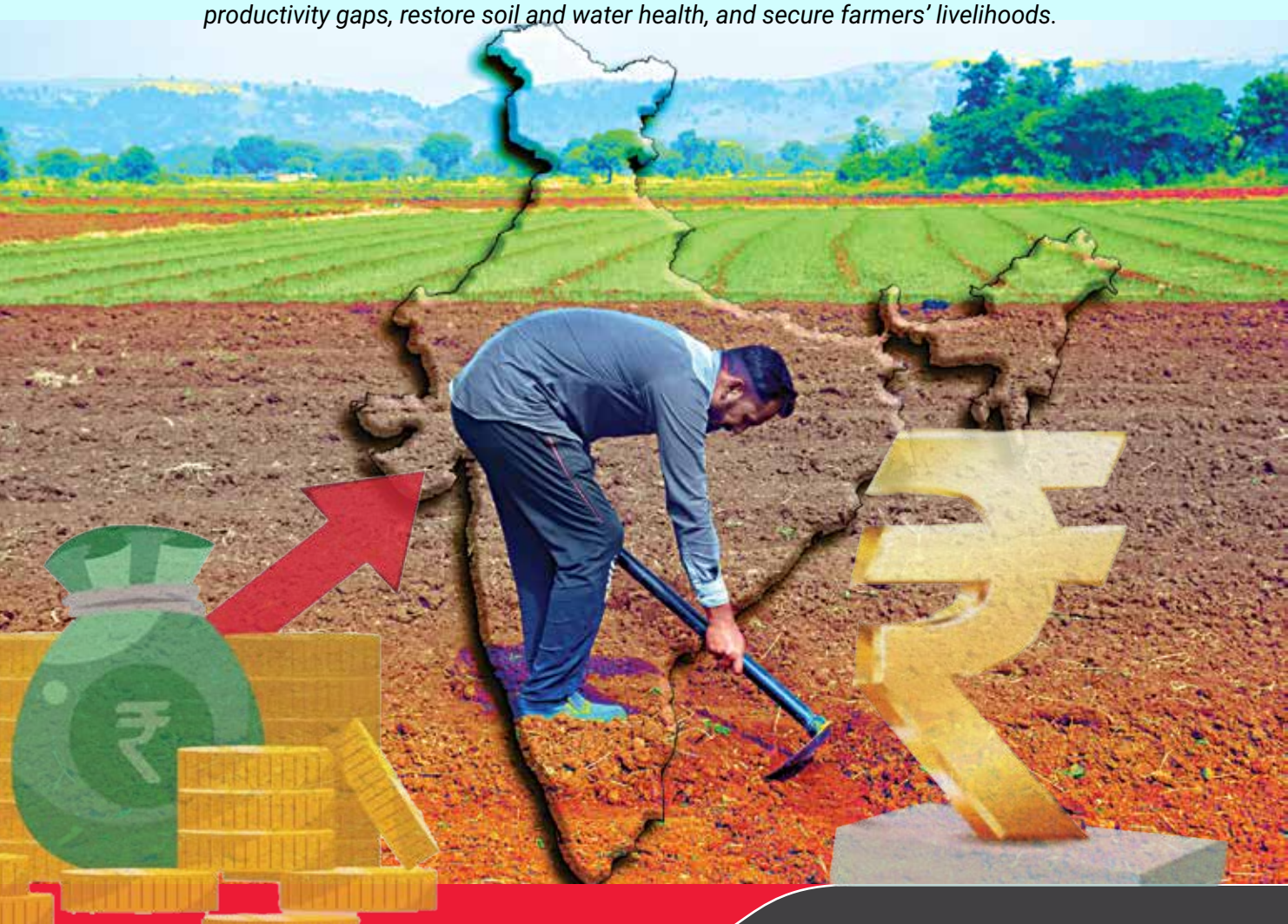
Agri-technocrats and policymakers aim to push innovation even further. They wish to go even above drones. Satellites orbiting over 800 kilometres above the earth are expected to monitor farm conditions and agricultural activities for precision farming. Recently, a $145 million contract was awarded to a consortium to build India's commercial Earth-observation satellite system for precision agriculture. This first-of-its-kind system comprises a 12-satellite network designed specifically for agricultural purposes.

Satellite surveillance is considered to be particularly effective for monitoring small landholdings, making it well-suited to India's agricultural landscape, where over 80 per cent of farmers operate on less than two hectares of land. Government-promoted programmes such as Krishi-DDS (Decision Support System) and the National Programme on the Use of Space Technology for Agriculture (NPSTA) are already enabling data-driven decision-making for farmers, including smallholders. These initiatives not only improve crop yields but also promote sustainable and environmentally friendly farming practices. Contributions from the Indian Space Research Organisation (ISRO) further enhance these efforts by providing real-time information on weather patterns and crop conditions, thereby improving productivity, sustainability, and resource efficiency.At a time when land and water resources are shrinking and food demand is steadily rising, enhancing resource efficiency has become a critical objective for the agricultural ecosystem—both from productivity and sustainability perspectives. Several such technology driven initiatives are important in helping a long way in increasing productivity despite less recourses and still maintaining sustainability.

Dr Milind Kokje,
Chief Editor
milind.kokje@mmactiv.com

UNION BUDGET 2026 EXPECTATIONS: Resilience, Efficiency & Prosperity

As Finance Minister Nirmala Sitharaman unveils Budget 2026, the nation demands more than routine allocations. Indian agriculture is at a historic inflection point. This Budget is expected to operationalise the Viksit Bharat 2047 vision, aiming to transform farming from a low-margin, input-heavy, staple-focused sector into a high-productivity, high-value, globally competitive engine. Economists, industry leaders, and multilateral agencies concur: Incremental tweaks have run out of runway, and structural reforms are imperative to bridge productivity gaps, restore soil and water health, and secure farmers' livelihoods.



"Budget 2026 must signal a decisive move from blanket input subsidies to outcome-linked support that rewards water-use efficiency, balanced fertilisation, and low-emission practices at the farm level," asserts ***Prof. Ramesh Chand, Member (Agriculture), NITI Aayog***.

Dr Ashok Gulati, Infosys Chair Professor for Agriculture at the Indian Council for Research on International Economic Relations (ICRIER) and former Chairman, Commission for Agricultural Costs and Prices (CACP), echoes the call for digitally verifiable, efficiency-led support: "Linking direct benefit transfers with soil health cards, precision nutrient management, and diversified cropping will reduce fiscal stress while lifting total factor productivity across both rainfed and irrigated systems."

The imperative is clear: Budget 2026 must transition from fragmented schemes to a coherent, science-led, productivity-centric agricultural strategy — a structural foundation for a globally competitive, climate-smart, and high-income Indian agriculture.

The Foundation of 2025: From Intent to Implementation

Budget 2025 laid important groundwork, signalling a shift from stop-gap support toward structural measures aimed at productivity and resilience. The launch of the Prime Minister Dhan-Dhaanya Krishi Yojana, targeting 100 low-productivity districts, marked the start of district-level agricultural renewal. Coupled with a six-year protein security initiative under the Mission for Aatmanirbharta in Pulses, it created stable procurement for tur, urad, and masoor, reducing India's import dependence in key pulses. Experts argue the next step must embed climate intelligence into farm-level decisions. "Budget 2026 must fund monsoon-contingent nutrition advisories at scale — using rainfall analytics and soil data to dynamically adjust fertiliser recommendations — so farmers can shift from fixed schedules to climate-responsive feeding of crops," says **Dr Manish Singh, AVP–Technical & Marketing, Transworld Furtichem Limited.** He proposes a unified Nutrient Efficiency Index (NEI), integrating soil-test data, cropping patterns, water use efficiency, and fertiliser balance. "Budgets and subsidies should be allocated based on NEI improvement, not fertiliser consumption. This drives balanced nutrition and scientific fertiliser use rather than volume-driven demand," he added.

Budget 2026 also sought to ease liquidity bottlenecks by raising Kisan Credit Card limits from Rs 3 lakh to Rs 5 lakh, supporting smallholders, dairy farmers, fishers, and allied producers. Sectoral reforms — from the National Mission on High-Yielding Seeds and a five-year cotton revitalisation plan to institutions like Bihar's Makhana Board — aimed to modernise production, while allocations for storage, logistics, and market infrastructure addressed post-harvest losses.

Yet, experts insist these gains must now converge into a coherent resilience architecture. "The next Budget should consolidate irrigation, watershed, soil health, and climate missions into a single 'National Resilient Farms Mission' with district-level targets for water productivity and soil organic carbon," says **Dr V. K. Singh, Director, ICAR–Central Research Institute for Dryland Agriculture (CRIDA).**

Dr Himanshu Pathak, Director General of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), adds, "Every rupee for irrigation must be co-anchored with micro-irrigation, fertigation-ready soils, and climate-resilient varieties so public investment translates into real resilience on farmers' fields."

Budget 2026 will ultimately be judged on whether it can convert these incremental foundations into a mission-driven, 2047-ready agricultural architecture that delivers genuine resilience, competitiveness, and prosperity for India's farmers.

Fixing the Foundations: The Budget That Must Rewire Subsidies, Markets and Science

As Budget 2026 approaches, it is evident that Indian agriculture stands at a pivotal crossroads. The long-standing promise of doubling farmers' incomes, once a political mantra, now demands a sober re-examination. Structural pressures—from climate volatility and shrinking margins to global competitiveness and rising nutritional expectations—have made incrementalism insufficient.

"The allocation of the budget should be done across three horizons: the immediate year, the next five years, and the long-term vision through 2047," asserts **Sandeepa Kanitkar, Chairman of BASAI and Managing Director of Kan Biosys**, highlighting that India's agricultural budget—barely 2 per cent of total expenditure—is glaringly inadequate for a sector that contributes 17 per cent of GDP, sustains 55 per cent of the population, and underpins the nutrition of 140 crore citizens.

The inefficiencies of current spending are stark when viewed through the prism of subsidies. India invests roughly Rs 1.75 – 2 lakh crore annually on fertilisers, electricity, MSP procurement, crop insurance, and other input-linked supports, yet the returns in productivity, soil health, water security, and farmer incomes remain worryingly low.

"Subsidies have historically encouraged consumption rather than efficiency," Sandeepa notes. Cheap urea drives over-application, subsidised electricity has accelerated groundwater depletion, irrigation grants rarely incentivise precision water use, and MSP procurement entrenches cropping patterns that undermine soil regeneration.

For sectoral leaders, Budget 2026 must mark a decisive philosophical pivot—from input-heavy, subsidy-driven policies to a science-led, technology-driven, and outcome-oriented framework.

S. Soundararadjane, CEO of HyFarm, points to the potato sector as a model: "India could build the world's most advanced, predictable, and globally competitive potato ecosystem through a National Potato Innovation Mission. CRISPR-edited varieties, AI-powered breeding, drone-led phenotyping, and mass deployment of True Potato Seeds can transform production while reducing costs and disease risks. Region-specific varieties are not optional anymore—they are strategic imperatives."

Sandeepa further advocates restructuring through Direct Benefit Transfers (DBT). "Subsidies must be given through DBT to farmers and allow them to use this money as per their wish. This has started with Kisan Samman Nidhi but must be extrapolated by diverting subsidies given for insurance, fertilisers, electricity, and water to DBT," she explains. Such a shift would correct long-standing distortions, empower decision-making, sharply reduce leakages, and create the fiscal headroom necessary to invest in science, innovation, and climate resilience.

"A key priority must be efficiency-driven subsidy reform. We need to shift from consumption-based subsidies to scientifically designed, Package of Practice (PoP)–linked incentives tied directly to production outcomes. Performance-based support improves soil health, enhances resource efficiency, and strengthens farmer incomes. Mechanisation support should be delivered through DBT and restricted strictly to FMTTI/BIS-approved equipment to ensure quality and impact in the field," says **Ravindra Agrawal, Chairman, KisanKraft Ltd,** emphasizing that combining DBT with outcome-linked incentives can amplify impact across mechanisation, inputs, and farm management practices.

Markets, too, are evolving in ways that demand more sophisticated production systems. The rising domestic and global appetite for residue-free food is already accelerating India's biopesticide segment. Sandeepa emphasises that a formal residue-free label—jointly administered by the Ministries of Health and Agriculture—could unlock higher farmer incomes through premium market categories. "Blanket reduction on CIB-registered biopesticides must be done at the earliest to 5 per cent," she cautions, noting that inconsistent GST categorisation is harming

both growers and industry participants seeking safer input adoption.

The export ecosystem is entering a decisive phase. "India must position itself as a trusted global supplier," says **Kuchibhotla Srinivas, Partner, Deloitte.** Strategic export corridors, residue-free clusters, bilateral agreements, and harmonisation with global standards, he argues, can convert India's scale into global influence.

"If India wants to lead in exports, supply chains must embed traceability, quality assurance, and sustainable input use," adds **Ankur Aggarwal, Executive Chairman, Crystal Crop Protection.**

The global opportunity is clear. "India's next big leap will come from shifting towards processed, residue-compliant, traceable, and climate-smart agri-exports rather than relying mainly on bulk commodity shipments," says **Abhishek Dev, Chairman of Agricultural and Processed Food Products Export Development Authority (APEDA).**

Value addition must become central to India's strategy, particularly in crops like sugarcane. "Exports of sugar quota have to be restricted to further increase production of alcohol for oil substitution. Value addition is the key. Targets of 20 per cent plus substitution have to be the new target for easing some oil dollars. The money thus freed up can be used to improve irrigation, research, and perfecting models which are customised for Indian agriculture," adds Sandeepa.

Circularity, too, must become integral. **Krishna Mohan Puvvada, Regional President, (Middle East, India and Africa), Novonesis** stresses, "Adequate support must be provided for harnessing the waste-to-wealth potential in agriculture, including robust logistics for storage and transportation of agricultural waste feedstocks that can be transformed into fertilizers and bioenergy."

Domestic market architecture requires equal attention. **Dr Ashok Dalwai, Chairman, Board of Governors of the Institute for Social and Economic Change (ISEC) and Chairman, Karnataka Agriculture Price Commission,** notes, "Targeted support for FPOs, agri-startups, and interoperable e-market platforms can cut post-harvest losses, stabilise prices, and make climate risk more manageable for smallholders." Institutional strengthening, he stresses, is vital for farmers to remain competitive amid market volatility.

Budget 2026, therefore, must reimagine subsidies, shifting from input-centric to outcome-centric frameworks. "Water, soil and climate must be planned as one ecosystem. Budget 2026 should institutionalise watershed-scale irrigation planning, incentivise soil regeneration, and embed climate-risk analytics into district planning. This is not sustainability for compliance; it is sustainability for survival," says Srinivas.

"For a water-starved nation like India, drip should be made compulsory. This would conserve soils along with improving the area of irrigation. The river-joining project must have allocation for short, medium, and long term. Bonds must be raised to mobilise domestic and World Bank funds," adds Sandeepa.

Structural gaps in specialised inputs also demand urgent attention. **Dr Rahul Mirchandani, President, Indian Micro-Fertilizers Manufacturers Association (IMMA)** observes, "India's agricultural ecosystem is at an inflection point, yet not structurally prepared for large-scale reforms. One major gap lies in the micronutrients and specialty fertilizer industry, which remains outside mainstream policy despite its direct link to soil health, crop quality, and farmer income. Fragmented licensing under FCO, uneven state compliance frameworks, and the absence of a unified national policy slow innovation, restrict ease of doing business, and prevent rapid scale-up of advanced nutrition technologies like chelates, water-soluble fertilizers, and fortified micronutrient blends."

Dr Singh underscores the strategic imperative: "Budget 2026 can back a flagship 'Sulphur- and Potash-Secure India' initiative that promotes sulphate-based potash and balanced secondary nutrients, improving taste, colour, shelf-life, and exportability of fruits, vegetables, and plantation crops while reducing import vulnerability."

Complementing this, **Vinod Goyal, CEO, Agricare Corporation** advocates a pragmatic DBT-based reform: "Fertilizers shall be sold on full cost price at dealer shops—farmers register purchases on a Point of Sale (POS) machine at the time of pick-up, and subsidies are directly transferred to their bank accounts."

Sandeepa adds, "Chemical fertilizers should be bundled with organic and biofertilisers—25 kg of CF, 15 kg of OF, and 5 kg of BF per bag. This allows fertilizer to cover 30 per cent more land with improved use efficiency. Organic and biofertilizer industries can be supported through PLI schemes to attract private investment, improve soils, and build climate resilience."

