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THE FORCE MULTIPLIER: ATG AWARDS AND THE RISE OF AGRICULTURAL PRIDE

As Group Editor of the Agriculture Today Group, I am filled with immense pride and excitement as we prepare for another edition of the ATG Leadership Conclave and Awards. These events are not just annual milestones for our organisation; they represent a pioneering vision that has transformed the way achievement and leadership are celebrated in Indian agriculture.

When we first conceptualised the ATG Leadership Conclave and Awards, our aim was simple yet ambitious: to build pride and recognition for excellence across the diverse and dynamic sectors of agriculture. India's agricultural landscape is vast and varied, encompassing not just farming, but also research, agri-business, policy, technology, and allied sectors. Yet, for too long, the remarkable achievements within these fields went unnoticed and underappreciated. We saw the need for a platform that would shine a spotlight on innovation, perseverance, and leadership—where every stakeholder, from the smallholder farmer to the agri-tech entrepreneur, could be acknowledged and celebrated. The ATG Group institutionalised these pioneering awards in 2008.

The force multiplier effect of these awards has been truly inspiring. By recognising outstanding individuals and organisations, we have ignited a spirit of healthy competition and aspiration. For farmers, scientists, entrepreneurs, policymakers and other diverse stakeholders, the awards have become a benchmark for excellence, encouraging all to strive for recognition and, in the process, elevate the standards of the entire sector.

Awards and accolades are essential for more than just recognition—they are vital tools for building pride in agriculture. In a country where urban opportunities often overshadow rural vocations, it is crucial to make agriculture an appealing and respected career choice for our youth. When young people see their peers and mentors honoured for their achievements—whether on the farm, in research labs, or in the boardrooms of agri-businesses—they are inspired to consider agriculture as a viable and rewarding path. This is especially important as we seek to attract fresh talent and new ideas to tackle the challenges of food security, sustainability, and rural development.

Organising the ATG Leadership Conclave and Awards is both a privilege and a responsibility. It is a thrilling experience to witness the passion and dedication of our awardees, and to see the ripple effect of their achievements across the sector. As we continue this journey, we remain committed to building pride, encouraging excellence, and shaping a future where agriculture is celebrated as a vibrant, innovative, and indispensable part of our nation's progress.

Rajni Shaleen Chopra

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From the CEO's desk

Celebrating Excellence and Redefining Agriculture

With immense pride and a sense of deep responsibility, we gear up for the much-anticipated ATG Agriculture Leadership Conclave and Awards. A remarkable journey that has brought us here—a journey marked by collaboration, innovation, and the shared vision of transforming India's agricultural landscape.

There is an undeniable thrill in being part of an event that brings together the brightest minds, leading practitioners, policymakers and diverse stakeholders in the field of agriculture. The process of organizing the ATG Agriculture Leadership Conclave and Awards is both exhilarating and humbling. It is exhilarating because it allows us to curate a platform where ideas are exchanged, best practices are shared, and partnerships are forged. It is humbling because it reminds us of the immense trust reposed in us by stakeholders across the spectrum—farmers, entrepreneurs, scientists, government officials, and industry leaders.

The Awards are a celebration of excellence and resilience. They honour those who have demonstrated exemplary leadership, innovation, and commitment to sustainable agricultural practices. Recognizing these trailblazers not only motivates others to follow suit but also sets new benchmarks for the sector. The Conclave, on the other hand, is a melting pot of ideas, fostering dialogue on the most pressing challenges and opportunities in agriculture. It is a testament to our collective resolve to drive positive change.

The edition this month focuses on "Redefining Agriculture"—a theme that is both timely and transformative. Agriculture is at a crossroads. Climate change, resource constraints, technological disruption, and evolving consumer preferences are reshaping the sector. To thrive in this new era, we must reimagine our approaches—embracing innovation, sustainability, and inclusivity.

Redefining agriculture means moving beyond traditional paradigms. It means leveraging digital technologies to empower farmers, adopting climate-smart practices to ensure resilience, and creating value chains that are fair and transparent. It also means recognizing the vital role of women and youth in agriculture, ensuring they have access to resources, knowledge, and opportunities.