As multiple industry leaders emphasise, this reform will determine whether Indian agriculture can truly align with the aspirations of Viksit Bharat 2047, delivering prosperity, sustainability, and global competitiveness for generations to come.

Tech, Traceability, and Transformation: Budget 2026's Agri-Vision

Budget 2026 is not merely a fiscal exercise—it represents a strategic inflection point for Indian agriculture, an opportunity to pivot from incremental measures to transformative, technology-driven reforms.

"Agri-drones are no longer a novelty; they are an important part of the agritech landscape. Subsidies, public-private partnership models, and targeted R&D incentives can accelerate manufacturing and deployment, creating rural employment while increasing productivity. We must also potentially look at integrating drone data with national agricultural databases to enable smarter crop planning, soil monitoring, and weather resilience strategies," says **Agnishwar Jayaprakash, Founder and CEO of Garuda Aerospace.**

Echoing this vision, Soundararadjane, stresses that Budget 2026 should introduce a Digital Farming Acceleration Subsidy—shifting support from traditional inputs to IoT and automation tools such as soil moisture sensors, disease-warning IoT nodes, digital soil intelligence kits, smart irrigation systems, automated grading and sorting units, and low-cost climate stations for cold stores. "A 40–60 per cent capital subsidy will democratise access and unlock predictive, precision farming at scale," he asserts.

Equally critical is the foundation of clear land rights and reliable credit. "When a farmer has clear land ownership and predictable finance, they can finally shift from reactive decisions to planned, technology-led farming," observes Ankur.

Srinivas adds, "The Budget should focus on the two biggest unlocks for farmer prosperity: clean digital land records and frictionless credit. A legally robust Digital Land Ledger, interoperable with crop data and credit scoring, can unlock formal finance, insurance, and market contracts for millions of farmers currently outside the system."

The systemic importance of logistics and digital marketplaces is reinforced by **Sanjiv Puri, Managing Director, ITC Ltd:** "To truly raise farm incomes, storage, grading, logistics, and digital marketplaces must be treated as core agricultural infrastructure, not peripheral add-ons."

Nutrient management, too, must be integrated. **Yogesh Chandra, VP-Sales & Marketing, Transworld Furtichem Limited,** explains, "Fertiliser purchases must be linked to a unified Digital Farm ID, allowing tracking of nutrient use efficiency, preventing over-application and enabling customised advisory. It builds India's first data-driven nutrient intelligence system."

Budget 2026 must therefore deliver measurable, integrated reforms—embedding science, finance, technology, and policy into a unified, farmer-centric framework. It is the launchpad for the Viksit Bharat Kheti Vision 2047, enabling high-productivity, high-value, climate-smart agriculture and positioning India as a globally competitive agri-economy.

Suchetana Choudhury
suchetana.choudhuri@agrospectrumindia.com

Assessing India's Biostimulant Need vs Innovations

India's proscription of animal protein–based biostimulants reverberated far beyond the farmlands they once nourished. What appeared, bureaucratically, as a mere withdrawal of approvals was, in truth, a profound reconstitution of how a nation sustaining 18 per cent of the world's population envisions crop nutrition. A Rs 7,000–8,000 crore industry—once hailed as the quiet panacea for a climate-stressed food system—suddenly found itself confronting questions of provenance, integrity, and accountability long postponed in the pursuit of expedience.

The decision's significance lies not in exclusion but elevation—erasing ambiguity and setting a new moral-scientific bar where innovation must be ethical, evidence-based, and globally aligned. The "biological boosters" that once bridged soil fatigue and fertiliser dependence must now be reborn on foundations of traceability, molecular precision, and ecological coherence.

"The policy shift away from animal protein–based biostimulants underscores India's evolving agricultural ethos—one that integrates cultural sensitivity, regulatory discipline, and scientific innovation," observed Dushyant K. Tyagi, CEO, Farmgate Technologies Pvt. Ltd. "This transition should catalyse R&D in bio-based and microbial formulations, create new pathways for startups and manufacturers, and align India's agri-input ecosystem with global sustainability frameworks."

By proscribing formulations derived from fish waste and abattoir by-products, India has effectively rewritten the lexicon of modern agronomy—compelling a pivot toward next-generation, plant- and microbe-based biostimulants shaped by synthetic biology, precision fermentation, and AI-driven discovery. This is not a proscription but a paradigmatic reset — a recalibration that may well elevate India from the uncharted margins of bio-input innovation to the vanguard of sustainable agricultural transformation.

A Grey Zone Meets a Clear Line

For years, biostimulants have been India's unsung sentinels of soil vitality — amino acid complexes, seaweed distillates, and microbial consortia quietly sustaining crops as fertiliser efficacy waned and climate shocks intensified. From paddy fields to horticultural belts, they promised deeper roots, greater resilience, and a fragile thread of profitability amid volatility. Yet this ascent masked a crisis of credibility: over sixty percent of products entered markets without validation, their labels ornamental, their contents indeterminate. Science had ceded ground to chance.

That permissive era is ending.

"Under the Fertiliser (Control) Order, 1985 — Schedule VI, the government rightly mandated disclosure of biostimulant sources for transparency and cultural sensitivity. However, the 2025 amendments, culminating in S.O. 4441(E), effectively banned animal-based variants. This shift raises spray volumes and costs

for farmers and compels companies to redesign feedstocks, altering production economics," explained CA Aditya Sesh, Member, Ministry of Agriculture & Farmer Welfare, Committee on ENWR, and Founder MD, Basiz Fund Services. "Both natural decomposition and animal-based hydrolysates embody the Bharatiya ethos of life's cyclical renewal — the 'Dharma of the soil.' Yet pragmatic reforms — from floriculture exemptions to DBT-linked biostimulant support and nano-fertiliser integration — can honour faith while advancing self-reliance and soil intelligence," he added.

Manufacturers must now rebuild trust molecule by molecule, replacing improvisation with integrity. For once, regulation is not reactive but visionary, transforming compliance into the new currency of innovation. India's biostimulant sector now stands at the cusp of legitimacy and moral congruence, where biology's promise must answer to both science and society.

From Conscience to Crop: The Civilizational Logic of India's Biostimulant Ban

India's agricultural reform is inseparable from its civilizational ethos. In a society where vegetarianism shapes ethics and social norms, the origin of agricultural inputs carries moral weight. Fish emulsions or abattoir derivatives do not remain confined to soil—they resonate in kitchens, temples, and export corridors, influencing trust, purity, and market legitimacy.

The reform is equally strategic. India's high-value exports—basmati rice, grapes, tea, spices—compete in markets demanding vegan certification, origin fidelity, and molecular traceability. Animal-derived inputs threaten these assurances, risking regulatory censure and potential border rejections that could erase a season's earnings. By excising such materials, India has redefined agronomy's moral and commercial boundaries, aligning food systems with ethical, cultural, and global standards.

Yet practical challenges loom. Animal-based amino acid formulations were inexpensive scaffolds for horticulture, mitigating climate stress and supporting fragile margins. Their plant- or microbial-based successors offer precision but cost 20–40 per cent more and require expertise often beyond smallholder capacities, creating a tension between ethical rigor and on-ground feasibility.

"The policy shift away from animal protein–based biostimulants underscores India's evolving agricultural ethos—one that integrates cultural sensitivity, regulatory discipline, and scientific innovation. This transition should catalyse R&D in bio-based and microbial formulations, create new pathways for startups and manufacturers, and align India's agri-input ecosystem with global sustainability frameworks."

-Dushyant K. Tyagi, CEO, Farmgate Technologies

"Both natural decomposition and animal-based hydrolysates embody the Bharatiya ethos of life's cyclical renewal — the 'Dharma of the soil.' Yet pragmatic reforms — from floriculture exemptions to DBT-linked biostimulant support and nano-fertiliser integration — can honour faith while advancing self-reliance and soil intelligence."

-CA Aditya Sesh, Member, Ministry of Agriculture & Farmer Welfare, Committee on ENWR, and Founder MD, Basiz Fund Services

"Sourcing plant nutrition from animal-based materials is neither novel nor unsafe — it is a centuries-old practice rooted in agricultural science. Bone meal, leather meal, blood meal, and fish meal have long nourished crops effectively once properly processed and treated. Yet, in recent times, biostimulants have come under disproportionate regulatory scrutiny," observed Vinod Goyal, Director, Agricare Corporation. "Excessive regulatory demands for toxicity data and field trials have burdened the fertiliser industry while leaving systemic inefficiency and administrative corruption untouched. It is time to decontrol the biostimulant sector and restore farmers' autonomy to choose locally developed, cost-effective products suited to their soils and crops," he advocated.

The moral calculus of the decision is unimpeachable; its operational translation, however, remains precarious. Unless affordability, farmer training, and credible substitutes converge, virtue risks being recast as a burden. India's ethical leap must now sustain agronomic gravity — lest moral coherence come

at the expense of productivity.

As Vipin Saini, CEO, BASAI, cautions: "The sun may have set on animal-derived biostimulants, but it should not set on scientific objectivity. To base sweeping regulatory decisions on sentiment or selective interpretation — rather than empirical data and stakeholder consultation — is to compromise both innovation and credibility. These formulations have long demonstrated agronomic efficacy and global acceptance. If India's agricultural policy begins to privilege faith over fact, it risks undermining the very ecosystem of research, enterprise, and farmer trust that drives sustainable productivity."

From Grey Markets to Green Innovation: India's Biostimulant Shift

India's biostimulant sector stands at an evolutionary inflection — a reckoning that separates improvisation from innovation. For decades, the industry straddled two realities: organised enterprises fortified by R&D and audited provenance, and a shadow economy of informal formulators blending animal residues in semi-urban sheds. The ban on animal-derived inputs has ruptured this coexistence, catalysing a Darwinian reordering. For science-led incumbents, it is less disruption than acceleration. Portfolios now pivot toward marine algal extracts, soy- and pea-based hydrolysates, and microbial consortia built on Bacillus, Pseudomonas, and Azotobacter. Compliance has evolved into competitive capital, and salesmanship now trades in molecular validation and traceability rather than folklore.

Yet the reform is no repudiation of science — it is science enforcing its own discipline. Animal-protein hydrolysates delivered measurable plant benefits, but their molecular heterogeneity undermined credibility. Clean-label biology demands quantifiable design: fermentation-borne peptides tuned for stress physiology, and microbes calibrated to regenerate soil ecologies. These tools, however, presuppose agronomic literacy and living soils — luxuries increasingly rare in India's urea-drained belts. The reform's endurance will hinge not on theory, but on translation. Digital agronomy — AI nutrient mapping, IoT-enabled fertigation, satellite-guided advisories — must convert biological intelligence into operational insight. Only then will regulatory ambition crystallise into practical renaissance.

"The sun may have set on animal-derived biostimulants, but it should not set on scientific objectivity. To base sweeping regulatory decisions on sentiment or selective interpretation — rather than empirical data and stakeholder consultation — is to compromise both innovation and credibility. These formulations have long demonstrated agronomic efficacy and global acceptance."

-Vipin Saini, CEO, BASAI

Excessive regulatory demands for toxicity data and field trials have burdened the fertiliser industry while leaving systemic inefficiency and administrative corruption untouched. It is time to decontrol the biostimulant sector and restore farmers' autonomy to choose locally developed, cost-effective products suited to their soils and crops,"

Vinod Goyal, Director, Agricare Corporation

India's proscription of animal-origin biostimulants is no mere regulatory footnote but a profound reconstitution of its agrarian ethos. It signals a passage from an epoch of anecdote and opacity to one governed by empiricism, ethics, and institutional accountability — a new covenant linking the state, science, and the cultivator. Accountability now diffuses across the agronomic continuum: Manufacturers must embrace validated innovation over volume trade; policymakers must provide swift, transparent oversight; and farmers, long passive recipients, ascend as arbiters whose adoption choices will determine the reform's legitimacy.

The stakes verge on the existential. By 2050, India must sustain 1.6 billion lives on contracting soils and vanishing aquifers. Biologicals, conceived with scientific rigor and deployed with agronomic intelligence, cease to be adjuncts; they become imperatives. If executed with coherence and conviction, this policy will not endure as a ban but as the historical juncture when India elevated innovation above improvisation and moral coherence above expedience.

Suchetana Choudhury
suchetana.choudhuri@agrospectrumindia.com

Dairy Technology: Big Potential, Slow Uptake

The Indian dairy sector has been undergoing a far more consequential transformation, from a volume-driven ecosystem to a technology-led, science-backed, and innovation-oriented industry. The country, known for its Operation Flood and White Revolution 2.0, has helped the rural economy at large. With technology in hand, the next phase of growth is touted to be a game-changer for the dairy industry. However, these technologies come at a cost, and how far they can penetrate dairy farmers in remote areas remains a question.

India stands first in global milk production and contributes nearly a quarter of the world's supply. Initiatives like Operation Flood and White Revolution 2.0 have helped the rural economy and have also become the centre stage for food and nutritional security. As per the National Accounts Statistics, the dairy sector contributes 5 per cent to the national economy and directly employs more than 8 crore farmers. It can be noted that the majority of the farmers are marginal and many are women.

According to the Department of Animal Husbandry and Dairying, milk production rose by 63.56 per cent from 146.30 million tonnes in 2014–15 to 239.30 million tonnes in 2023-24. Amidst this humongous growth, technology has been playing a key role in enhancing the dairy sector.

Key Govt Initiatives

The Union Cabinet in March 2025 approved the Revised National Program for Dairy Development (NPDD). The Revised NPDD, a Central Sector Scheme, has been enhanced with an additional Rs1000 crore, bringing the total budget to Rs 2790 crore for the period of the 15th Finance Commission cycle (2021-22 to 2025-26). This initiative focuses on modernising and expanding dairy infrastructure, ensuring the sector's sustained growth and productivity.

The revised NPDD will give an impetus to the dairy sector by creating infrastructure for milk procurement, processing capacity, and ensuring better quality control. The implementation of NPDD has made a huge socio-economic impact already benefiting over 18.74 lakh farmers and has created over 30,000 direct and indirect jobs and increased milk procurement capacity by an additional 100.95 lakh litres per day.

The NPDD has also supported promoting cutting-edge technology for better milk testing and quality control. Over 51,777 village-level milk testing laboratories have been strengthened, while 5,123 bulk milk coolers with a combined capacity of 123.33 lakh litres have been installed. In addition, 169 labs have been upgraded with Fourier Transform Infrared (FTIR) milk analysers, and 232 dairy plants now have advanced systems for detecting adulteration.

Role of MeitY

The Ministry of Electronics and Information Technology (MeitY) in October 2025 has announced the transfer of technology for Electronics &IT-based Dairy Solution for cattle health monitoring and quality detection of pulses, rice, dry red chilli and the launch of sensor-based Odour Monitoring system for various applications, including municipal solid waste (MSW) management recently. According to S Krishnan, Secretary, MeitY, the indigenous technologies like cattle health monitoring systems would help farmers to boost productivity and enhance economic gain.

The Electronics-based Dairy Solutions was developed by C-DAC (K), IIT, Kharagpur and ICAR-NDRI, Kalyani and the technology was transferred to Handholders Global, Bhubaneshwar. The Electronics based Dairy Solutions is a package of two technologies i.e., Cattle Health Monitoring System (Go-P) and Mastitis detection (MAST-D).

The Go-P is a wearable collar-mounted IP67-rated device for cattle to monitor the real-time physiological temperature change to predict the 'heat' condition of cattle for Artificial Insemination, a major requirement for cattle breeders. The Mastitis detector can electrochemically detect the presence of mastitis infection in the cattle milk by detecting ion concentrations in the infected cattle, which causes huge dairy loss in milk products.

Technology as a key player

With over 300 million cattle contributing nearly 25 per cent of global milk, it is emerging as

a major hub for dairy-tech innovation. Precision dairy farming uses sensors, data analytics, and AI for feed optimisation, animal health monitoring, and disease detection are being used across the dairy sector.

Sensors and data analytics that monitor animal health, feed, and water usage are enabling early disease detection. Automated milking systems, IoT-enabled dairy monitoring, blockchain for milk traceability, AI-powered cattle health monitoring, precision feeding for optimal nutrition, smart wearables, mobile veterinary clinics with assisted modern technologies, AI-based disease prediction and prevention, diagnostic kits for cattle health, Sustainable dairy farming with the help of technologies etc, are revolutionising the dairy segment.