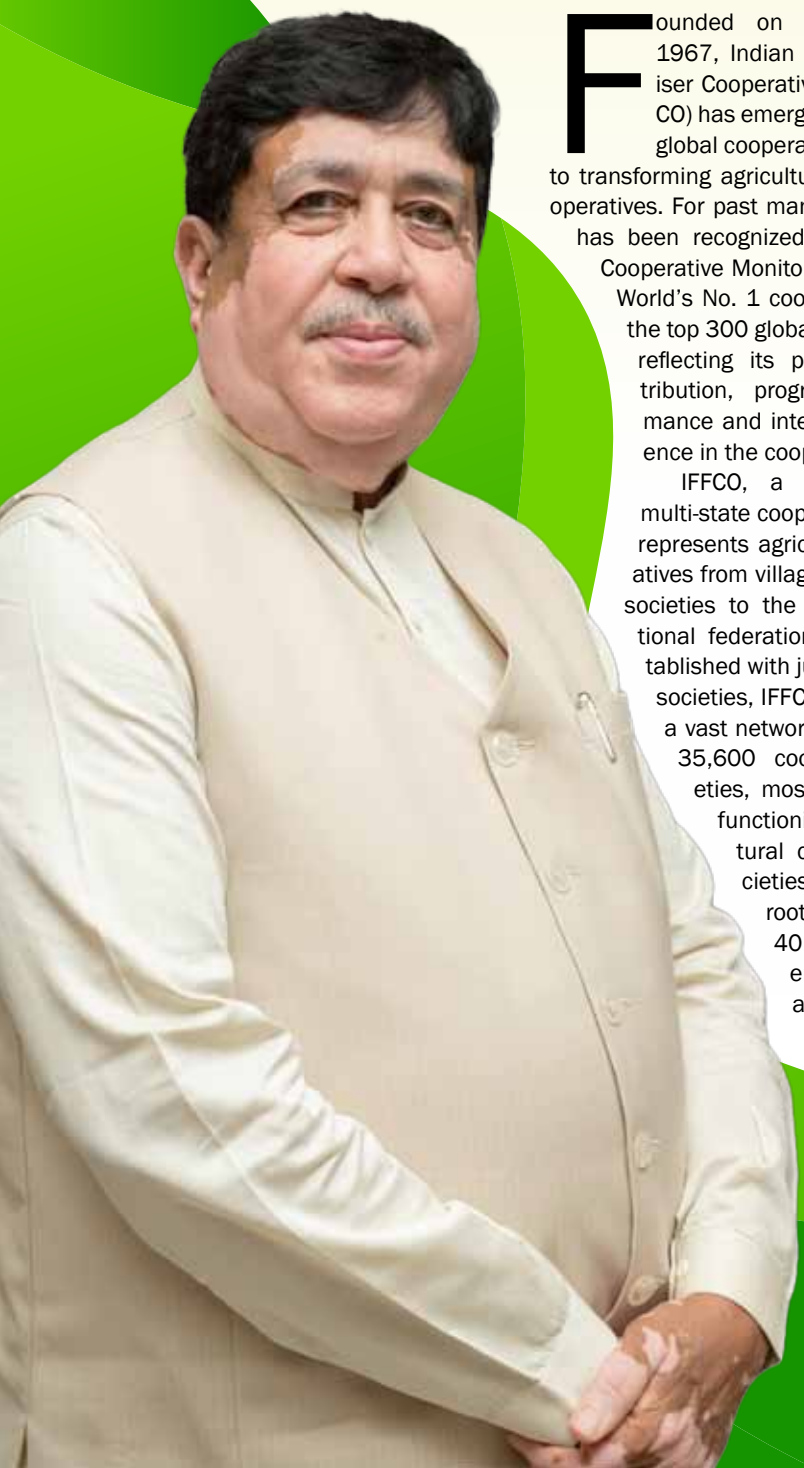
This theme is a call to action—a reminder that the future of agriculture depends on our ability to adapt, collaborate, and innovate. As we gather at the Conclave and celebrate the achievements of our awardees, let us recommit ourselves to the noble cause of building a more sustainable, equitable, and prosperous agricultural sector.

Thank you for being part of this journey. Together, we can redefine agriculture and shape a brighter future for generations to come.

Haris Khan

IFFCO

Dedicated to Agriculture, Cooperatives and Rural Development



Founded on 3rd November 1967, Indian Farmers Fertiliser Cooperative Limited (IFFCO) has emerged as a leading global cooperative committed to transforming agriculture through cooperatives. For past many years, IFFCO has been recognized by the World Cooperative Monitor (WCM) as the World's No. 1 cooperative out of the top 300 global cooperatives, reflecting its pioneering contribution, progressive performance and international influence in the cooperative sector.

IFFCO, a wholly owned multi-state cooperative society, represents agricultural cooperatives from village level primary societies to the state and national federations. Initially established with just 57 member societies, IFFCO today has as a vast network of more than 35,600 cooperative societies, most of which are functioning as agricultural cooperative societies at the grassroots. More than 40 million farmers are associated with IFFCO through these societies. Their grassroot operating channels helps in the last mile delivery of IFFCO's quality fertilizers to India's farmers. For 23 consecutive years, IFFCO has benefited its members by giving 20% dividend YoY on their share capital—unmatched by any cooperative in the sector and by many corporate companies. This reflects IFFCO's complete dedication towards inclusive, equitable and sustainable development of its member cooperatives.

Tremendous Contribution To Nation

IFFCO has made tremendous contribution to the nation's food security. India is self-sufficient in production of food grains, and IFFCO's contribution through fertilizers cannot be ignored. Every third bag of phosphatic fertilizers and every fifth bag of nitrogenous fertilizers used by India's farmers is from IFFCO.

IFFCO has diversified its product portfolio from time to time to meet farmers' needs including seeds, agrochemicals, various grades of fertilizers, specialty fertilizers, bio-decomposers, bio-pesticides and bio-fertilizers etc. Along with promotion of latest agricultural technology, IFFCO has done R&D on innovative agri-input products. For the first time globally, IFFCO has developed and commercialised novel nano fertilizers; it

About the **AUTHOR**

Mr Dilip Sanghani is Chairman, Indian Farmers Fertiliser Cooperative Limited (IFFCO)

has provided indigenous biostimulants like 'Sagarika' to the farmers; developed and promoted improved Neem varieties. Efforts of IFFCO will bring a new revolution in the agricultural sector which will benefit farmers and increase their income along with improvement in soil health and protection of environment.

Introduction of Nano Fertilisers

IFFCO has introduced nano fertilizers in the agriculture sector as a solution to the environmental and economic challenges posed by indiscriminate use of conventional fertilizers. To prove the effectiveness of nano fertilizers, IFFCO organized demonstrations in various agro-climatic zones (ACZs) of the country, in which Krishi Vigyan Kendras (KVKs) of the Indian Council of Agricultural Research (ICAR) actively participated. IFFCO Nano Model Village clusters were established in many states and lakhs of farmers have benefited.