Institutions such as the National Dairy Development Board (NDDB), under the Department of Animal Husbandry and Dairying (DAHD), have played a pivotal role in this shift. The launch of indigenous sex-sorted semen technology (GauSort) in 2024, unified genomic chips for cattle and buffalo (Gau Chip and Mahish Chip), and a national bovine DNA biobank covering more than 2.2 lakh samples mark India's entry into advanced genomic and reproductive technologies—tailored specifically for Indian breeds and production systems. Temperature sensors, pH sensors and conductivity sensors etc. help to aid in quality milk procurement.

Says **Devinder Singh, Dairy Specialist and Founder, Dilli Creamery,** "Globally, dairy innovation has traditionally been dominated by regions such as Europe, the US and New Zealand—known for robotic milking, precision nutrition, and high-capex automation. India's path has been different and, in many ways, more complex. With over 70 million dairy households and a predominantly smallholder structure, India has focused on indigenous, scalable, and cost-sensitive technologies rather than capital-intensive imports."

Bengaluru-based Stellapps, a startup, is working towards the digitisation of the dairy supply chain. Stellapps digitises and optimises milk production, milk procurement and cold chain management through the SmartMoo platform (Full Stack IoT solution), which helps dairy farmers and cooperatives maximise profits while minimising effort.

Ranjith Mukundan, Co-Founder and CEO, Stellapps Technologies, mentions, "We digitise every step of the supply chain from herd management, animal wearables, farmer mobile apps, and tech-enabled collection centres to cold chain monitoring. This ensures true traceability so consumers can know where their milk comes from, the breed, the vaccination history and the farmers involved, delivering full transparency and product integrity."

Climate tech company eVerse.AI infuses intelligence into every cow, farm, and carbon credit. With CowGPT delivering instant insights on fertility, health, and nutrition, and MethaneGPT converting methane data into climate action, the company has been able to transform livestock into a driver of both productivity and sustainability. In 2024, eVerse. AI partnered with the Maharashtra government for an unprecedented 20 million cattle methane reduction initiative, generating 30 M MT CO2eq credits. The company plans to enter markets in Bangladesh, Africa, New Zealand, and the US.

Says **Ashish Sonkusare, CEO and Co-Founder, eVerse.AI,** "Our mission is to prove that artificial intelligence (AI), when designed for real people and real animals, can nurture not just profitability but purpose. The Indian dairy farmer deserves modern tools, and the world deserves a cleaner dairy industry—and that's exactly what we are endeavouring to build."

Mumbai-based GormalOne is the provider of AI-led digital solutions for the dairy sector. It offers NITARA to transform dairy farming into a highly profitable venture, keeping a focus on empowering the smallest farmers in often overlooked regions.

It can be noted that NITARA won the International Dairy Federation (IDF) Dairy Innovation Award 2025 for its work in socio economic sustainability in farming using AI and data to uplift smallholder dairy farmers.

GormalOne's product NITARA Connector plays a transformative role by integrating directly with dairy's systems and pouring digital

data into a unified dashboard. NITARA enables dairies to see quality trends across villages, agents and routes. Its analytics highlight anomalies that may indicate dilution, skimming, or intentional tampering, thereby turning what was once guesswork into data-backed action. Systems like NITARA's Farmer app and Farm Management app create transparency by linking farm practices like breeding, health, and milking hygiene. NITARA's NASL engine is part of this emerging direction, helping farmers choose bulls based on actual field performance, not assumptions.

Creamline Dairy Products, a subsidiary of Godrej Agrovet, selling products under the brand name Godrej Jersey, recently signed a Memorandum of Understanding (MoU) with the Government of Telangana (GoT). The company will invest Rs 150 crore to set up a state-of-the-art dairy processing facility across 40 acres.

Novonesis, which provides biosolutions across the dairy value chain, brings in innovations through its new range of Yoflex Satya cultures. The solutions accommodate the need for increased shelf life in the absence of adequate cold chain infrastructure and logistics in retail (BioProtective cultures like FreshQ). Yoflex range of cultures produces high viscosity and improved textures for lassi and buttermilk.

Novonesis provides end-to-end expertise on phage management across various dairy product formats. Novonesis' Galaya Smooth solution allows for achieving superior texture in their high-protein drinking yogurts. In cheese, the company's new age coagulant, Chymax Supreme, solution helps with delivering higher yield, and enabling faster, more precise coagulation and production. It improves the textures and reduces the inline wastages.

Artificial Insemination

Under the National Artificial Insemination Programme (NAIP) free AI services are being delivered at the farmers' doorstep across districts. As of August 2025, the programme has covered 9.16 crore animals, 14.12 crore Artificial Insemination have been performed benefitting 5.54 crore farmers. Multipurpose AI Technicians in Rural India, known as MAITRIs, have also been introduced and are now delivering services directly at farmers' doorsteps.

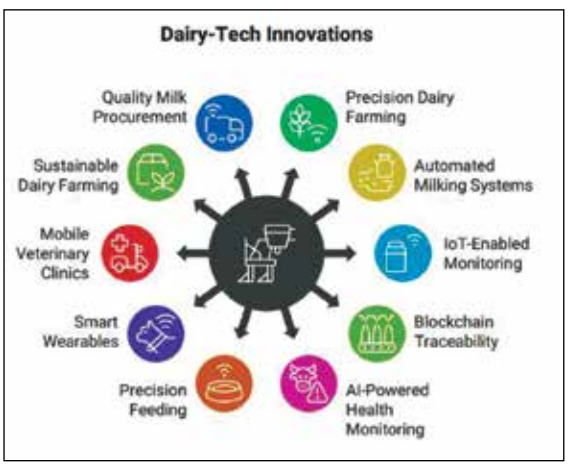
Challenges in Adoption

Unlike Western countries, where farms often manage more than two hundred animals and chill milk at the farm itself, the story is different in India. India's dairy sector is dominated by smallholder farmers who typically own only two to three cows. This creates challenges around digital readiness, infrastructure and affordability.

It can be noted that India still faces foundational barriers like low trust, limited last-mile veterinary access, and decades of farmer exploitation. Technology alone cannot solve these; solutions must be built with empathy, transparency, and long-term engagement with farmers and dairies.

Says **Manish Jain, Founder, GormalOne,** "Most small dairy farmers have never used structured record-keeping or scientific dairy practices. When technology appears 'too advanced', it creates hesitation rather than confidence. The learning curve needs to be simple, visual and built around daily routines. Poor network availability, lack of veterinary access, and lack of awareness for correct dairying practices make uniform technology adoption difficult. Tech must be adaptable to Indian realities like offline modes, regional languages, and low-cost hardware integrations."

Dr Chandrakiran N Sant, Dairy Farming & Milk Procurement Advisor, says that in Maharashtra alone, there are around 700 plants that have shut shop because of



Adoption of advance technique for milk productivity

Nationwide Artificial Insemination Programme under Rashtriya Gokul Mission	Extend artificial insemination coverage in the districts with less than 50 per cent coverage. Artificial insemination services with semen of high genetic merit bulls are made available free of cost at the farmers' doorstep.
Accelerated breed improvement programme	Using bovine In-Vitro Fertilization Technology (IVF) for faster genetic upgradation of bovines. Incentive at the rate of Rs 5000 per assured pregnancy is made available to dairy farmers for adopting this technology.
Accelerated breed Improvement programme using sex sorted semen	For production of female calves with more than 90 per cent accuracy. Under the component incentive up to 50 per cent of the cost of sex sorted semen on assured pregnancy is made available to farmers.
High Genetic Merit (HGM) animals and to accelerate genetic improvement of cattle and buffaloes	Unified genomic chips—Gau Chip for indigenous cattle and Mahish Chip for indigenous buffaloes—specifically designed for initiating genomic selection of high genetic merit animals in the country has been developed. Genomic testing facility is available to farmers through dedicated portal developed for this purpose
App	1962 Farmers App in collaboration with National Dairy Development Board has been developed that provides advisory services on ration balancing and educates farmers on optimising animal feeding using locally available resources, ensuring a balanced intake of protein, energy, and minerals. The ration balancing functionality is also being extended to field workers for assisting the farmers in adopting scientific ways to arrive at optimal ration balancing in terms of cost and productivity.

milk procurement, where the plants are unable to collect the required milk. Dr Sant further mentions, "A dairy farmer still today does not have a profit loss account software and is following age-old systems. Technology doesn't necessarily mean it is giving the required ROI. A dairy farmer who used to generate a certain amount of milk has to do it more, but doesn't have the needed cold chain logistics due to affordability issues."

According to **Anurag Chadha, Director, Food and Beverages Biosolutions, South Asia, Novonesis,** there are a series of challenges, including the outdated infrastructure and equipment that is used, which would need to be replaced for offering the dairy solutions of the future, and the high capex costs incurred in cheese-making infra, an advancing segment in India. He adds, "Further, work still needs to be done to prevent the risk of antibiotic contamination in raw milk, and adequate phage management practices in dairy."

Dairy technologies have become far more cost effective through subscription pricing and modular deployment. Stellapps enables the scale by working directly with dairy processors who can implement these solutions across their procurement networks, giving them real time visibility and data-driven decision making. This approach reduces losses, improves yield and strengthens compliance, making digital transformation financially viable for farmers and processors alike.

Outlook

Any adoption of new technology in any sector needs in-depth studies. In this case, marginal dairy farmers are mainly deprived of basic technology needs. As pointed out by dairy experts, affordability and accessibility remain a big question. The government is doing its bit; however, the benefits can only be reaped once the entire dairy sector can take advantage of the new technologies. AS

Sanjiv Das
sanjiv.das@mmactiv.com

"Higher regulatory standards raise the bar for new antibiotics but create an opportunity for low-risk, biodegradable alternatives"

PROFESSOR PAULA HAMMOND, Institute Professor and Executive Vice Provost at Massachusetts Institute of Technology (MIT) and Principal Investigator at SMART AMR,

PROFESSOR MARY CHAN, NTU Singapore's School of Chemistry, Chemical Engineering and Biotechnology, and the Lee Kong Chian School of Medicine, as well as a Principal Investigator at SMART AMR

In this exclusive AgroSpectrum interview, experts discuss their groundbreaking antimicrobial polymer platform poised to rewrite the rules of dairy health management. Addressing Bovine Mastitis—a $22 billion global challenge—they explain how Oligoimidazolium carbon acids (OIMs) and Polyimidazoliums (PIMs) deliver potent, low-dose, biodegradable protection without contaminating milk or driving antibiotic resistance. Their early farm trials in China, Malaysia, and Singapore exposed a startling technological stagnation in udder hygiene, revealing an urgent need for modern, eco-safe disinfectant solutions. With regulatory pathways complex and market systems fragmented, they outline a hybrid commercial model balancing direct product development with strategic global partnerships for scale. Their message is clear: antimicrobial innovation must now serve One Health—protecting animals, consumers, and the environment in equal measure. Edited excerpts;

Prof. Hammond, bovine mastitis is one of the costliest animal health challenges worldwide. What led your team to focus on this long-standing issue, and what scientific insight unlocked the possibility of developing OIMs as a safer antimicrobial alternative?

Prof. Mary Chan (my close colleague and collaborator at NTU Singapore) and I have always shared a strong interest in the generation of new polymeric materials for health applications, and we have been particularly interested in charged polymers. Through a collaboration launched by a visiting student from the Chan lab, the Imidazolium set of polymers was generated and advanced. Prof. Mary's lab continued to develop more active antibiotic versions and discovered a unique mechanism in this family of materials that makes them highly effective for treatment and prevention of infection. As our research team at SMART began to work toward applying these systems for human health applications, leveraging methods developed in my lab, we saw the potential for these compounds to have an immediate impact on agricultural health. An early SMART researcher working within our shared team first began investigating the potential of the system in a small farm trial and, from that point, we have been pursuing ways in which these novel Oligoimidazoliums (OIMs) can be used for safe agricultural applications.

Antibiotic resistance has often been framed as a human health crisis, but its agricultural dimension is equally alarming. How does your research reposition the conversation—bridging human, animal, and environmental health under the One Health paradigm?

We developed a new class of cationic antimicrobial polymers based on Carbene chemistry, so that these cationic polymers are a new class by themselves that are potent and

effective in a complex environment and yet biodegradable – able to be degraded into smaller fragments. Our compounds are a class of main chain PIMs/OIMs.

By designing compounds that are effective at low doses, biodegradable, and leave negligible residues in milk, we directly address resistance, agricultural food safety concerns and ecological contamination in one stroke. In practice, that means fewer antibiotics entering the food chain, fewer selective pressures for resistance in farm settings, and reduced downstream environmental impact.

Prof. Mary Chan, the initial field trials in Malaysia and Singapore showed encouraging results—no udder irritation, no milk contamination, and strong bacterial suppression. What were the most surprising learnings from translating this molecular innovation to real-world dairy operations?

Our initial farm trial was completed in China, and our ongoing farm trial is in Malaysia and Singapore. One of the most striking learnings was how little the technology in modern dairy farming has evolved for udder hygiene, especially in regard to the gap between antibiotics and disinfectants. Despite advances in overall farming practices, there aren't disinfectants that are both safe and quick acting. The teat dips used today, which typically consist of iodine or Chlorhexidine, are essentially the same as several decades ago. This revealed a critical gap between the growing sustainability requirements in modern agriculture and the outdated tools currently available, underscoring the urgent need for innovations like degradable PIMs that are effective, safe and environmentally friendly.

You mentioned industry interest from Australia, Belgium, Malaysia, and New Zealand. What does it take to move from promising lab results to full-scale commercialisation in the heavily regulated animal health industry?

Commercialisation requires a coordinated programme: scaled Good Manufacturing Practice (GMP) systems, larger and geographically diverse field trials, robust safety testing, regulatory dossiers for each target market, and credible industry partnerships for distribution and farmer education. Because animal health regulation is regionally fragmented, a pragmatic pathway is to pair focused pilot commercialisation in receptive markets with licensing or joint ventures for wider rollout.

The research is now transitioning to a spin-off company. What is the envisioned business model—direct product commercialisation, licensing to agribusiness majors, or joint ventures with dairy cooperatives?

We envision a flexible, hybrid model. Initially, the spin-off will drive product development and secure key regulatory approvals and pilot customers. For broad, rapid deployment, we expect to pursue strategic partnerships with established agribusiness and animal health companies that already have market reach and customer relationships. Joint development agreements with regional partners will also help customise formulations and application protocols for different farming systems.

What regulatory or policy shifts—whether in the US, EU, or Asia—would most accelerate the adoption of antibiotic alternatives like OIMs in mainstream agriculture?

Concrete regulatory actions are already reshaping antibiotic use in agriculture: the European Union (EU) prohibited the preventive use of antibiotics in groups of animals and tightened veterinary oversight under Regulation EU 2019/6. In China, the Ministry of Agriculture and Rural Affairs banned the use of most antibiotic growth promoters in animal feed in 2020. Specifically in the United States, the Food and Drug Administration (FDA) phased out growth-promotion uses via Guidance for Industry (GFI) #213; at the same time, GFI #152 requires rigorous microbiological risk assessment for any new antimicrobial in food animals. These higher regulatory standards raise the bar for new antibiotics but create an opportunity for low-risk, biodegradable alternatives like OIMs that do not select for human-relevant resistance.

Suchetana Choudhury
suchetana.choudhuri@agrospectrumindia.com

"Agriculture will become the primary source of income in many parts of the world by 2030"

PRASHANT MISHRA, CEO & Founder, AgriPilot.ai

AgriPilot.ai is a global real-time agricultural intelligence platform created to enhance crop productivity, livestock management, and promote an efficient and sustainable future. This paradigm encompasses AI innovation in open and controlled environment agriculture, livestock management, offering a sustainable path forward. It empowers growers to make data-driven decisions, enhancing productivity and profitability while conserving vital resources such as water, energy, and land. In an exclusive interview with AgroSpectrum, Prashant Mishra,CEO & Founder, AgriPilot.ai shared his insights about AI driven agriculture and how it will bring transformation in the global agriculture sector. Edited excerpts;

How does the use of AI in agriculture impact the overall global agriculture sector?

First of all, AgriPilot.ai is a Microsoft research-based initiative going on for almost 6 years. And as you rightly asked, AgriPilot.ai with Microsoft research has been creating impact in 15 different countries currently.

Some of the key highlights I would like to bring are the projects in Dubai and Sharjah, where water is in such a scarcity and there is no fertile land also. So what we have done is we have taken mulch and cow dung related process and cocopeat in that area to grow the vegetable in Sharjah and Dubai area which is becoming very popular because it is an autonomous agriculture and that is controlled environment and you can actually see some sites in Sharjah, in the desert there is no other thing but growing almost like 50-100 kg vegetable per day. So that's a remarkable thing.