To incorporate modern technology in the agriculture sector, IFFCO has adopted drones. With drones, spraying of nano fertilizers and other agricultural chemicals, safety and efficiency of farmers have increased. IFFCO has taken inspiring initiative towards women empowerment by introducing women in rural areas as 'Drone Didi' by training them in drone operation. This is a step towards technological empowerment, social change and enhanced self-reliance of women.

Expanding the scope of its nano fertilizers, IFFCO has also developed Nano Zinc, Nano Copper and Nano NPK (solid/liquid), which will soon be available to the farmers. These initiatives will increase crop productivity and significantly reduce cost of cultivation with added benefits of better soil – air and water, quality of produce and less chemical load in crops.

There is increasing demand of IFFCO nano fertilizers from abroad. IFFCO nano fertilizers have been exported to more than 40 countries, including America, Brazil, Suriname, Mexico, Zambia, Kenya, Bangladesh and Nepal. Crop tests overseas have encouraging results. In America, there has been an increase in production as well as quality of almonds, pistachios, maize, cotton and grapes. In Brazil, there has been an increase of up to 14 percent in crops like soybean, sugarcane and maize.

Through its multiple efforts, IFFCO has demonstrated that cooperation is not only an economic arrangement, but it is also an effective medium to bring the desired social change

Growing interest in IFFCO's nano fertilizer in various countries displays global recognition of Indian agricultural technology. International organizations such as FAO have recognized IFFCO's innovations as a contribution towards sustainable agriculture.

Contribution in Diversified Areas

IFFCO is active in diversified areas like insurance, agrochemicals, rural finance and Special Economic Zones (SEZ). More than 21 IFFCO associate/subsidiaries are operational in sectors such as IFFCO-Tokio in insurance sector; IFFCO-MC in agrochemicals, IFFCO-Kisan Finance in agricultural loans, IFFCO-e Bazaar in retail; CORDET for rural development and IFFDC for environmental improvement through afforestation.

Through these associate organizations IFFCO provides a holistic solution to farmers, increasing their income and improving their standard of living. Taking forward the concept of *Sahkar Se Samriddhi*, with the efforts of the Ministry of Cooperation, GOI, Bharatiya Beej Sahakari Samiti Limited (BBSSL) has been established, in which IFFCO is also a partner. Farmers will be able to get high quality seeds/varieties through seed cooperative societies along with traditional or *Meethae beej*, which will benefit them.

Indian Farm Forestry Development Cooperative Limited

For conservation of natural resources and improvement of environment in the rural areas, IFFCO has established Indian Farm Forestry Development Cooperative Limited (IFFDC), which aims to convert barren and unused land into greenery. By planting trees on thousands of hectares of land in many states, IFFDC has provided new means of environmental protection and livelihood to rural communities. To promote inclusive development, participation of women and tribal communities have been ensured. Recently, by earning 78,000 carbon credits, the organization has also provided benefits of Rs 6.7 crore to its stakeholders.

Through CORDET, regular training

programs are organized to train farmers about advanced methods of farming, animal husbandry, water conservation, soil testing and new agro technologies. This increases their confidence and motivates them to take up farming as a professional avenue.

IFFCO's agricultural development and promotion activities are centred around farmers and cooperatives viz. 'adopting villages' to bring about transformation in agriculture and rural life; providing agri-inputs and information through 'Kisan Seva Kendras'; providing accurate information on soil fertility through 'soil testing'; organizing Kisan Sabhas, crop demonstrations, field days/harvest days for 'transfer of better farm technology'; providing critical inputs and information through Critical Inputs Programme (CIP), crop seminars, sale point personnel training (SPPT) programme, soil testing campaigns, bio-fertilizer campaigns, Integrated Nutrition Management (INM) and Integrated Pest Management (IPM) campaigns, human and animal health check-up campaigns, organizing eye camps, tree plantation campaigns and promoting agro-forestry etc.

IFFCO's Village Adoption Programme

IFFCO's village adoption programme has become an effective model of rural development. Activities like agricultural awareness, health camps, women training, veterinary services and community development are conducted in the selected villages with the objective of overall rural upliftment.

IFFCO's 'Save the Soil Campaign' in 2009-10 paved the way for increasing productivity of crops through activities like soil testing services, soil amendment, making farmers aware of the importance of organic manure, reuse of crop residues and waste management, biogas unit, green manuring, biofertilizer, balanced and efficient nutrient management (INM and SSNM), crop diversification and intensification, inclusion of pulses in crop rotation, inclusion of oilseeds and high value commercial crops (fruits, vegetables, flowers, seed spices etc.), awareness about cropping systems and more income and employment opportunities, water resource development, micro irrigation (drip and sprinkler) and fertigation, promotion of agricultural equipment and machinery, providing machinery services through cooperative societies, beekeeping, storage space and storage bins etc. were provided. These techniques have led to a significant increase in crop production and quality.

Initiatives For Farmers' Welfare

IFFCO has taken many initiatives for social and economic upliftment of farmers, reflecting its sense of social responsibility. Relief and rehabilitation work during natural disasters, scholarships for education to the children of poor and deprived farmers, and financial assistance for serious diseases are continuously undertaken by IFFCO. Through this, IFFCO has built economic relationship with farmers and established long term social and emotional understanding with them.

Through these multiple efforts, IFFCO has demonstrated that cooperation is not only an economic arrangement, but it is also an effective medium to bring the desired social change. IFFCO' cooperative model is an example to the world that how through professionalism and technological innovation, social responsibility and participation, rural India can be transformed towards farmers empowerment and sustainability.