The sugarcane story that we did in ADT Baramati is now replicated in Peru, in Uruguay, in Brazil, in several other countries and showing significant results in that area. Similarly, we have been working in Kenya, Mozambique, also in different parts of Africa along with Microsoft in growing agriculture and their growth in general. Gates Foundation is our partner in that project, where we are enabling the success story based on AI based agriculture.

As we can see many small-scale farmers are under this belief that AI is not affordable technology. So, what are your action plans, especially for small scale farmers in the Asia Pacific region?

Basically, farmers are in touch with their local languages. They would like to understand the local language. So just like ChatGPT you can ask any questions. We are creating a software called AgriGPT. AgriGPT you can ask any question in any language. Marathi, Hindi, Telugu, Tamil, Urdu, Arabic any language and it will answer you in the same language as the ChatGPT is answering. This is based on the local language, local understanding of the ground data and we are also trying to make it available at a very reasonable cost.

We are offering this service for Rs 150 per month per acre and we are guaranteeing at least 10 times return on their investment. If they are not able to recover that investment, we are saying that you can take your money back or you don't have to pay it upfront, we will take care of it. The second problem we are solving is another software which is based on Farmazon which is a direct sale to the large FPO's or large procurement offices through our ecosystem where you can have a spot pricing reserve. Something that we did with Sunset Grower, Masternod in Canada and in America where they

grow it in Mexico but they sell it to the large pizza owner that I mentioned about Pizza Hut and Dominos kind of companies.

How would you envision the future of the agriculture industry especially with the help of AI by 2030 and which segment of the agriculture sector will benefit more because of this technology?

By 2030 I think 50-60 per cent farmers will be using their mobile application for getting the advisories. We will be seeing a lot of diseases gone from the picture because they will have a good visibility on the kind of insects and diseases that are happening so their early prediction systems will be far more improved than what we see today. In the last one and half years generative AI has changed the world that we could see.

I mean nobody has imagined. Agriculture will become the primary source of income in many parts of the world by 2030. So only way to avoid the civil unrest in the larger ecosystem because of the joblessness in IT or joblessness in another industry, food safety, food security, adulteration of the food these are will become major issues and that only countries like India, China or Brazil who are below the 23 degree line which are known as like very solar orientated area or biophotonic energy level area will get a higher advantage of those things because the nature is generally supporting it. We will see the agriculture economy going multi fold and we might again become an agrarian country as we used to be if the right mindset is there.

What are the plans of the company for FY 2025-26 and growth strategies you are planning especially in other regions?

We are seeing significant growth actually. As a businessman I am in a very interesting problem that I have a huge demand and less supply right now available. So, we are going to grow probably 1000-fold in the next year which is very good for any business to happen and we are trying to cater with proper ventures and institutions to back us up. One of them is the Gates Foundation who is a big supporter of our company and we are also tapping into World Bank related initiatives. In India, having an association with agro-region and leaders like honourable Nitinji Gadkari who is known for actually making the things happen and his support will definitely change the landscape of Vidarbha as well as the Indian agriculture.

According to you, what inputs are required especially for the better deployment of this AI in agriculture in India like in the form of policy support, infrastructure development or financial support?

Basically, the major issue of any technology is the adoption footprint and the government has a higher role in making that policy enabled. So, in the beginning the government must have to offer those services for free till the farmer sees the value of those services and they can help in policy breakthroughs, financial breakthroughs, and adoption of this technology. I can see significant interest in different part of the India like Krishi Vigyan Kendra, Indian Council of Agricultural Research (ICAR), all these groups are partnering with us which is very good and the institutional universities which is actually helping a significant difference in the data that's where the policy and decision making comes into the play.

But I can see a very positive outlook for India, at least in the agriculture sector with the use of AI. In every stage from soil preparation, pre-planting, planting, pre-emergence, post-emergence, pre-harvest, post-harvest and managing the waste management everything is very well controlled by the AI because AI learns from the data and slowly it helps the farmer to sort of interject in every single stage all the way to traceability and supply chain which is directly tied up to large corporations like Walmart, Pizza Hut and Dominos who can purchase directly from the farmers. Therefore, we don't remain just a consumer market but we also become a production market where we supply these things to the large companies which end up selling into our Indian market anyway. It's a circular economy which is going to generate more income for the farmer, more income for the society and in term more customer base for the overall India with a healthy food cycle.

Dipti Barve
dipti.barve@mmactiv.com

Scale, Structure, and India's Path to 2030

K MUTHU, Crop Protection Lead, Crop Science Division, Bayer in India, Bangladesh & Sri Lanka

After years of disruption caused by the pandemic, geopolitical tensions, and supply-chain volatility, the global agrochemical industry is entering a new phase of structural growth. Demand is being reshaped not just by scale, but by sustainability, regulatory rigor, and technology integration. For India, this transition presents a strategic opportunity. With strong manufacturing capabilities, supportive policy frameworks, and rising global demand for reliable crop protection solutions, India is well positioned to emerge as a key export and innovation hub as the industry moves toward 2030.

After years of volatility driven by pandemic disruptions, geopolitical tensions, and supply-chain shocks, the global agrochemical industry has entered a phase of renewed momentum. As global supply chains stabilise and demand recovers, the sector is moving beyond short-term correction toward a structurally stronger and more diversified growth trajectory.

Global agrochemical markets are projected to expand from approximately $270–285 billion in 2024 to nearly $400–425 billion by 2030, driven by resilient demand for crop protection and fertilisers, rising food-security needs, and increasing climate-related production risks. Importantly, growth toward 2030 will not be defined by scale alone, but by composition, sustainability, and technology integration.

For India, this transition presents a significant opportunity. Government of India reports and policy frameworks consistently highlight agrochemicals as a priority export sector, supported by domestic manufacturing scale, improving regulatory alignment, and rising global demand for reliable, cost-efficient, and sustainable agri-inputs.

How the Agrochemical Industry Will Evolve by 2030

By 2030, the agrochemical industry will be characterised by a dual transformation.

First, traditional crop protection and fertilisers will remain foundational, especially for large-scale cereal, oilseed, and horticulture systems. However, they will increasingly coexist with biological solutions, precision inputs, and digitally enabled application models and solutions.

Second, sustainability and regulatory compliance will move from being differentiators to baseline requirements. Globally and in India, regulatory scrutiny on residues, environmental impact, and worker safety is increasing. This is accelerating the shift toward safer chemistries, biologicals, and integrated crop solutions rather than standalone products.

India is well positioned in this context. Government initiatives such as the Production Linked Incentive (PLI) scheme for agrochemicals, emphasis on Atmanirbhar Bharat, and support for export-oriented manufacturing are strengthening India's role as a trusted global supplier. At the same time, domestic demand is

evolving toward more efficient, climate-resilient, and resource-smart solutions, reinforcing innovation-led growth.

Segments That Will Drive Export Demand

Crop protection will continue to anchor agrochemical exports through 2030, particularly herbicides, fungicides, and insecticides, driven by rising pest pressure, labour constraints, and the need for yield protection across geographies.

Within this, herbicides will remain the dominant export segment, supported by large-scale cereal and oilseed production in Asia-Pacific, Latin America, and parts of Africa. Fungicides are also expected to grow steadily, reflecting climate variability and increasing disease incidence.

At the same time, biologicals will be the fastest-growing export segment. Biopesticides, biofertilisers, microbial solutions, and adjuvants are expanding at double-digit rates globally. From a relatively small base today, biologicals are expected to have a significant share of growth in future agrochemical portfolios, driven by residue regulations, ESG expectations, and demand for sustainable intensification.

Fertilisers remain important to India's agrochemical sector, but exports are limited compared with imports. Export growth is therefore likely to come from high-value inputs such as precision fertilisers, customised nutrient blends, and biofertilisers, rather than bulk products.

Overall, while crop protection will remain the volume anchor, biologicals and precision-enabled inputs will generate the highest incremental export growth over the next decade.

Key Drivers of Global Agrochemical Export Growth

Several structural factors are driving the recovery and expansion of global agrochemical exports:

- **Supply-chain normalisation:** The severe disruptions seen during Covid, followed by a glut in key active ingredients due to capacity build-up in China, are now largely behind the industry. Supply chains are stabilising, although full normalisation is still expected to take a few more quarters.
- **Rising food demand:** Population growth, dietary shifts, and pressure on arable land are increasing reliance on productivity-enhancing inputs across emerging and developed markets alike.
- **Climate variability:** Increasing frequency of extreme weather events is intensifying pest and disease pressure, driving demand for advanced and reliable crop protection solutions.
- **Regulatory and consumer expectations:** Stricter residue standards and sustainability requirements are accelerating innovation in bio-based, low-toxicity, and precision-applied products.
- **Technology integration:** Digital platforms, AI-driven advisories, variable-rate application, and satellite-enabled monitoring improve input efficiency and driving adoption of integrated solutions rather than isolated products.

These drivers align closely with India's export strengths—scale manufacturing, process excellence, and a growing innovation ecosystem.

India's Role in the Future

India is not just an export base; it is a strategic growth hub where proximity innovations in crop protection chemistries, biologicals, and digital farming are increasingly being localised through strong partnerships across the agri-input value chain.

At Bayer, our approach is aligned with this evolution. We are leveraging our strong R&D capabilities to meet regulatory and sustainability expectations and expanding precision agriculture offerings that integrate crop-health intelligence with active ingredients. Strengthening resilient supply chains and working closely with local partners across Asia-Pacific, Africa, and Latin America remain central to our strategy.

The recovery in agrochemical exports is therefore not about returning to pre-pandemic levels. It represents a selective ascent, driven by sustainability, biotech innovation, and efficient resource use. Companies that successfully integrate these elements into their portfolios will lead the next phase of global growth.

As the industry looks toward 2030, India, with its manufacturing strength, policy support, and innovation potential, is well positioned to play a defining role in shaping the future of the global agrochemical industry.

How We Can Tackle Counterfeiting and Raise Agricultural Integrity

ANKIT GUPTA, President,
Authentication Solution Providers' Association (ASPA)

Agriculture remains the backbone of India's economy, underpinning food security, farmer livelihoods, and rural growth. Yet the rapid spread of counterfeit agrochemicals—particularly pesticides—has emerged as a serious and largely invisible threat. Estimates suggest that fake products may account for up to 30–40 per cent of the market, eroding crop yields, degrading soil health and undermining farmer confidence. Beyond economic losses, counterfeiting weakens trust across agricultural value chains and threatens India's credibility as a reliable food producer, making urgent action on authentication and traceability essential.

Agriculture is the backbone of India's economy, and agrochemicals remain central to ensuring crop protection, food security, and rural productivity. Yet counterfeiting in agricultural inputs especially pesticides has emerged as one of the most serious threats to the sector. The ASPA–CRISIL report estimates that counterfeit agrochemicals may account for 30-40 per cent of the Indian market, with pesticides being the most counterfeited due to their high consumption volumes. This is not merely an economic challenge; it directly affects crop yields, farmer incomes, soil health, and the long-term resilience of agricultural systems. The latest ASPA–Accenture study further reinforces this urgency by identifying Agro Chemicals as a "critical and resilient" end-user segment for authentication and traceability, noting that counterfeits in this category threaten not only brand reputation but the physical yield of crops and the livelihoods of millions of farmers.

When farmers unknowingly purchase fake or substandard pesticides, the consequences are severe. Such products can reduce yields by three to four per cent and often contain banned, diluted or incorrect formulations that accelerate pest resistance and degrade soil quality. Beyond immediate losses, the use of counterfeit inputs destabilises farmer confidence in brands, distorts markets, and weakens India's reputation as a reliable agricultural producer. The ASPA–CRISIL Report 2022 also highlights that the threat of falsified products across sectors remains widespread in semi-urban and rural regions, reflecting how deeply the counterfeit ecosystem has penetrated everyday commerce.

Complicating matters further is the increasing sophistication of counterfeit pesticides. Fake products sold in plain or deceptive packaging may contain anything from water and talc to obsolete or restricted chemicals, while more advanced counterfeits often replicate branded packaging so accurately that even experienced farmers struggle to distinguish them from genuine products. Illegal parallel imports add another layer of risk by introducing repackaged or mislabelled products that bypass regulatory scrutiny. In an environment of low awareness and cost pressure, farmers often fall prey to such products without realising the long-term damage they cause.

Strengthening Awareness and Farmer Education

Awareness remains the first defence against counterfeiting, yet it is also one of the weakest links. Many farmers do not ask for specific molecules or brands, rely heavily on retailer recommendations, and frequently overlook inconsistencies in packaging or labelling. In remote and rural areas, limited access to authentic supply channels and the lure of lower prices make counterfeit products appear deceptively attractive. This information gap lies at the heart of India's counterfeit agrochemical problem.

To counter this, awareness must evolve into a continuous, locally contextualised effort. Traditional outreach models, seasonal awareness drives or occasional training camps are no longer sufficient. Farmers need sustained, practical guidance on identifying genuine inputs, understanding regulatory markings, verifying labels, and using digital authentication tools.

The ASPA–Accenture 2025 study indicates that only around 34 per cent of agrochemical brands currently use authentication or traceability solutions, despite the sector's high growth potential. As more brands adopt secure packaging and digital verification tools, awareness drives must evolve to teach farmers how to use these tools effectively. When farmers gain the confidence to verify products independently through QR scans, scratch codes, or hotline checks they transition from passive consumers to active protectors of their own livelihood.

Over time, higher farmer awareness also strengthens the ecosystem by discouraging informal sales practices and incentivising retailers to maintain integrity. A vigilance-driven culture, where farmers recognise and report suspicious products, can significantly disrupt counterfeit networks at the grassroots.

Strengthening the Supply Chain through Multi-Layered Measures

Awareness alone cannot address the depth and sophistication of counterfeiting in India. A fragmented supply chain, the involvement of informal distributors, and decentralised enforcement create vulnerabilities that counterfeiters exploit. Regulatory oversight is shared between central and state authorities, but resource gaps and inconsistent coordination often limit the frequency and impact of inspections. Inputs as critical as pesticides and fertilisers have historically received less enforcement focus compared to high-profile sectors.

A more structural transformation is needed. Manufacturers must adhere to robust documentation, maintain secure packaging protocols, and ensure strict quality control at every stage of production. Distributors and retailers must be trained and certified to handle agrochemical products, with mechanisms for real-time verification and accountability. Regulators, in turn, need integrated data systems that enable them to track product movement, flag anomalies, and carry out targeted interventions.

The ASPA–Accenture analysis reveals that only 9 per cent of authentication and traceability providers currently serve the agrochemical sector. This gap signals significant untapped potential. As the sector formalises and companies move toward organised distribution, demand for secure packaging, serialisation, and digital verification will increase rapidly. When every stakeholder from manufacturer to retailer operates within a verifiable and transparent framework, the overall probability of counterfeit infiltration reduces dramatically.

Harnessing Technology for Traceability, Transparency and Trust

Technology represents the most decisive shift in building an authentic agricultural ecosystem. The ASPA–Accenture study identifies Agro Chemicals as a fast-growing A&T segment, currently expanding at around 7 per cent, driven

by increasing industry recognition of the need for tamper-proof, digitally verifiable supply chains. A phygital security model is becoming central to the industry's evolution. Physical features like holograms, embossing, microtext printing, and tamper-evident seals provide immediate visual assurance to farmers. These features are especially useful in rural markets where digital literacy may vary.

However, physical features alone are no longer sufficient. Digital authentication systems—serialisation, QR-based verification, blockchain-backed track-and-trace enable companies to monitor each product unit across its lifecycle. Serialisation assigns a unique digital identity to each pack, enabling granular tracking across manufacturing, warehousing, transport, and retail. When linked to blockchain, this identity becomes part of an immutable ledger, preventing manipulation of records and enabling regulators to trace the origin of any suspicious product instantly. AI-powered analytics further enhance monitoring by identifying unusual stock movements, predicting likely hotspots, and supporting early intervention.

For farmers, QR-code verification has emerged as one of the most accessible solutions. Scanning the code using a basic smartphone allows farmers to confirm authenticity, access usage instructions, check expiry details, and report anomalies instantly. The ASPA–Accenture study notes that such hybrid verification models are particularly crucial for rural markets, where purely physical or purely digital tools may face adoption challenges.