KHET SE KITCHEN TAK

HOW LEADSCONNECT IS TURNING FARMERS INTO FARMPRENEURS

Empowering farmers is not just about giving them tools—it's about giving them their due and control over their future. Ensuring their smile is our mission. The agricultural fields were once rich with generations of stories, woven into every harvest.

Today, rising costs, rapid urbanisation, climate risks, and shrinking margins have pushed many away from agriculture. Land is being sold, youth are migrating, and farming is fast losing its generational appeal. This is not just a loss to the farming community, but a looming threat on the civilisation.

This is where LeadsConnect step in.

We are committed to restoring dignity and profitability to agriculture. And we are determined to put farmers in the driver seat of this human race. From advisory and risk mitigation to direct produce buyback for our industries, we support farmers across the entire value chain. By addressing fundamental problems such as opaque pricing, delayed insurance claim settlement, limited credit access, and market exploitation, the company is empowering farmers to transform into farmpreneurs—farmers who act as entrepreneurs, equipped with data, decision-making tools, and direct access to value chains. We ensure that the say of farmers should be at the heart of the journey of agriculture. Their words and wisdom should find the right place.

With, India's agricultural landscape is undergoing a silent revolution—powered not just by tractors and seeds, but by data, digital tools, and decentralised decision-making, Agri Analytics and value chain company like us, is at forefront of this revolution, transforming Indian farmers into empowered farmpreneurs.

With our bold mission of "Khet Se Kitchen Tak"—from farms to fork—LeadsConnect is building a sustainable, inclusive, research driven and tech-powered value chain. The goal? Not just higher yields, but higher incomes. Not just higher incomes but ensured stability.

The Problem: A Familiar Story

From opaque pricing and inadequate crop insurance to limited access to formal credit and reliable market linkages, Indian farmers have long battled an inefficient ecosystem. But LeadsConnect saw opportunity in these gaps—and built a solution that integrates space-tech, AI/ML, crop analytics, market access, and financial empowerment. The result is AGRANI—an in-house Agri FinTech SaaS platform providing real-time advisory, risk management, and agri value chain solutions through three key mobile apps:

About the **AUTHOR**

Mr Navneet Ravikar is Chairman & MD, LeadsConnect Services Pvt. Ltd.

- **AGRANI KISAN** – Empowering farmers with hyperlocal advisory and access to insurance, credit, and right market.
- **AGRANI SAATHI** – Onboarding village-level entrepreneurs as facilitators
- **AGRANI PRO** – A full-stack marketplace connecting FPOs, buyers, processors, and exporters

We empower farmers by linking them directly with a network of institutional buyers, eliminating middlemen and ensuring they receive fair prices for their produce.

Our farmer-centric platform, AGRANI KISAN enables farmers to sell their harvest conveniently, without the burden of transportation or intermediaries, ensuring better returns and improved livelihoods.

Real Change, Real People

"Agrani have helped many sells directly to the mandi without paying any commission".

Case 1: Better Prices for Basmati in Eastern Uttar Pradesh

In eastern Uttar Pradesh, remote sensing and drone-led assessments enabled Basmati growers to access direct institutional procurement—improving price realization.

Integrated warehousing, weather alerts, and price forecasting helped farmers store crops during market gluts and sell at the right time—turning marginal gains into meaningful profits.

Case 2: Smart Crop Forecasting in Assam

Working with ARIAS Society, LeadsConnect deployed **AI-based crop yield estimation models** across 41 districts in Assam. Farmers received early yield forecasts, which improved input planning and MSP procurement operations. The project covered rice, maize, mustard, and tea farmers across Lakhimpur, Sonitpur, and Dhemaji.

"When you know your harvest in advance, you can make smarter moves,"

Case 3:

Most recently, in Prayagraj district (Uttar Pradesh), we worked directly with mustard-growing farmers—right from sowing to harvest under project Maati—and conducted direct procurement of mustard at the farm level. This eliminated middlemen, ensured better pricing, and offered farmers a dependable marketing channel via our AGRANI platform.

All these projects—executed in partnership with entities like MNCFC, NABARD, HCL Foundation, MoA, SBI, APEDA, and major insurers—are grounded in real impact.

Tech with a Heart

What makes LeadsConnect stand apart is its SpaceTech, DeepTech & Strong AI capabilities fused with grassroots empathy.

Proven Impact on Ground

With over 10 lakh hectares of agricultural land covered, LeadsConnect's integrated model has already:

- Reached over 4 lakh farmers across 4 states
- Executed more than 15 large-scale projects
- Onboarded 5,000+ farmers, 10 traders, and 1 major manufacturer
- Disbursed loans worth ☐100 crore+ to farmers and SHGs
- Sourced 1,000+ MT of farm produce directly through AGRANI PRO
- Conducted 3.5 lakh+ Crop Cutting Experiments (CCEs)
- Monitored 1 lakh+ hectares of crop health
- Enabled 50,000+ crop insurance settlements

- Delivered analytics across 45 + crop types in 15+ Indian states

Credit, Insurance & Livelihoods

"Financial access is the lifeline of prosperity. We ensure that no farmer is left behind."

Leveraging our strategic partnership as a leading Corporate Business Associate with India's largest public sector bank and private sector banks, we are proud to provide a wide array of financial services aimed at supporting the growth and development of farmers, SMEs, FPOs, and SHGs. Through these efforts, we facilitate access to various loan products, such as KCC, ABAL, PMFME, and AIF, specifically designed to meet the unique financial needs of these stakeholders.

In addition, we are sourcing loans for Farmers, FPOs and Corporates under various schemes such as ABAL, AIF, and PMFME, targeting sectors like Goat Farming, Pig Farming, Fisheries, and Food Processing Units. These schemes also extend support to projects including Agri Gold Loans, Mini Oil Mills, Sugarcane Juice Processing Units, and Cattle Feed Processing Units.

Insurance: Offering health, crop, motor, and cattle insurance to mitigate production risks due to weather conditions or market fluctuations.

Climate-Smart and Inclusive

As climate change reshapes agriculture, LeadsConnect is building resilience into the system through NatCAT analytics, Flood modelling, Crop yield models powered by AI and SpaceTech, Real-time risk analytics for insurers and reinsurers and Climate-smart advisories for sustainable practices.

From a small advisory firm to a full stack agri value chain enabler, LeadsConnect's journey is rooted in one core belief: "Farming must be profitable again. Not just for the farmer's survival, but for India's future."

What's Next?

"The future of agriculture is digital, distributed, and driven by data. We're already building it. Soon, the solutions like PixStack from LeadsConnect will be on ground to create IMPACT in the lives of farmers and all stakeholders of the risk ecosystem."

The Circular Economy Vision: From Soil to Sustainability

What truly sets our group apart is its vision of a 360-degree circular economy—leveraging the group's full capabilities across agriculture, food, dairy, and clean energy.

At the center of this vision is our recent initiative, which integrates:

- **Agri-residue buyback** (e.g., straw and stubble) from local farmers to power our **CBG (Compressed Bio Gas)** plant
- **Cattle feed procurement** for its dairy operations from contract farmers
- **Buyback of milk and food grains** for its in-house processing and FMCG brands
- **Support for setting up primary processing units** near farms with loan facilitation, equipment guidance, and offtake assurance

This creates a closed-loop system where farmers not only grow, but sell, supply, and gain continuous value from their produce and by-products.

"We connect every dot in the value chain—so the farmer isn't just a supplier, but a stakeholder in the entire ecosystem."

A Model for India's Agri Future

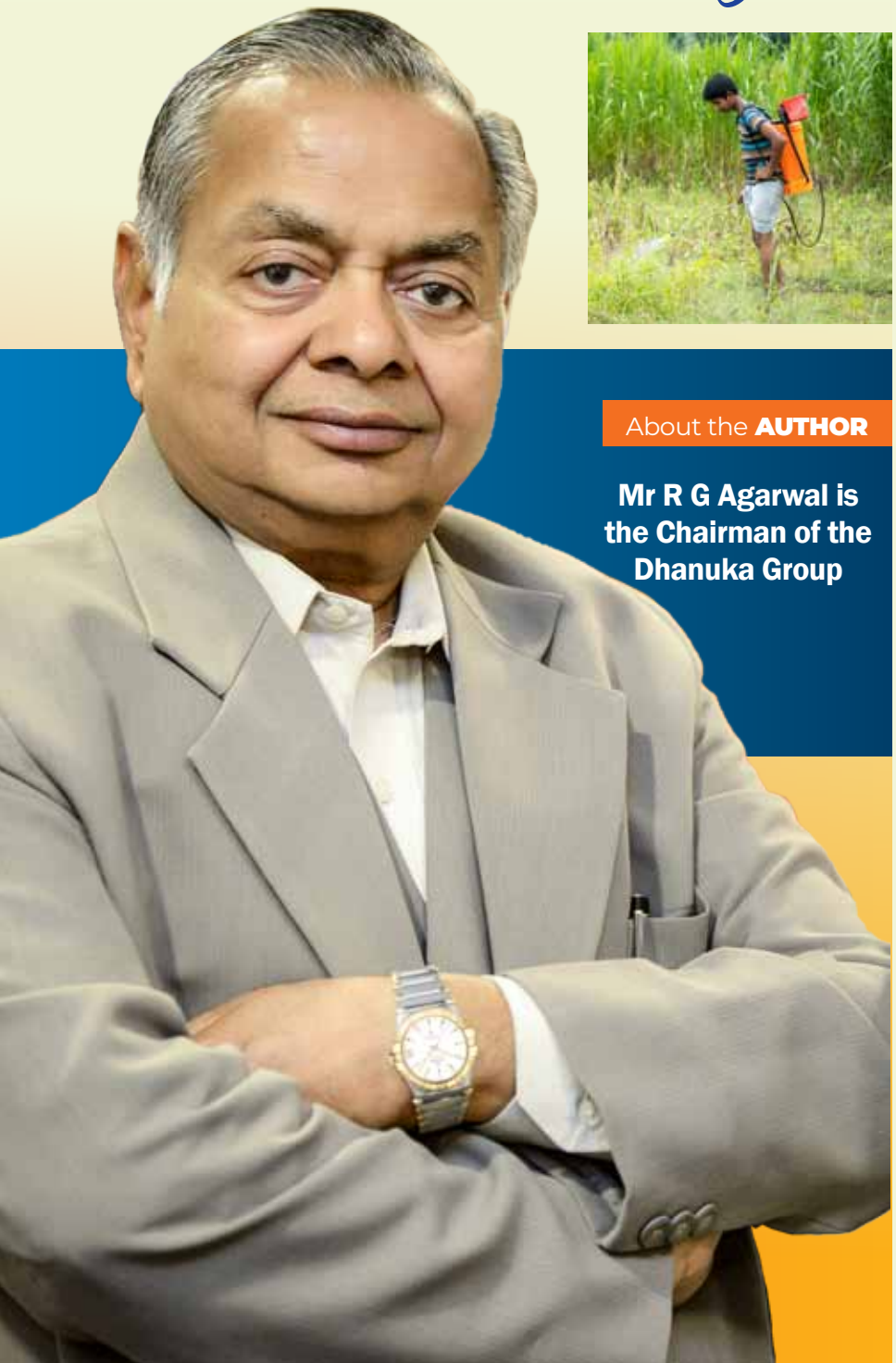
As India aspires to double farmer incomes and expand agri-exports, it must:

- Digitize value chains with real-time traceability
- Promote decentralised processing and procurement
- Strengthen rural credit and insurance infrastructure
- Connect smallholders to institutional and global markets
- Enable end-to-end farm-to-fork traceability

LeadsConnect is already doing this—demonstrating a replicable and scalable model of agri empowerment. We call it farmer-first digitization. When you put the farmer at the center, everything else follows—data, efficiency, and prosperity.