A useful analogy is to see the agrochemical container as a "passport" of the crop's journey. Just as a passport uses physical security features and digital chips to authenticate a traveller's identity, an agrochemical pack uses holograms and QR codes to prove its identity to the farmer. If this passport is fake, the chemical becomes a dangerous imposter one that harms the crop, compromises soil health, and undermines the harvest instead of protecting it.

Internationally, standards like ISO 22383 play a pivotal role in guiding the deployment of authentication solutions. They enable uniformity, help companies undergo structured audits, and align Indian practices with global benchmarks. Adopting such standards also prepares the sector for future export market requirements, where traceability and product integrity are non-negotiable.

Building a Reliable and Future-Ready Agricultural Ecosystem

India's agricultural sector stands at a defining moment. With counterfeit agrochemicals potentially making up a third of the market and authentication adoption still in its early stages, the need for coordinated action is urgent. Creating a trustworthy ecosystem will require aligned efforts across farmers, manufacturers, distributors, policymakers, and technology providers. Global experience shows that when authentication technologies are combined with strong supply-chain discipline and community-level vigilance, counterfeit penetration drops significantly. These learnings underscore that India too can achieve measurable impact by building an ecosystem where every stakeholder from manufacturers to retailers and farmers actively participates in verification and reporting.

A future built on traceability and transparency empowers farmers to invest confidently, encourages manufacturers to innovate responsibly, and strengthens India's standing as a competitive agricultural economy. Most importantly, it creates a system where trust is not assumed but verified at every step.

But the responsibility does not rest with agriculture alone. Counterfeiting is a cross-sectoral threat, and the advances made in Agro Chemicals can and should serve as a blueprint for other industries facing similar vulnerabilities. From pharmaceuticals to FMCG and industrial goods, the broader manufacturing ecosystem must align around common principles: shared traceability frameworks, transparent data flows, interoperable authentication systems, and unified enforcement mechanisms. Only when industries stop working in isolation and come together through coordinated, technology-driven action can India build a national anti-counterfeiting framework strong enough to protect consumers, brands, and economic value across the board. Agriculture can lead the way, but the fight must be joined by all sectors.

The time to act is now. With unified commitment and sustained implementation, India can transform not only its agricultural input landscape but also set the foundation for a nationwide marketplace defined by integrity, accountability, and long-term prosperity.

How AI Is Solving India's Farm Labour Crisis: A Bottom-Up Model Led by Farmers Themselves

Ask any farmer today what their biggest challenge is, and the answer will invariably be the same: labour shortage. This problem becomes particularly acute in horticulture, where time-sensitive operations—from fruit care to harvesting and grading—demand both skilled and unskilled workers at precise intervals. The consequences of delayed access to labour translate into massive economic losses as crops deteriorate and market windows close. Yet, beneath this widely acknowledged crisis lies a fundamental question: Is there really a shortage of labour in India, or is the problem rooted in something deeper?

The numbers tell a revealing story. According to the Periodic Labour Force Survey (PLFS) 2023-24, agriculture still accounts for approximately 46.1 per cent of total employment in India. The last Census recorded about 144 million agricultural labourers out of 263 million agricultural workers. The government's e-Shram portal shows over 160 million registrations—more than 50 per cent of enrollees—under the agricultural worker category. Even Mahatma Gandhi National Rural Employment Guarantee Act 2005, popularly known as MGNREGA, mandates that 60 per cent of jobs be directed toward agriculture-related work. These figures demonstrate that India possesses a substantial pool of people willing to work in agriculture. The disconnect is not one of availability but of accessibility, visibility, and organisation.

The Real Challenge: Beyond Simple Shortage

India's farm labour challenge is a complex web of interconnected problems:

Visibility Gap: No real-time visibility exists into where agricultural workers are located, where they migrate, and for how long. While macro-level understanding exists, precise data on workers from specific locations with particular skill sets remains elusive.

Categorisation Deficit: Every worker is bundled as "agricultural labourer" with no skill differentiation. Urban professionals have resumes and LinkedIn profiles; cab drivers have ratings. Yet workers specialising in grape cultivation or mango harvesting have nothing beyond word-of-mouth recommendations.

Availability and Communication Barriers: Workers frequently migrate across states, changing phone numbers due to high recharge costs. Network issues and location changes make consistent contact extraordinarily difficult.

Absence of Standardisation: Unlike urban employment with defined hours and job descriptions, agricultural work lacks standardised procedures. Wage structures vary enormously, leaving workers vulnerable to exploitation.

Trust Deficit: Labour markets operate through referrals and word-of-mouth. Unlike ride-sharing platforms with institutional trust, workers hesitate to explore opportunities unless validated by their social circle.

Farmers Face Parallel Challenges: Fragmented landholdings prevent ordering large worker groups; non-standardised cultivation practices confuse workers; seasonal requirements cannot guarantee year-round employment; and farmers rarely publish crop cycle information for workers to plan around.

This disorganised system has been held together by informal agents—contractors or mukadams—who cannot scale beyond limited worker networks due to inherent relationship-based limitations.

Recognising these systemic challenges, farmers themselves are driving technological solutions through AI-powered labour platforms. Rather than immediately changing entrenched behaviours, these platforms believe immense productivity improvements can be achieved by bringing intelligence and transparency to existing processes.

Demand-Side Organisation: AI platforms onboard farmers, collecting comprehensive data on crop types, cultivation practices, and anticipated labour requirements. Using historical patterns and agronomic knowledge, AI systems forecast labour needs with remarkable accuracy. Once sufficient data is aggregated, these platforms achieve demand visibility that no informal channel has possessed—understanding precisely where labour will be needed, when, and for which activities.

Supply-Side Transformation: This is where AI demonstrates profound impact. Platforms

integrate various data sources—government registries, NGO partnerships, offline records—to identify labour pockets geographically. The challenge then becomes micro-level engagement: reaching individual workers and building trust.

Vernacular Voice AI: Recognising that many workers prefer oral communication, platforms deploy voice-based AI interfaces allowing interaction in native languages through speech rather than text. Workers can build professional profiles through conversational interactions, recording skills and availability without navigating complex forms.

WhatsApp Integration: Leveraging WhatsApp's rural ubiquity—described as pervasive as "breakfast tea"—platforms meet workers where they are, using AI-powered chatbots for communication. Progressive Web Applications functioning offline, coupled with voice and button chatbots, maintain engagement despite infrastructure limitations.

Intelligent Matching: AI algorithms perform sophisticated matching considering skills, location, availability, and preferences. Route optimisation ensures efficient deployment across farms, while automated reconciliation manages attendance and payments. Review and rating systems for both farmers and workers continuously improve matching accuracy, building institutional trust.

Digital Infrastructure: Jan Dhan accounts and UPI penetration—reaching 38 per cent preference in rural areas—have smoothened digital payment pathways, enabling transparent and prompt wage disbursement.

Digital Twins and Hyper-Personalisation: The Next Leap

A standout frontier for AI in Indian agriculture is the building of "digital twins"—virtual replicas of both farmer and labour villages. These digital twins offer a spatial and contextual map highlighting the availability and needs of each stakeholder on both sides of the equation. Farmers can see labour pools nearby with the right skills and availability, while workers see demand by location and crop need, all updated nearly real time. Such hyper-contextual mapping enables smarter, fairer, and more responsive matchmaking than ever before.

Additionally, AI is extensively used for advanced persona creation and segmentation. Each worker and farmer is profiled using multidimensional datasets—location, skills, languages, work history, preferences—allowing the system to address them in a way that is hyper-personalised, timely, and empathetic. The AI adapts content, offers, and support to the individual's context and history, not as a monolith but as unique participants in the ecosystem.

Such sophistication in digital twin creation and persona-based segmentation is possible only because of the massive contextual information and integrated data systems now available. The result: higher trust, more responsive solutions, and a leap toward empathy-driven technology.

Impacting Livelihoods and Productivity

The impact is particularly valuable in labour-intensive horticulture where scarcity during critical stages has historically caused quality deterioration and economic loss. AI-enabled matching offers precision and predictability where uncertainty previously reigned. For labourers, benefits extend beyond immediate income. Digital systems create wage cards, attendance records, and credibility scores—crucial for building reputational capital. This documentation facilitates access to welfare schemes and skilling initiatives. The AI for Agriculture Innovation initiative in Telangana demonstrated this potential: working with 7,000 farmers, it helped double incomes while achieving 21 per cent yield increases.

Crucially, this model enhances dignity. Tribal and migrant workers gain structured employment. Women workers—now 64.4 per cent of India's agricultural workforce—access verifiable opportunities and consistent earnings, improving autonomy and household stability.

A Road to Formalisation

AI-led platforms are building granular, village-level employment graphs that can integrate with credit systems and welfare delivery. A future emerges where workers build longitudinal employment records, farmers gain productivity insights, and policymakers access real-time analytics on rural labour flows. The government's Digital ShramSetu Mission envisions voice-first AI interfaces overcoming literacy barriers, smart contracts ensuring transparent payments, and micro-credentials enabling on-demand learning for informal workers by 2035.

AI-driven labour platforms are becoming the cornerstone of a new rural labour economy—balancing dignity for workers with efficiency for farmers.

Can Indian Citrus Crack Global Markets?

AZHAR TAMBUWALA,
Executive Director, Sahyadri Farms Post Harvest Care

India's citrus sector stands at a pivotal moment. As one of the world's largest producers, the country has built a strong foundation of diverse agro-climatic zones, robust domestic demand, and established research capabilities. Yet, despite this scale, India's presence in global citrus trade remains limited. With rising international demand for fresh fruit, processed citrus products, natural ingredients, and sustainably produced food, the coming decade presents a significant opportunity. By strengthening varietal development, post-harvest infrastructure, value addition, and market linkages, India can transition from a volume-driven producer to a value-led, globally competitive citrus exporter.

Citrus fruits — including oranges, mandarins, limes, and lemons — are among the most valuable fruit crops worldwide. They contribute significantly to the global fresh fruit market and are a cornerstone of the juice, essential oil, and nutraceutical industries. India, with its vast climatic diversity and agricultural base, stands as the third-largest citrus producer globally, after China and Brazil. Yet, despite this scale, India's share in global citrus trade remains modest, revealing both a challenge and a powerful untapped opportunity.

In the evolving global agri-trade landscape, where demand for high-quality, safe, and sustainably grown fruit is rising, India's citrus industry is now at a pivotal point. A blend of technological innovation, varietal improvement, and market integration can transform the sector from being domestically driven to globally competitive.

India's Citrus Landscape: Strengths and Structure

India cultivates citrus across over 10.8 lakh hectares, producing roughly 14 million tonnes annually. Major citrus-growing states include Maharashtra, Madhya Pradesh, Punjab, Rajasthan, Telangana, and the North-Eastern region. Among Indian citrus, the Nagpur mandarin, Kinnow (Punjab and Rajasthan), Mosambi (Maharashtra), and acid lime (Andhra Pradesh, Telangana, and Tamil Nadu) dominate production.

India's strength lies in:

- Agro-climatic diversity, allowing multiple citrus varieties throughout the year.
- Strong domestic demand, which absorbs most of the production.
- Established research institutions, such as the ICAR–Central Citrus Research Institute (CCRI), Nagpur, that lead varietal improvement and processing innovations.

However, unlike grapes or mangoes, citrus exports are still limited — mostly to the Middle East and neighbouring Asian countries. The current export share of Indian citrus is less than 3 per cent of total production, underscoring the gap between potential and realisation.

Key Challenges Hindering Global Competitiveness

Despite impressive production numbers, several constraints restrict India's citrus from achieving global competitiveness.

- **Quality and varietal limitations:** Many Indian citrus varieties are loose-jacketed, have high seed counts, and a short shelf life — making them unsuitable for long-distance shipping. Global markets prefer seedless, uniform, brightly coloured, and tight-jacketed fruit with consistent sweetness and acidity.
- **Post-harvest losses and logistics gaps:** Up to 25–30 per cent of citrus fruit is lost post-harvest due to poor handling, lack of pre-cooling, inadequate packaging, and limited cold-chain infrastructure. These inefficiencies

raise costs and reduce export-grade supply.

- **Low processing and value addition:** Only about 5 per cent of Indian citrus is processed into juice, concentrates, or by-products, compared to 70–80 per cent in developed citrus economies such as the US and Brazil. The absence of processing clusters results in fruit wastage and lost value from by-products like peel and seed oil.
- **Fragmented supply chain:** Most citrus growers are smallholders. Without organised farmer producer organisations (FPOs) or cooperative marketing, achieving consistency and traceability for exports is challenging.
- **Pest and disease management:** Diseases like citrus greening (Huanglongbing) and canker continue to affect productivity and export compliance, calling for robust rootstock management and biosecurity practices.

Emerging Opportunities in the Global Citrus Sector

Despite challenges, the global citrus sector is expanding rapidly — driven by demand for healthy, natural, and functional foods. This trend positions India to leverage its production base and scientific capabilities for new global opportunities.

- **Value-added processing and by-product utilisation:** With processing penetration at just 5 per cent, this remains India's biggest growth frontier. The CCRI and several agritech startups are now focusing on converting surplus and imperfect fruits into:
- Citrus juices, concentrates, and pulps.
- Marmalades, jams, and dehydrated powders.
- Essential oils, pectin, flavonoid extracts, and aromatic compounds from peel and seeds.

Globally, demand for natural citrus extracts and oils in food, cosmetics, and wellness industries is booming. These products fetch high margins and require less stringent logistics than fresh exports.

Improved and imported varieties: ICAR-CCRI has introduced 17 elite US citrus varieties — including seedless and low-acid types — for Indian adaptation. Similarly, our collaborations with Eurosemillas has introduced premium, climate-resilient, high yielding and bee-friendly "Tango" mandarins. Over the next few years, these efforts could help Indian orchards align with international quality expectations. Another collaboration with EMCOCAL introduced "Sugar Belle" mandarin variety claimed to be tolerant to citrus greening, a major problem today in Brazil and Florida.

Expanding export markets: The Middle East, South-East Asia, and Africa offer immediate export prospects for Indian citrus due to geographic proximity and cultural familiarity. With appropriate cold-chain and phytosanitary compliance, India could gradually target Europe and North America, where demand for off-season or sustainable citrus is rising.

Trade liberalisation is also creating new windows — for instance, recent bilateral agreements have allowed Brazilian and South African citrus access to India, signalling reciprocal opportunities for Indian exporters.

Functional and sustainable products: Global consumers are shifting toward functional beverages, natural flavors, and plant-based nutraceuticals. Citrus bioactives such as vitamin C, flavonoids, and limonoids make Indian citrus ideal for this segment. Moreover, sustainability-driven innovation, such as biodegradable packaging from orange peel waste (an initiative by CCRI and VNIT, Nagpur), can provide a premium edge to "green citrus" branding. Dried citrus peel, pectin and citrus oil has found much favour in the flavours and nutraceutical industry.

In addition to its culinary and cosmetic applications, citrus extract is making waves in the agricultural sector. Citrus pulp, a byproduct of juice and smoothie production, is gaining traction as a natural, fiber-rich ingredient. Its incorporation into food products as a thickener and moisture enhancer reflects the industry's shift towards utilising sustainable and wholesome ingredients. As consumers increasingly prioritise health and wellness, the demand for citrus pulp as a natural food additive is expected to surge further.

Branding of regional citrus identities: Just as "Nagpur Orange" has a Geographical Indication (GI) tag, other varieties like Kinnow and Khasi mandarin can be globally positioned as regional specialties. Branding based on territory, taste, and sustainability can command a premium like Mediterranean citrus.

Strategic Pathways for the Next Decade

To unlock global opportunities, India's citrus industry must focus on coordinated action across production, post-harvest management, processing, and market development.

Orchard modernisation: Adopting high-density planting systems and improved rootstocks

can significantly enhance yields and strengthen resilience, while the introduction of seedless and climate-resilient varieties aligned with export market demand can improve competitiveness. At the same time, encouraging precision farming practices and integrated pest management will support consistent fruit quality, reduce input inefficiencies, and promote more sustainable production systems.

Strengthening post-harvest infrastructure: Establish modern packhouses with grading lines, pre-cooling, and cold-storage facilities close to production clusters to strengthen post-harvest infrastructure, promote the use of controlled-atmosphere transport to preserve fruit quality during export, and train farmers in standardised harvesting and handling practices to ensure uniformity and reduce post-harvest losses.

Boosting processing and value addition: Developing citrus processing parks and FPO-led mini units can help utilise non-exportable fruit and reduce wastage, while fostering R&D partnerships will enable the development of high-value products such as essential oils, flavonoids, pectin, and dietary supplements. At the same time, encouraging private investment and public–private partnerships through schemes like PMFME and MIDH can accelerate scale, innovation, and value addition across the citrus value chain.

Certification and compliance: Encouraging the adoption of GlobalG.A.P., HACCP, organic, and ISO certifications will enable access to premium markets, while ensuring strict compliance with the phytosanitary and residue requirements of importing countries. In parallel, implementing digital traceability systems will enhance transparency and credibility across the supply chain.

Market linkages and export promotion: Mapping potential export destinations and aligning production cycles accordingly will help improve market targeting and reduce demand–supply mismatches, while participation in international fruit expos, trade fairs, and B2B missions can showcase Indian citrus to global buyers, supported by APEDA marketing subsidies and roadshows. In addition, building partnerships with global retail and processing companies for direct supply contracts will strengthen market access and create more stable export channels.

Sustainability and circular economy: Utilising citrus peel and processing waste for eco-friendly packaging and other bio-based materials can strengthen circularity, while adopting energy-efficient processing methods and water-saving irrigation systems will reduce the environmental footprint of production. Highlighting “sustainably grown” branding can further enhance market appeal and attract environmentally conscious global consumers.

Policy and Institutional Support

Government programmes such as the National Horticulture Mission, Mission for Integrated Development of Horticulture (MIDH), and PM Formalization of Micro Food Processing Enterprises (PMFME) provide crucial support for infrastructure, FPO formation, and value-addition.

Strengthening linkages between research (ICAR, SAUs), industry players, and export bodies like the Agricultural and Processed Food Products Export Development Authority (APEDA) is essential to integrate India into global citrus supply chains. Export facilitation centers and region-specific citrus boards could play a major role in market access and branding.

India’s Place in the Global Citrus Future

The next decade offers India a rare opportunity to transform from a volume producer to a value-driven exporter. With strategic varietal improvements, strong post-harvest systems, and innovative value chains, India can emerge as a credible player in the global citrus landscape.

The future of Indian citrus lies not merely in shipping fresh fruit abroad but in exporting innovation — citrus-based products, sustainable packaging, natural ingredients, and regional brands. By blending science, sustainability, and smart marketing, India can turn its citrus story into a model of inclusive and globally competitive agri-business.

In conclusion, the citrus fruit processing industry presents a wealth of opportunities for enterprising individuals seeking to capitalise on the popularity and versatility of citrus fruits. By understanding market dynamics, addressing challenges proactively, and implementing effective strategies, entrepreneurs can establish thriving businesses that contribute to the vibrant landscape of the citrus industry. Whether it's juicing, essential oil extraction, or specialty product manufacturing, the possibilities in citrus-based business are as abundant and refreshing as the fruits themselves.

Feed Is the New Battleground in India's Blue Revolution

ANKIT ALOK BAGARIA, CEO & Co-Founder, Loopworm

Aquaculture isn't just another allied sector in India. It is increasingly becoming important for food security because of the protein requirements of the nation. Fishes and shrimp are being cultivated not just to meet domestic demand, but also being sought after globally as capture fisheries hit ecological limits.

India currently produces 195 lakh tonnes of fish. This is almost double of what we produced a decade ago. Powering this rise is inland aquaculture. Fishes like rohu, catla, mrigal, tilapia, trout, seabass and coastal shrimps have expanded this rise by 140 per cent.

The biggest push has come from policy. The Pradhan Mantri Matsya Sampada Yojana (PMMSY) for instance supports 60 lakh livelihoods through Rs 20,000 crore investment. This momentum also translates at state level with Tamil Nadu, committing Rs 1,100 crore to MSME hubs and aquaculture infrastructure. The push toward intensive systems with biofloc, Recirculating Aquaculture Systems (RAS), and cage culture is accelerating.

Metrics that really matter - volume to value

In recent years, the story has shifted from how much can India produce to how sustainably can India produce it. As farms scale and intensify, feed, which makes up 60–70 per cent of production costs, has moved to the centre of the conversation, prompting farmers to ask sharper questions: How efficiently does it convert to harvest weight? How stable is it in water? Can it reduce mortality?

These questions are already reshaping on-ground practices. Floating extruded feeds let farmers observe consumption and cut waste, critical in densely stocked ponds. Stronger pellets work better with mechanical feeders, now widespread in pangasius, seabass, and shrimp farms, helping maintain both survival rates and water quality.

Performance, however, is only half the story. Fishmeal prices are volatile, deep-sea fishing not only has ecological consequences but also economic ones, meanwhile soybean cultivation is a drain on land and water. That's why feed which goes into the ponds are becoming the anchor point of conversations. From plant protein concentrates to insect meals, from single-cell proteins to microbial biomass, and algae oils, the industry is innovating. The evidence is promising: across species, trials show that formulators can replace 20–30 per cent of marine proteins in shrimp and salmon diets without compromising growth.

The new protein playbook:

Insect-derived ingredients, especially black soldier fly larvae and silkworm pupae, are emerging as credible alternatives. In nature, insects are living bio-factories, turning low-value organic matter into nutrient-rich protein. The same biology is now being harnessed for aquafeed, offering high digestibility, balanced amino acids, and production systems that upcycle agricultural side streams.

Traceability and certification have aided this growth. Standards such as Marine Stewardship Council (MSC), Best Aquaculture Practices (BAP), and Aquaculture Stewardship Council (ASC) include feed-related requirements, checking ingredient sourcing, nutrient discharge, and social practices. These have become essential for Indian exporters selling to Europe and the US.

While still early-stage in India, pilot facilities and research trials show that insect meals can

increasingly complement fishmeal in shrimp and high-value fish diets. Yet adoption at scale faces real headwinds. The smallest difference in price points can determine profitability for farmers, even as low as Rs 5. Taking a bet on an ingredient could mean gambling with an entire crop cycle. Another angle that compounds resistance is the fragmented nature of India's aquaculture. Simply put: smallholders do not have sufficient capital, technical support, or market linkages to compete effectively.

Competing on both cost and quality is possible with steady improvements in production efficiency as marine ingredients costs increase. In a post-Covid world where supply chain fragility is impossible to ignore, investors and feed manufacturers are also now backing local, resilient, biotech-driven ingredients far more seriously.

The future of feed isn't one-size-fits-all

Precision nutrition is the new buzzword. Specialised feeds addressing specialised concerns across species can optimise for feed wastage, feed conversion ratios and gut health. Farmers want to feed immunity supporting diets to shrimps or manage stress of tilapias through special formulations. On larger farms, digital tools are beginning to optimise feeding schedules based on real-time water quality and growth trajectories.

The economics is compelling. A well-designed feed may cost 5–10 per cent more per tonne, but even modest reductions in mortality or shaving a week off grow-out periods can dramatically improve returns. In export shrimp farming, where global buyers pay 20–30 per cent premiums for certified, antibiotic-free products, the additional feed investment is the price of market access.

India's edge for the next wave of market innovation

Innovation can become India's competitive edge if resources align strategically. The country already has robust oilseed processing infrastructure and a BioE3-supported ecosystem that encourages experimentation around alternative proteins. This gives Indian feed manufacturers a genuine opportunity to develop region-specific, environmentally lighter formulations that compete both locally and internationally.

For farmers, feed choices in 2026 have a direct impact on survival rates, growth performance, water quality, and access to premium markets. An ASC or BAP certification can bag higher prices for the fish and transform farm economics.

For entrepreneurs, the aquafeed industry is a bag of opportunities. From developing novel protein ingredients to scaling insect-based feed or building digital platforms for farm management, from testing to traceability for compliance with international market standards, the possibilities are endless.

It is no longer enough to just create something impressive in a lab, it needs to be proven as a consistent model commercially as well. In my experience building Loopworm, success only comes when you simultaneously respect the farmer's tight economics and meet increasingly demanding global buyer expectations. Neither can be compromised.

Rewriting the rules in the era of circularity

Globally, aquaculture is moving decisively toward systems where feed quality, sustainability, and traceability define competitiveness. Europe is moving manufacturers to disclose where ingredients come from, how much carbon they emit, and whether their supply chains meet social standards. The USA is placing sustainable feed at the core of long-term growth plans and routinely assessing whether feed companies are incorporating alternatives to fishmeal like microbial proteins, insect meals, or plant concentrates.

Sustainability, transparency, and diversified protein sources have moved from aspirational goals to baseline market requirements.

The path forward

As India accelerates its Blue Revolution, the question is how quickly we can close the gap between market realities and global benchmarks while building on our unique strengths. The country that doubled its aquaculture output in a decade has proven production capacity. What remains is execution: translating potential into practice, pilot projects into scalable systems, and good intentions into measurable outcomes. For Indian aquaculture, the next decade depends not just on how much we produce, but also how intelligently we produce it.

Strengthening the Draft Seed Act, 2025

DR SHARAN ANGADI,
Director, Advanced Training in Plant Breeding – ATPBR Foundation

The Draft Seeds Bill, 2025, released by the Department of Agriculture & Farmers Welfare, marks a significant step towards modernising India's seed regulatory framework. Aimed at replacing the Seeds Act, 1966 and the Seeds (Control) Order, 1983, the proposed legislation seeks to ensure the availability of high-quality seeds, promote innovation, strengthen transparency in the seed supply chain, and protect farmers' interests, while also improving ease of doing business. The draft has elicited varied responses from industry, farmers' organisations, and other stakeholders, reflecting both opportunities and concerns associated with the proposed reforms.

The Draft Seed Act, 2025 represents an important step toward modernising India's seed regulation framework. However, the vegetable seed sector requires special consideration owing to its unique dynamics, short varietal life cycles, rapid innovation, diverse agro-climatic adaptability, and high private-sector participation. To ensure balanced growth and inclusivity, the Act can be further strengthened through targeted interventions that promote innovation, accountability, and farmer protection.

Vegetable crops typically have short commercial lifespans of three to five years, yet the current Value for Cultivation and Use (VCU) testing process extends over multiple seasons, delaying the market introduction of improved hybrids. A fast-track VCU protocol specifically designed for vegetables and other short-duration crops should be introduced, allowing multi-location private trials validated by accredited public laboratories. Private R&D data generated under NABL-accredited facilities must be formally recognised to avoid redundancy. Provisional registration for one season, based on preliminary VCU results, followed by post-release performance review, can help balance innovation with accountability. Developing crop-specific timelines, with single-season VCU testing for short-duration vegetables, will further accelerate innovation and availability.

Small and regional seed firms face disproportionate compliance costs due to uniform registration fees, infrastructure requirements, and extensive documentation. A tiered registration system based on company turnover or operational scale can alleviate this burden. Cluster-based or shared VCU trials for small enterprises, supported by public–private testing hubs established under

Feedback from Industry for Policymakers

Policy Area	Current Challenge	Recommended Improvement	Expected Benefit
VCU Testing	Too slow for vegetables	Fast-track and provisional registration	Faster innovation
Compliance Cost	High for SMEs	Tiered fees and shared testing	Inclusion and diversity
Digital Traceability	Too complex initially	Phased QR–blockchain system	Practical transparency
Penalties	Risk of overreach	Graded, intent-based penalties	Fair enforcement
Farmer Compensation	Ineffective consumer court system	Specialized seed tribunals	Quick, science-based relief
Breeding Collaboration	Weak public–private linkage	Joint trials and innovation consortia	Broader R&D participation
Biodiversity	Genetic uniformity risk	Local variety protection	Resilience and sustainability
Transparency	Limited public information	National seed data portal	Accountability and informed choice

a PPP model, would democratise access to testing infrastructure. Simplifying documentation through a single-window digital registration portal would further improve transparency and efficiency.

While digital traceability is essential for transparency, a full blockchain system may initially be impractical for smaller players. A phased approach should be adopted, beginning with mandatory QR codes carrying batch, source, and certification details, and later integrating blockchain for high-value crops and export-oriented varieties. Interoperable software standards should be encouraged to prevent vendor lock-in, and a national seed database API must link certification bodies, seed firms, and farmer grievance systems. Such an approach balances traceability with practicality while enhancing consumer trust.

Excessive penal provisions risk discouraging entrepreneurship and fostering corruption. It is therefore essential to distinguish between deliberate fraud, such as the sale of fake or misbranded seeds, and unintentional technical lapses, like labeling or documentation errors. A graded penalty system, with administrative fines for minor infractions and criminal liability reserved for willful misconduct, would ensure fair enforcement. Introducing self-reporting and rectification windows would also encourage voluntary compliance and reduce unnecessary litigation.

Public private collaboration in breeding and testing remains limited, despite complementary strengths. Institutionalising joint varietal trials under the Indian Council of Agricultural Research (ICAR) and State Agricultural University networks with active private-sector participation would help close this gap. Open innovation platforms that allow transparent sharing of public germplasm under fair intellectual property and benefit-sharing arrangements can accelerate the development of climate-resilient vegetable varieties. Furthermore, incentivising public, private consortia for region-specific innovation, such as heat-tolerant tomato or drought-resilient okra hybrids, would significantly enhance adaptive capacity and domestic R&D strength.

The current reliance on consumer courts for seed compensation is inadequate, given the slow and technical nature of such cases. Establishing State Seed Grievance Boards or specialised Seed Compensation Tribunals under the Act would provide a faster and more scientific resolution mechanism. Time-bound decision-making, ideally within sixty days, supported by field validation teams, would ensure credibility. A Seed Performance Assurance Fund, contributed by the industry, could provide interim relief to affected farmers, thereby enhancing trust in both the regulatory and commercial ecosystem.

Promoting biodiversity and farmer participation must remain a cornerstone of the modern seed framework. The Act should enable simplified local registration for traditional and regionally adapted vegetable varieties through community seed banks. Encouraging participatory breeding programmes that link farmers with private breeders and offering R&D tax incentives for the conservation or development of indigenous germplasm would safeguard genetic diversity while aligning with India's commitments under the Protection of Plant Variety and Farmers Right Act, 2001 (PPVFR Act) and biodiversity conventions.

Finally, a transparent and accessible national seed data platform should be developed to consolidate information on VCU results, registration status, germination and purity metrics, complaints, and redressal outcomes. Open access to such data, integrated with AgriStack and broader digital agriculture initiatives, would enhance accountability and empower farmers to make informed decisions. Comparative analytics between public and private varieties would also foster healthy competition and innovation across the industry.

Why Trade Secrets Matter More Than Patents for India's Seed Companies

DR KAVITA ARORA Partner - Patent (Biotechnology & Biosciences, Plant Variety, Biodiversity), K&S Partners

For India's agritech and seed companies, trade secret protection is becoming an increasingly strategic tool for safeguarding competitive advantage. Much of the sector's value is rooted in confidential breeding expertise, in-house analytics, proprietary genetic resources, and specialised production know-how - assets that traditional IP frameworks such as patents or plant variety protection rarely protect adequately, leaving businesses exposed. As the industry scales amid statutory exceptions and exclusions, market expansion, counterfeit risks, and growing export aspirations, the ability to manage and secure sensitive information is evolving into a critical business capability. Companies that integrate structured trade secret governance into their broader IP and commercial strategies are better positioned to protect high-value R&D, maintain differentiation in a crowded market, and convert long-term research efforts into sustained business value.

In the agritech domain, especially within the seed-industry ecosystem, the concept of protecting innovation through trade secrets merits serious attention. For companies engaged in crop-breeding, seed development, and hybrid technologies, the confidential know-how, whether that is parental inbred lines, marker-based selection pipelines, or tissue-culture and regeneration methods, often constitutes one of the most valuable competitive assets.

Several high-profile global litigations, such as the Pioneer Hi-Bred International v. Holden Foundation Seeds dispute concerning misappropriation of proprietary corn germplasm, studies have shown that the commercial stakes of unauthorised access to breeding know-how can be extremely high. Similarly, disputes such as Syngenta v. Farmers Business Network have demonstrated how employee movement can lead to disclosure of confidential hybrid pipelines and breeding files. When we bring this into the Indian context, the case for trade secrets becomes even more compelling.

Why trade secrets matter for crop breeding and seed companies

Seed innovation is intensive and layered, often requiring years of selecting parent lines, making genetic crosses, testing performance across environments, and applying genomic and phenotypic data before a successful variety is commercialised. Because a successful variety yields farmer advantages such as higher yield, pest and disease tolerance, climate resilience, and quality traits, companies naturally seek to retain exclusive control over the mechanisms that enable those traits.