THE MENACE OF FAKE FERTILIZERS

A Call to Protect Indian Agriculture



About the **AUTHOR**

Mr R G Agarwal is the Chairman of the Dhanuka Group

India's agricultural sector is the backbone of our economy, sustaining millions of families and ensuring food security for the nation. However, this vital sector faces a grave and growing threat: the rampant spread of fake fertilizers and agro-inputs. As Chairman of the Dhanuka Group, I have witnessed the catastrophic impact this menace has on our farmers, our food supply, and the credibility of our agricultural system.

The Scale and Nature of the Crisis

In recent years, the magnitude of the fake fertilizer problem has become alarmingly clear. In Rajasthan, for example, authorities recently uncovered a massive scam, raiding over 30 factories manufacturing adulterated fertilizers using industrial waste such as marble slurry, stone dust, and coloured dyes. These counterfeit products, packed to look like reputable brands, are distributed not just within Rajasthan, but across major agricultural states like Haryana, Punjab, Uttar Pradesh, and Bihar. Shockingly, more than two lakh bags of fake fertilizers were being supplied daily, deceiving thousands of unsuspecting farmers.

The issue is not limited to fertilizers alone. Fake pesticides and seeds are also flooding the market, with studies indicating that up to 40% of farm input sales by value may be counterfeit or substandard in some regions. The black market for these fake products is vast, sophisticated, and alarmingly well-organized, exploiting regulatory loopholes and weak enforcement mechanisms.

The Fallout: Farmer Livelihoods, Food Security, and the Environment

The consequences of this crisis are multifaceted and deeply damaging:

- **Farmer Livelihoods:** Farmers, often with limited education and resources, trust local vendors for their agricultural inputs. When they unknowingly purchase fake fertilizers or pesticides, their crops suffer. Yields decline, soil fertility is compromised, and the financial losses can be devastating.
- **Food Security:** The use of spurious agro-inputs has led to significant losses in crop production. According to a FICCI study, fake products cut over 10 million tonnes of potential agricultural output in a single year. This directly threatens India's food and nutritional security, with ripple effects on rural employment and national economic stability.
- **Environmental and Health Hazards:** Adulterated fertilizers and pesticides often contain harmful substances. Industrial waste, carcinogenic dyes, and non-biodegradable materials contaminate the soil and water, posing long-term risks to human health and the environment.
- **Industry Credibility and Innovation:** The proliferation of fake inputs erodes trust in genuine brands, discourages innovation, and undermines the growth of the legitimate agrochemical industry. Companies that invest in research and quality assurance are squeezed out by price-cutting fakes, stifling the sector's advancement.

Why the Scourge Persists

The fake fertilizer and pesticide trade thrives due to several systemic weaknesses:

- **Regulatory Gaps:** While India has laws banning and criminalizing the sale of counterfeit agro-inputs, enforcement is sporadic and often undermined by official negligence or complicity. Insufficient laboratory infrastructure and regulatory blind spots allow counterfeiters to operate with impunity.
- **Deceptive Packaging and Marketing:** Counterfeiters are adept at copying packaging, labelling, and even brand names, making it nearly impossible for the average farmer to distinguish genuine products from fakes.
- **Lack of Farmer Awareness:** Many farmers are unaware of the risks posed by fake inputs or how to identify them. Influential dealers in rural markets often push high-margin counterfeit products, further perpetuating the cycle of exploitation.

The spread of fake fertilizers and agro-inputs is nothing short of economic warfare against our farmers and against our country's future

The Way Forward: A Call to Action

The recent crackdown in Rajasthan, where 34 factories were sealed and multiple FIRs lodged, is a step in the right direction. However, piecemeal actions are not enough. The scale of the crisis demands a coordinated, war-scale response.

1. Stricter Laws and Enforcement

The Centre is preparing to introduce a new law with harsher penalties for those involved in the manufacture and sale of fake fertilizers and pesticides. This law must not only target individual offenders but also dismantle the entire supply chain of counterfeit products. Swift and exemplary punishment is essential to deter this criminal enterprise.

2. National Campaigns and Farmer Education

At Dhanuka Group, we have launched the "Jago Kisan Jago" initiative to educate farmers about the dangers of fake agro-inputs and how to avoid them. But this must become a nationwide movement. The government, industry, and farmer organizations must collaborate to raise awareness, provide training, and ensure that every farmer knows how to verify the authenticity of the products they buy.

3. Strengthening Supply Chains and Technology Use

The adoption of digital tracking, QR codes, and supply chain transparency can help farmers and authorities trace the origin of agro-inputs and verify their authenticity. Investment in laboratory infrastructure for rapid testing of products at the point of sale is also crucial.

4. Accountability and Vigilance

Officials responsible for monitoring the agro-inputs market must be held accountable for lapses or complicity. Regular audits, surprise inspections, and strict action against negligent officials are necessary to restore trust in the regulatory system.