Traditional intellectual property rights, such as patents and plant variety protection (PVP), can be useful but may not always cover what matters most in breeding. Patents expire after a fixed term and require full public disclosure, making it possible for competitors to eventually design around them. PVP allows statutory exceptions and may not protect parental lines or process-based advantages. Moreover, since India's regime limits patentability of plants and seeds per se under Section 3(j), some breeding methods or parental lines may not qualify.

Trade secrets, therefore, become a strategic complement, allowing companies to retain indefinite protection in principle without disclosure, provided confidentiality is actively maintained. They fill a gap not covered by patents and PVP when disclosure would enable competitors to replicate the genetic edge and

erode commercial value.

In the seed industry, this means that the identity of an elite inbred line, the crossing design, the molecular-marker array, the seed-production protocol, or the climate-adaptation pipeline may all be held as trade secrets. Globally, courts have recognised that even biological material such as germplasm or parent lines can be protectable trade secrets when confidentiality measures exist. Jurisprudence from the China Supreme People's Court has clarified that physical plant material may constitute a trade secret if commercial value and secrecy are demonstrated.

The Indian environment: special features and opportunities

India's seed sector is substantial and growing, forming the fifth largest in the world and accounting for approximately 4.4 per cent of the global seed market. The Indian Patent Act excludes plants or animals in whole or any part thereof, as well as essentially biological processes for the production of plants, from patentability under Section 3(j), while the Protection of Plant Varieties and Farmers' Rights Act, 2001 (PPV&FR Act), provides a sui generis regime that recognises breeders and farmers alike. In this landscape, trade secrets emerge as a strategic tool for seed companies when patenting or formal PVP protection is not possible, practical, or commercially desirable.

The business environment strengthens this need. The seed industry in India is increasingly exposed to unauthorised seeds, counterfeit or sub-standard seed packets, and seed piracy. It is estimated that nearly 25 per cent of seeds, pesticides, and fertiliser markets in India may be counterfeit or illegal, with "fraudulent labelling, IP infringements, thefts of proprietary material" being key issues.

Industry associations have been calling for stronger IPR enforcement so that Indian seed companies can move from being primarily local players to being global exporters. Trade secrets thereby become part of the value proposition: if a seed company in India has developed a climate-resilient variety or an efficient seed-production process, being able to protect that know-how keeps it export-ready and competitively differentiating.

The emergence of Indian disputes, such as National Agro Seed Corporation India v. National Seeds Corporation Ltd, and the recurring litigation track involving Sungro Seeds relating to parental line access and confidential breeding material, illustrates how, in the absence of a dedicated trade-secret statute, companies

rely on contract and commercial law to attempt to protect breeding know-how.

Practical challenges and limitations

Trade secret protection is not without its vulnerabilities. Once a seed variety is in the market, farmers multiply and analyse its performance, and sometimes backcross or self-pollinate. The information about the end-product may be effectively publicly accessible, and the question is whether the underlying secret is realistically impossible to reverse-engineer.

In India, there are added enforcement challenges: the seed supply chain is extensive, regulatory oversight varies across states, and counterfeiting remains a serious risk. Traceability, authentication, and contractual enforcement, therefore, become central, and many disputes arise simply due to a lack of awareness or weak monitoring.

Public policy considerations also need to be balanced. India's seed sector includes a significantly small-farmer base, traditional seed saving practices, informal seed networks, and biodiversity concerns. Strong secrecy regimes or over-extension of exclusive rights may end up restricting access, increasing costs for farmers, reducing agro-biodiversity, and raising food-security concerns.

Courts in India have shown caution in disputes such as the Sungro line of litigation, where expansive trade-secret claims over breeding material were not accepted without clear evidence of confidentiality and harm. This reflects the absence of a dedicated statutory framework and the reliance on general contract law and common-law principles, which results in uncertainty for innovators and investors.

These conditions highlight why India would benefit from a dedicated trade secrets legislation. Today, enforcement relies on contract law and scattered judicial interpretation, creating uncertainty and risk for companies handling high-value breeding data and production methods. A purpose-built statute that clearly defines confidential information, prescribes obligations for handling and misappropriation, and provides time-bound remedies would give seed companies the confidence to scale R&D and collaborate without fear of losing core know-how. Such a law would not only protect information that patents and PVP frameworks leave uncovered but also support India's ambitions of becoming a global hub for seed science and agri-biotechnology.

Implications for Indian seed companies and agritech players

For Indian seed companies, the strategic imperative is to integrate trade-secret protection into their broader IP and commercial strategy. This includes identifying which components of the breeding pipeline are best kept confidential, implementing internal controls and documentation, and managing employee mobility risks, as underscored by the Syngenta v. Farmers Business Network dispute.

Export readiness also becomes easier when proprietary methods and parent lines are protected and verifiable. Trade secrets can work most effectively when used in combination with PVP rights, balanced commercial licensing models, and compliance with regional certification systems. Policy engagement with regulatory and industry bodies also matters, as enforcement frameworks, awareness campaigns, and supply-chain authenticity can reduce piracy and unauthorised usage. For instance, in March 2025, the industry urged for stronger IPR enforcement in India's seed sector.

Concluding reflections

In conclusion, for crop-breeding and seed companies, especially in India, the value of confidential know-how is significant. Trade secrets offer a pragmatic complement to formal IP rights, protecting those aspects of innovation that may not be amenable to patents or PVP registration. In the Indian context, where patentability of seeds per se is limited, export ambitions are high, and counterfeiting remains a challenge, trade-secret protection becomes not only viable but rather critical.

The sector must, however, address practical and policy constraints, ensure secrecy is actively maintained, and adopt balanced models that respect farmer interests and biodiversity considerations. If India moves toward a dedicated statutory framework for trade secrets, the jurisprudence emerging from global and domestic seed disputes will remain a valuable reference for shaping a balanced system that protects innovation while respecting farmer and biodiversity considerations.

Agrovision to conduct activities for farmers throughout the year: Nitin Gadkari

Nearly 1.25 lakh farmers, along with researchers, producers, companies, and agri-related professionals, participated in the four day long biggest agriculture summit, 16th Agrovision 2025 at RTMNU Campus in Nagpur.

Dignitaries (from L-R) - Moreshwar Wankhede, Executive Committee Member PDKV; Ramesh Mankar, Organising Secretary, Agrovision; Girish Gandhi, Convener Agrovision; Ravindra Boratkar, Organising Secretary, Agrovision & President, Agrovision Foundation & Managing Director, MM Activ SciTech Communications Pvt Ltd; Nitin Gadkari, Union Minister of Road Transport and Highways and Chief Patron of Agrovision; Dr C D Mayee, Secretary, Agrovision Foundation; Dr Sharad Gadakh, Advisor, Agrovision Foundation and Vice Chancellor, Punjabrao Deshmukh Krishi Vidyapeeth (PDKV) Akola; Dr Indra Mani, Vice Chancellor, Vasantrao Naik Marathvada Krishi Vidyapith, Parbhani; Dr Niteen Patil, Vice Chancellor, Maharashtra Animal & Fishery Sciences University (MAFSU), and other dignitaries releasing the December issue of 'AgroSpectrum', the agri-industry B2B magazine at the 16th Agrovision in Nagpur on November 24.

"Agrovision, an annual agricultural exhibition filled with knowledge sessions, conferences, and panel discussions, will now conduct activities for farmers throughout the year", said Nitin Gadkari, Chief Patron, Agrovision Foundation and Union Minister Road Transport and Highways. He was addressing the valedictory session of 16th edition of Agrovision event in Nagpur.

Reflecting upon the last 16 years' journey of Agrovision, Gadkari said "We have started seeing fruitful results of the continuous efforts of Agrovision resulted in a reduction in farmers' suicides. It has also positively impacted with an increase in agriculture-allied industries in Vidarbha, growth of dairy as a subsidiary occupation through NDDB's work in the region, and overall development in agriculture and allied sectors." He also mentioned ongoing efforts to provide Vidarbha's farmers with advanced orange-farming technology modelled on Spain, where citrus cultivation and orange-technology systems have been perfected.

Gadkari further added that this year's Agrovision saw massive participation from the youth, with thousands of youngsters visiting every single day. He expressed happiness that nearly 1.25 lakh farmers, along with researchers, producers, companies, and agri-related professionals, participated in the event.

He also optimistically shared that possibly next year's Agrovision will be organised at the new convention centre coming up on the grounds of Dr Panjabrao Deshmukh Krishi Vidyapeeth on Amravati Road.

Baramati, Agrovision and NBSSLUP seal landmark MoU to drive AI-enabled agriculture across Vidarbha

In a move that could redefine the technological architecture of Indian agriculture, Baramati-based institutions, Agrovision Foundation and the National Bureau of Soil Survey and Land Use Planning (NBSSLUP) have signed a landmark Memorandum of Understanding to accelerate the deployment of artificial intelligence across Vidarbha's farming systems. The agreement positions NBSSLUP — a premier soil research institute under the Indian Council of Agricultural Research (ICAR) — as the central scientific partner responsible for developing advanced agronomic algorithms that will power AI-driven decision tools for crops, soils, irrigation, and climate management.

NBSSLUP scientists will lead the development of spatially precise soil–crop models, real-time nutrient guidance engines, and predictive decision-support modules calibrated specifically for Vidarbha's cotton, tur, and citrus ecosystems. The collaboration aims to create a unified, cloud-linked agronomy stack capable of assisting farmers with hyper-local insights on fertiliser dosage, irrigation scheduling, pest forecasting, and weather-linked advisories.

Prataprao Pawar, Chairman of Sakal Media Group and a long-time champion of agricultural transformation in Western Maharashtra, framed the MoU within a broader global context. "Baramati has the potential to be India's most consequential AI-agriculture innovation district," he noted, adding that initiatives by Microsoft and ongoing collaborations with scientists from Oxford have revived Baramati's agricultural capabilities over the last decade.

Nitin Gadkari delivered a pointed message on the need for credibility, efficiency, and accountability in India's agricultural modernisation. "Financial audits are important, but performance audits are far more important," he declared, arguing that AI, machine learning, and automation must become the backbone of farm-level performance monitoring. ■

Shivraj Singh Chauhan, Union Minister of Agriculture and Farmers' Welfare inaugurated Agrovision Exhibition on November 21 along with Nitin Gadkari, Union Minister of Road Transport and Highways and Chief Patron of Agrovision; Ashish Jaiswal, Union Minister of State for Agriculture and Ravindra Boratkar, Organising Secretary, Agrovision, President, Agrovision Foundation.

The event was graced by dignitaries Ashish Jaiswal, Union Minister of State for Agriculture; Pravin Tarde, Marathi film Director; Ravindra Boratkar, Organising Secretary, Agrovision, President, Agrovision Foundation and Publisher & Managing Editor, AgroSpectrum; Dr C D Mayee, Secretary, Agrovision Foundation; Dr Sharad Gadakh, Advisor, Agrovision Foundation and Vice Chancellor, Punjabrao Deshmukh Krishi Vidyapeeth (PDKV) Akola; Dr Niteen Patil, Vice Chancellor, Maharashtra Animal & Fishery Sciences University (MAFSU), and other dignitaries.

Ravindra Boratkar presented an overview of key highlights of the Agrovision event, MoUs signed during the event, and various activities held during the four-day event. He said, "Agrovision will launch 'Farmers Training Centre' at Wardha road in January which will be equipped with the modern facilities such as soil testing labs, organic produce certification and also an incubation centre for budding agritech

startups. A special market for organic foodgrains, vegetables and fruits will be set up at the venue where farmers will get modern cold storage and warehousing facilities for their produce. Farmers can directly sell their produce without interference from the middleman at a good price."

He further said "We are trying to disseminate the AI technology in agriculture till it reaches the last stakeholder i.e. farmers. We have groups of 1000 farmers which will work as a pilot for use of AI in orange, sugarcane, cotton and tur farming in Vidarbha region."

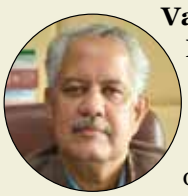
Gadkari released a special issue of AgroSpectrum based on the latest innovations and technologies in the agriculture industry during the event. Dr C D Mayee proposed a vote of thanks to all contributors, exhibitors and sponsors of the event.

The 16th edition of Agrovision, India's leading agricultural summit, took place from November 21–24, 2025, at the RTMNU Campus in Nagpur, Maharashtra. Organised under the theme "Transforming Agriculture, Empowering Farmers," the four-day event brought together farmers, agri-innovators, policymakers, industry leaders, and global experts on a single platform to explore advancements in agriculture and agri-business.

Spanning over 25,000 sq m, Agrovision 2025 hosted more than 450 participating organisations. The event featured a variety of specialised pavilions, including the Agri Incubation Centre, Agri Start-ups, MSMEs, Animal Husbandry, and Self-Help Groups, fostering collaboration among grassroots innovators, small-scale enterprises, and large corporates. ■

Vidarbha poised to emerge as India's next agro-processing powerhouse: Experts

Vidarbha's long-acknowledged strengths in agriculture may soon translate into a national-scale agro-processing hub, if industry, academia, and other stakeholders succeed in aligning infrastructure, technology, and market systems. This was the central message at a high-level panel.



Opening the discussion, **Dr Atul Vaidya, Vice-Chancellor, Laxminarayan Innovation Technological University** underscored that Vidarbha has the fundamentals to become one of India's most competitive agro-processing regions—but only if the value chain is treated as an integrated system rather than a series of fragmented interventions. Subhashini Dwivedi highlighted that the success of any agro-processing cluster depends on understanding the "foundations of the food-processing ecosystem"—infrastructure, markets, and compliance. According to her, even the most ambitious FPO-led ventures falter when these three pillars are weak or disconnected.

"Processing should ideally begin once the FPO matures—when it has working capital, strong leadership, and proven market linkages,"**Mridula Singh, Project Consultant, Digital Governance and MERL,** Palladium India explained, adding that viable business plans, demand-supply pilots, and a clear understanding of trade terms are essential prerequisites.

In her view, the role of FPOs in sustainable food processing goes beyond economics: they help reduce post-harvest losses, strengthen collective bargaining, improve market access, generate rural employment, and stimulate long-term regional development.

Concluding the panel, **Vikram Sheoran, Manager – ITC MAARS, ITC Limited** emphasised that economies of scale, digital transparency, and value addition are the primary levers through which farmers can substantially improve incomes. "When farmers form FPOs, they gain access to extension services, credit support, precision-agriculture tools, and improved price realisation," he said.

Besides Subhashini Dwivedi, Manager Operations – ITC MAARS, ITC Limited; Kapil Sahoo, CEO -- Mae Rim engineers; Madhav Labhe, LITAA Chairman; Ajay Deshpande, Ex Chairman LITAA also shared their thoughts on the topic. ■

Vidarbha should adopt FPO model for making farming profitable: Experts

While small scale farmers are struggling with higher cost of farm inputs and climate issues, the Farmer Producer Organisation (FPO) model can help the farmers in getting the latest farm technologies and inputs at a lesser cost. FPOs in Vidarbha should make use of AI for increasing yield and export growth, discussed the experts and FPO founders at the special conference on FPO.

Founders of FPOs in Vidarbha region shared their success stories at a session, chaired by Radheshyam Chandak, Founder and Chairman, Buldana Urban Co-Op. Credit Society and informed the audience about new opportunities for FPOs.

Nitin Gadkari, Chief Patron, Agrovision Foundation and Union Minister Road Transport and Highways said that saving production cost, increasing yield and better market for the produce are three major objectives of FPOs and to achieve these, FPOs should adopt AI driven farming methods in near future. He also highlighted the need for the creation of an apex body of FPOs at district, state and national level for the growth of the FPO network across the country.

Sharing his thoughts **Vilas Shinde, Chairman and Managing Director Sahyadri Farms** said, "FPOs should adopt new farming technologies and study the demand for agri commodities in the global market and then plan the strategy for their farm. We are providing end to end solutions for orange FPOs which includes development of citrus varieties which are in demand in global markets, use of AI and biotechnology for farming and facilitating market linkages in global markets". ■

AI driven orange farming: a key to increased yield and export opportunities for Vidarbha

"Use of AI driven orange farming methods, new high-yield orange varieties and use of latest post-harvest technologies will help make orange farming profitable in Vidarbha region," said the experts in the special workshop "Citrus production and Processing technologies" held as a part of the Agrovision recently.

The experts in orange farming including Dr Harihar Kausadikar, Director, Maharashtra Agriculture Education & Research Council; Dr Yogesh Ingale, plant Scientist, PDKV, Dr Darshan Kadam, Scientist Central Citrus Research Institute (CCRI) Nagpur; Dr Bansode, Scientist, CCRI; Dr Rajesh Shirole, Sahyadri Farmer Producer company guided the farmers on latest technologies in orange farming and disease management. Dr Dilip Ghosh, Director, CCRI; Dr Sharad Gadakh, Vice Chancellor, PDKV, Akola, Dr Umesh Landge, Joint Director, Agriculture Department, Nagpur; Sudhir Dive, Founder, Dive Farms; Shreedhar Thakare, President, MahaOrange and Dr C D Mayee graced the session.

While emphasising the importance of AI driven orange farming Nitin Gadkari, Chief Patron, Agrovision Foundation said, "A pilot of AI driven orange farming should be run in every taluka of Vidarbha region so that small-scale orange grower will get the benefit of AI farming methods which will reduce the input cost and grow quality oranges at large scale. We have selected a group of 1000 farmers from Vidarbha for this pilot. Farmers will learn lessons from the orange farmers from Spain and Brazil about from seed to packaging of oranges through this pilot."

Gadkari also said "We are in process of developing best quality nurseries for oranges with help of Maharashtra state government, research institutes and agricultural universities and aid from central government."

Sharing his views, **Dr Vivek Bhoite, Scientist, Agricultural Development Trust (ADT)** – Baramati said "AI helps the farmers at every stage of farming by issuing advisory and warning alerts. IoT tools collect data of farming through farm mapping systems. Farmers receive alerts about early pest occurrence through AI systems and also provide the customised solutions for pest management".

Nitin Gadkari released a book "Orange: Spain, Israel via Vidarbha", a compilation of the study tour learnings about high-yield orange farming, grading, and packaging techniques used in Spain and Brazil during the session. ■

AgroSpectrum–GFAiR Webinar

Building Climate Resilience from Seed to Shelf

At a time when climate volatility, water stress, nutritional insecurity, and biodiversity loss are converging into a systemic food crisis, agrobiodiversity is no longer a peripheral concern—it is rapidly becoming a strategic imperative. This was the central message that emerged from "Mainstreaming Agrobiodiversity in Global Value Chains," an AgroSpectrum webinar organised in partnership with GFAiR – The Global Forum on Agricultural Research and Innovation, bringing together leading voices from international research, plant breeding, policy, and state-level implementation.

The webinar moved deliberately beyond conservation rhetoric to examine how biodiversity can be operationalised across seed systems, breeding pipelines, food processing, and markets. By anchoring global scientific insights alongside grounded implementation experiences, the discussion reframed agrobiodiversity not as a nostalgic return to the past, but as a forward-looking economic and resilience strategy for climate-constrained food systems.

Dryland Crops: Not Underutilised, but Underinvested

Setting the global analytical frame, Dr Stefania Grando, International Consultant, Agronomist and Plant Breeder, challenged one of the most persistent assumptions in agricultural development—that millets, sorghum, barley, and dryland legumes are marginal crops with limited relevance to modern food systems. Drawing on more than three decades of work across CGIAR systems, she argued that this narrative fundamentally misdiagnoses the problem. The constraint facing dryland crops, she emphasised, is not agronomy or farmer reluctance, but scientific prioritisation—and the investment architecture that flows from it.

At a moment when climate change has transformed agriculture into a moving target rather than a predictable system, Dr Stefania Grando noted that breeding for uniformity has become a structural weakness. The global food system remains anchored to a narrow triumvirate—rice, wheat, and maize—optimised for an era of climatic stability and cheap inputs. In contrast, dryland crops evolved under stress, variability, and low external inputs. Yet they receive only a fraction of global research funding and breeding attention.

The consequences of this concentration are systemic: accelerated genetic erosion, hollowed-out value chains, rising dependence on water and fertilisers, and the displacement of nutrient-dense traditional diets by calorie-heavy alternatives. In many arid and semi-arid regions, dryland crops now represent the last viable defence against land degradation and desertification. Still, their strategic importance remains largely invisible in mainstream policy and investment decisions.

At the centre of this neglect lies a missing link—seed systems. Without functional pathways connecting gene banks, breeders, farmers, processors, and markets, biodiversity remains frozen in collections rather than alive and adaptive in farmers' fields. Restoring diversity, Dr Stefania Grando argued, requires a decisive shift from conservation to use—building networks of adaptation that make biodiversity economically viable rather than morally symbolic.

From Legacy to Leverage: Odisha's Biodiversity Playbook

If Dr Stefania Grando articulated the global diagnosis, Odisha offered a rare example of treatment at scale. Representing the Department of Agriculture and Farmers' Empowerment, Government of Odisha, Dinesh Balam outlined how the state has deliberately reframed agrobiodiversity from a legacy issue to be preserved into a forward-looking economic and climate resilience strategy.

Rather than importing varietal solutions designed elsewhere, Odisha began by taking stock of its own agroecological wealth. Across intervention blocks, the state assembled the full spectrum of available millet diversity—farmer-conserved landraces alongside formally released varieties—and subjected them to participatory varietal trials under real farm conditions. Farmers

acted not as technology recipients but as primary evaluators, assessing crops on yield, taste, lodging resistance, pest tolerance, and performance under Odisha's increasingly erratic rainfall patterns.

The outcomes were instructive. In over 80 per cent of cases, farmers preferred local landraces to formally released varieties. Subsequent scientific assessments validated these preferences, revealing that at least 14 traditional varieties outperformed university-bred lines on both yield and resilience traits within local micro-agroclimatic conditions. The bottleneck, as Balam noted, was not performance but institutional recognition.

To address this, Odisha built a dedicated seed system for landraces—anchored in crop diversity blocks, scientific purification protocols, and decentralised seed production led by farmer producer organisations (FPOs), with technical backstopping from public research institutions. Conservation was treated as a public good, and farmers were rewarded as custodians and innovators. What began with millets is now expanding to pulses, oilseeds, and vegetables through a formal state scheme on neglected crops and forgotten foods, signalling a shift from pilot interventions to systemic policy adoption.

Africa's Perspective: Diversity Exists, Scaling Does Not

Bringing a grounded African perspective to the discussion, Dr Juliana Jepkemoi Cheboi, Vice Chairperson, Plant Breeding Association of Kenya (PBAK), argued that the continent's central challenge has never been a lack of genetic diversity, but the failure to scale innovation without marginalising smallholders. In countries such as Kenya—where more than 80 per cent of land lies in arid and semi-arid zones—the dominance of maize-centric research and policy has created a structural mismatch between crops and climate. Dr Juliana Cheboi highlighted how landraces and wild relatives of sorghum, finger millet, and indigenous vegetables such as amaranth and spider plant already carry the traits required for heat tolerance, low water use, and nutrient density. Yet they remain largely excluded from formal breeding pipelines.

Reintegrating these crops, she stressed, requires participatory varietal selection, stronger links between formal seed systems and community gene banks, and deliberate inclusion of women and youth across value chains. Only by aligning farmer demand, breeding priorities, and policy incentives can biodiversity transition from conservation rhetoric to an engine of inclusive, climate-resilient food systems.

"Climate change is not a single stress but a moving constellation of uncertainties. While rising temperatures and declining rainfall are globally visible, their local expression is impossible to predict. Breeding, therefore, must target variability itself, not a fixed outcome. Uniform, input-intensive varieties are ill-suited to this reality. Dryland crops, shaped by centuries of stress and uncertainty, already embody the resilience modern breeding systems urgently need—but continue to be systematically underinvested."

Dr Stefania Grando, International Consultant, Agronomist and Plant Breeder

"Odisha built an institutional bridge between conservation and commerce by redesigning seed systems around farmers. Through 'crop diversity blocks,' landraces are evaluated side by side under real farm conditions, selected by farmers, and then purified, multiplied, and scaled through FPO-led seed production. By treating in-situ conservation as a public good and rewarding farmers for it, biodiversity becomes not a legacy to preserve, but a productive, income-generating asset embedded in the state's agricultural strategy."

Dinesh Balam, Representing the Department of Agriculture and Farmers' Empowerment, Government of Odisha

Rethinking Staples: Biodiversity From Within

Challenging the perceived trade-off between staples and diversity, Dr Natalia Palacios Rojas, Principal Scientist, International Maize and Wheat Improvement Center (CIMMYT), reframed the role of maize and wheat in future food systems. As global agriculture confronts the simultaneous transgression of planetary and health boundaries, she argued that staples must deliver nutrition, sustainability, and economic viability—without sacrificing yield or farmer adoption.

At CIMMYT, this has translated into embedding nutritional biodiversity directly into maize and wheat through biofortification for zinc, provitamin A, protein quality, and fibre. Participatory breeding now ensures that nutrition-enhanced varieties reflect farmer and consumer preferences, guiding

target product profiles that respond to real-world demand rather than laboratory assumptions.

Dr Juliana Palacios Rojas also emphasised that breeding alone is insufficient. By drawing on traditional farming systems such as Latin America's milpa, and rethinking food processing through whole-grain use, fermentation, nixtamalization, and blended flours combining staples with sorghum, millets, legumes, and indigenous crops, CIMMYT is reconnecting genetics, diets, and culture—while reducing food loss and waste.

From Silos to Systems: The Global Policy Lens

Placing these field-level experiences within the wider architecture of global research and governance, Joanna Kane-Potaka, Executive Secretary, GFAiR – The Global Forum on Agricultural Research and Innovation, argued that agrobiodiversity remains structurally disadvantaged by fragmented policy frameworks. While biodiversity features prominently in national strategies, most governments continue to operate through siloed mandates—separating nutrition, environment, and commodity support.

For biodiversity-led innovation to scale, Joanna Kane-Potaka stressed the need for whole-of-value-chain alignment—integrating seed systems, markets, processing, certification, and consumer demand. Dryland crops and underutilised species already embody a triple dividend of nutrition, environmental sustainability, and farmer livelihoods, yet remain excluded due to weak incentives and eroded market infrastructure.

Reversing this trajectory, she concluded, requires "smarter staples," rebuilt demand from seed to plate, and a shift from partnerships to co-partnerships—where farmers are not beneficiaries of innovation, but co-architects of it.

From Narrative to Strategy

The AgroSpectrum–GFAiR webinar underscored a central truth: Agrobiodiversity does not fail because farmers reject it. It fails when institutions lack the mechanisms to recognise, validate, and reward it. Across geographies—from Odisha to East Africa to global breeding programmes—the science exists, farmer willingness exists, and the climate imperative is unmistakable.

What remains is a strategic choice. In a climate-constrained world, resilience will not emerge from uniformity. It will come from diversity—scientifically supported, economically rewarded, and mainstreamed into global value chains.

Africa's challenge is not a lack of biodiversity but the failure of seed systems to scale it inclusively. In arid regions like Kenya, maize-centric policies have created a mismatch between crops and climate. Landraces and wild relatives of sorghum, millets, and indigenous vegetables already offer heat tolerance, low water demand, and superior nutrition. Reintegrating them into breeding systems—through participatory selection and community seed banks—can turn biodiversity from rhetoric into climate-resilient livelihoods."

Dr Juliana Jepkemoi Cheboi, Vice Chairperson, Plant Breeding Association of Kenya (PBAK)

Nutrition cannot be delivered by genetics alone. At CIMMYT, we are reconnecting breeding with farming systems and food culture—learning from models like the milpa, where maize, legumes, and vegetables are grown together to build productivity, soil health, and resilience. Processing innovations such as whole-kernel use, fermentation, nixtamalization, and blended flours allow staples to carry greater nutritional diversity, showing that yield, health, and market acceptance can reinforce—not compete with—each other."

Dr Natalia Palacios Rojas, Principal Scientist, International Maize and Wheat Improvement Center (CIMMYT)

Biodiversity will not scale through isolated interventions. It requires whole-of-value-chain alignment—linking seed systems, markets, processing, certification, and consumer demand. Dryland and underutilised crops already deliver a triple dividend for nutrition, the environment, and farmer livelihoods, yet remain locked out by weak incentives. Rebuilding demand from seed to plate, through smarter staples and true co-partnerships, is essential—where farmers are not beneficiaries of innovation, but its co-architects."

Joanna Kane-Potaka, Executive Secretary, GFAiR – The Global Forum on Agricultural Research and Innovation

Suchetana Choudhury
suchetana.choudhuri@agrospectrumindia.com

The India–New Zealand FTA Shows Trade Can Be Pro-Farmer

India and New Zealand have concluded a comprehensive, balanced and forward-looking Free Trade Agreement (FTA), marking a major economic and strategic milestone in India's engagement with the Indo-Pacific. Announced on December 22, 2025, the Agreement is among India's fastest-concluded FTAs and is closely aligned with the national vision of Viksit Bharat 2047.

Formal negotiations were launched on March 16, 2025, and concluded within nine months through five intensive rounds, supported by sustained in-person and virtual intersessional engagements. The speed and depth of the negotiations reflect strong political commitment on both sides. The resulting FTA establishes a high-quality, future-ready economic partnership focused on employment generation, skill mobility, trade- and investment-led growth, innovation, and deeper MSME participation, thereby strengthening long-term economic resilience and bilateral cooperation.

A defining feature of the Agreement is its carefully calibrated approach to agriculture and allied sectors, particularly agri-technology, marine products and dairy. Rather than pursuing blanket market opening, the FTA aligns trade liberalisation with productivity enhancement, livelihood protection and sustainability, signalling an important evolution in India's agricultural trade strategy. In agri-technology, the emphasis is on structured cooperation rather than tariff concessions. Recognising New Zealand's global strengths in farm productivity, horticulture management, food safety and agri-innovation, and India's need to raise yields, quality and value-chain efficiency for small and marginal farmers, the Agreement establishes focused Agri-Technology Action Plans for apples, kiwifruit and honey. These are supported by Centres of Excellence, access to improved planting material, farmer capacity building, and collaboration in orchard management, post-harvest handling, cold-chain development and food safety standards.

Limited market access for select New Zealand products is tightly managed through Tariff Rate Quotas, minimum import prices and seasonal restrictions, with oversight by a Joint Agriculture Productivity Council to ensure that imports remain linked to measurable domestic capability building. This framework enables India to move from price-support-driven agriculture to productivity- and quality-led growth, improving farmer incomes and export readiness while mitigating risks of import-led displacement. The FTA also provides for mutual recognition of organic certification for organic primary products, subject to agreement between regulators. This is expected to reduce compliance costs, facilitate smoother market access, and enhance the credibility and export potential of India's rapidly expanding organic farming ecosystem in premium global markets. The marine sector emerges as a clear export winner with minimal downside risk. India, a global leader in shrimp, frozen fish and value-added seafood, gains immediate zero-duty access across 363 marine tariff lines in New Zealand, previously subject to duties of up to 5 per cent. This improves price competitiveness and margins for Indian exporters and supports employment in labour-intensive coastal value chains such as processing, packaging and logistics. Given New Zealand's small, niche marine import market and India's strong net-export position, risks of import surges are limited. Enhanced Sanitary and Phyto-Sanitary (SPS) cooperation and regulatory disciplines further incentivise Indian exporters to upgrade quality, traceability and sustainability standards, strengthening their positioning in New Zealand and other premium global seafood markets.

Dairy, the most sensitive sector, remains fully protected. Supporting over 80 million Indian households through smallholder-based cooperatives, dairy has been completely excluded from tariff concessions, quotas or phased liberalisation. This preserves farmer livelihoods, prevents price undercutting and safeguards food security, while allowing limited non-trade cooperation in animal health and productivity. Overall, the treatment of agri-technology, marine and dairy sectors under the India–New Zealand FTA illustrates India's shift from defensive protectionism to selective, capability-driven integration. Export-competitive sectors receive full market access, productivity-constrained segments benefit from targeted technology cooperation, and highly sensitive livelihood-dependent sectors remain fully protected. This balanced approach ensures that trade liberalisation supports income growth, employment generation and resilience, while safeguarding rural stability and aligning India's external economic policy with the broader vision of inclusive growth and a globally integrated Viksit Bharat 2047.

Narayan Kulkarni,
Editor
narayan.kulkarni@mmactiv.com

AgroSpectrum
Envisaging Future | Updating Present
www.agrospectrumindia.com

Read E-Magazine

Stay up-to-date on the latest agricultural news and developments in India and beyond!

OUR REACH

75,000+	50,000+	30,000+
Page views	Readers of Print Magazine	Newsletters/ EDM Weekly

For more information, visit:
www.agrospectrumindia.com / www.agrospectrumasia.com