5. Industry Collaboration

The legitimate agrochemical industry must work together to share intelligence, support enforcement efforts, and develop best practices for packaging and product verification. Only through collective action can we outpace the counterfeiters and protect our farmers. If we fail to act decisively now, the consequences will be felt for generations.

I urge the government, industry, and every stakeholder to join forces in this fight. Let us eradicate the menace of fake fertilizers, restore trust in our agricultural inputs, and ensure that Indian agriculture continues to thrive as the pride of our nation.

The time for action is now. Let us stand united to defend our fields, our farmers, and our future.

AGRICULTURE RENEWED

ROADMAP FOR A SUSTAINABLE FUTURE

India's agriculture sector is undergoing a critical transformation. As the nation aims to double farmers' income and ensure food security for its growing population, agriculture must evolve to become more market-oriented, technology-driven, and environmentally sustainable. However, despite contributing nearly 18% to India's GDP and employing over 40% of the workforce, the sector continues to face structural challenges — low productivity, climate unpredictability, and market inefficiencies.

We believe the growth of Indian agriculture must rest on five strategic pillars: Market Reforms, Resource Regeneration, Farmer Reskilling, Research and Innovation, and Robust Rural Infrastructure. Here's how these pillars can be strengthened, with live examples reflecting real progress and overcoming challenges.

Reforming Agricultural Markets

A fundamental shift is needed in how agricultural markets function in India. Fragmented supply chains, high post-harvest losses, and poor market linkages often mean that farmers earn just a fraction of the final consumer price.

To replicate such success, the focus must be on expanding rural mandi infrastructure, cold chains, and online platforms like e-NAM, which today connects over 1,200 APMCs across India. Farmer Producer Organizations (FPOs), supported under the government's 10,000 FPO scheme, are another way to increase bargaining power and scale direct marketing. Companies are actively partnering with FPOs to provide technical training and market linkage support, enabling value addition through processing, grading, and packaging.

Regenerating Natural Resources

India is witnessing severe environmental stress. According to NITI Aayog, nearly 600 million Indians face high to extreme water stress in parts of Rajasthan repeatedly facing drought-like conditions.

The adoption of Micro-irrigation, such as drip and sprinkler systems, offers a solution. The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) has expanded irrigation coverage and promoted water-use efficiency. Maharashtra's Jalyukt Shivar Abhiyan has successfully revived water bodies in drought-hit districts by using decentralized watershed management techniques.

About the **AUTHOR**

Mr Sanjay Aggarwal is the Managing Director of Indogulf Cropsciences Ltd.

Reskilling and Empowering Farmers

Today's farmer must be a decision-maker, entrepreneur, and technologist. This calls for a comprehensive reskilling effort. Government institutions like Krishi Vigyan Kendra (KVKs) and private players are stepping up to train farmers in modern farming practices.

In states like Maharashtra and Gujarat, farmers are now using drone-based spraying, mobile soil testing, and GPS-guided tractors to reduce input costs and improve yields.

Investing in Research and Agricultural Innovation

India's agricultural research institutions, led by ICAR, have made notable decisive steps in developing high-yielding and climate-resilient crop varieties. Precision farming—backed by AI, satellite imagery, and IoT—offers another frontier. Startups are leading in this change. The government's Digital Agriculture Mission launched in 2021 is also creating a unified Digital Agri-stack to accelerate this innovation.

Building Strong Rural Infrastructure

No transformation is complete without infrastructure. Rural roads, electricity, warehousing, and cold storage are vital to unlock agricultural potential. Programs like Pradhan Mantri Gram Sadak Yojana (PMGSY) have improved road connectivity, but challenges persist, especially in eastern and hilly states.

The road to agricultural transformation must be covered with inclusive policies, grassroots innovation, and collaborative efforts between government, industry, and the farming community

The expansion of solar pumps under Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) is helping reduce irrigation costs and carbon emissions. Meanwhile, states like Odisha have built mega cold chains for seafood and horticulture products under Public-Private Partnership (PPP) models, enabling access to export markets.

Financial inclusion is equally critical. The Jan Dhan-Aadhaar-Mobile (JAM) trinity and rural banking expansion have helped bring millions of farmers into the formal economy. However, access to crop insurance and institutional credit remains uneven – especially among smallholders.

Biologicals: The Way for Sustainable Agriculture

As agriculture evolves towards eco-conscious practices, biologicals—including Bio-stimulants, Biofertilizers, and Biopesticides—are emerging as key tools for sustainable farming. Derived from natural sources, they improve nutrient uptake, enhance crop resilience to abiotic stress, and reduce dependence on synthetic inputs. With the rising demand for organic food, biologicals offer a safe and effective way to boost productivity while preserving soil health and biodiversity. Companies like Indogulf Cropsciences are leading this shift by promoting science-backed biological solutions that ensure long-term sustainability and support the transition to a greener, more resilient agricultural ecosystem.

Promoting Responsible Agri-Input Practices: The 5R Framework

As agriculture embraces technology and sustainability, the responsible use of agrochemicals remains a cornerstone of productive and safe farming.

Choosing the Right Product tailored to the crop and pest situation prevents unnecessary chemical exposure. Applying it at the Right Time, such as during the pest's vulnerable stage, increases efficacy while reducing quantity. Accurate calculation of the Right Dose avoids resistance build-up and ensures cost-effectiveness. Using the Right Method - be it seed treatment, or drip application—enhances uniform coverage. Finally, ensuring application at the Right Place, such as root zones or specific leaf surfaces, ensures maximum benefits.

Time to Nurture The Seeds of Change

India's agriculture is rich with potential but weighed down by complexity. The road to agricultural transformation must be covered with inclusive policies, grassroots innovation, and collaborative efforts between government, industry, and the farming community.

The future of Indian agriculture is not just about increasing yields—it is about building resilient livelihoods, regenerating the environment, and transforming rural India into a hub of opportunity.

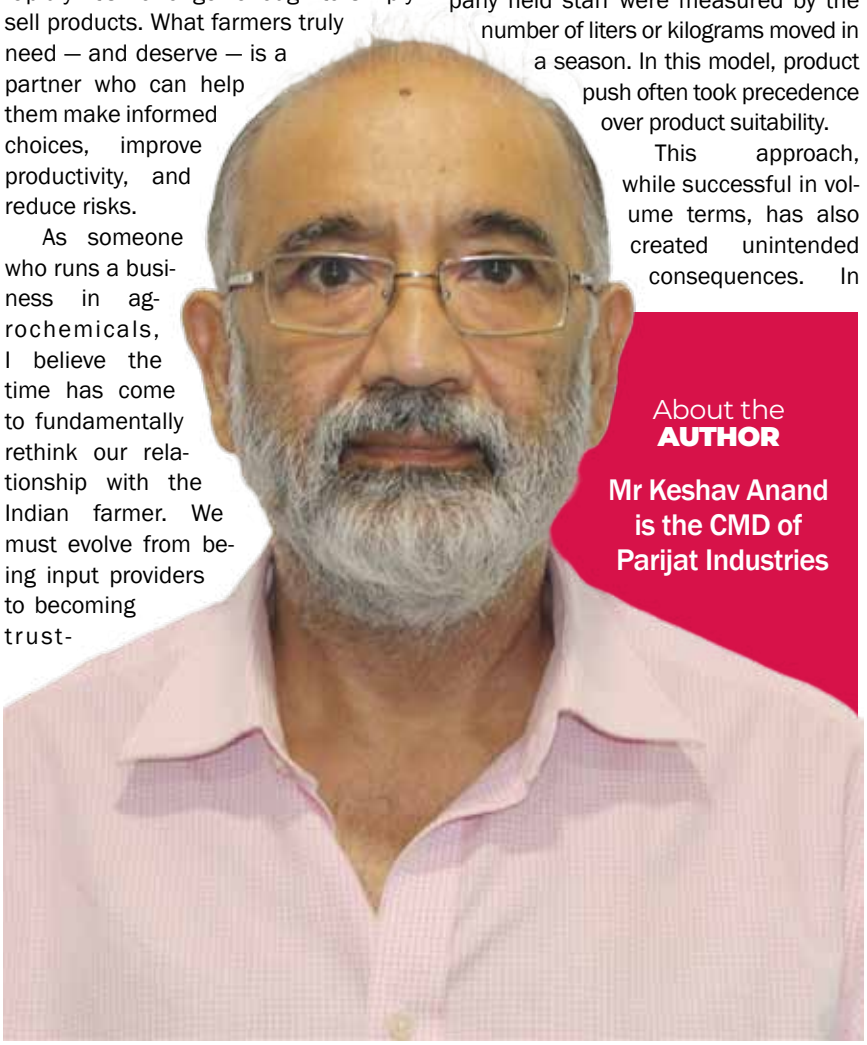
The seeds of change have already been sown. Now, it's time to nurture them—together.

FROM INPUTS TO IMPACT

RETHINKING THE AGROCHEMICAL INDUSTRY'S RELATIONSHIP WITH THE INDIAN FARMER

Indian agriculture stands at a crossroads. With rising input costs, erratic weather, and increasing pest resistance, the challenges facing the Indian farmer today are far more complex than ever before. At the same time, the expectations from the agrochemical industry are changing rapidly. It's no longer enough to simply sell products. What farmers truly need — and deserve — is a partner who can help them make informed choices, improve productivity, and reduce risks.

As someone who runs a business in agrochemicals, I believe the time has come to fundamentally rethink our relationship with the Indian farmer. We must evolve from being input providers to becoming trusted advisors — focused on outcomes, not just outputs.



About the **AUTHOR**

Mr Keshav Anand is the CMD of Parijat Industries

The Legacy Model: Sales-Led, Product-Pushed

For decades, the agrochemical sector in India has been built on a sales-first approach. Dealers, distributors, and company field staff were measured by the number of liters or kilograms moved in a season. In this model, product push often took precedence over product suitability.

This approach, while successful in volume terms, has also created unintended consequences. In some cases, farmers were encouraged to use broad-spectrum pesticides when targeted interventions would have sufficed. At other times, products were promoted without considering local pest prevalence, weather conditions, or crop stage.

The result has been mistrust. Farmers sometimes view agrochemical companies with suspicion — seeing them as profit-driven entities disconnected from the realities of their fields. That perception must change.

The New Imperative: Farmer-Centric Value Delivery

Today's farmer is more informed and connected than ever. With smartphones in hand and access to peers, extension services, and digital platforms, they are looking beyond flashy product claims. What they seek is practical, localized guidance.

This is where agrochemical companies have a huge opportunity. Instead of focusing solely on what product to sell, we must ask: What problem are we solving for the farmer? Is it a sucking pest at early growth? A fungal infection during flowering? Or the stress of an early-season drought?

Being farmer-centric means:

Recommending products based on local data and crop phenology

Communicating usage instructions clearly and honestly

Tailoring solutions based on geography and season

Helping farmers avoid overuse that could harm yield or violate residue limits

Farmer education campaigns — whether through field demonstrations, mobile advisories, or WhatsApp groups

— must become core to our engagement model.

The Role of Field Staff: From Salespeople to Agronomic Advisors

In the rural landscape, our field executives are more than just employees — they are the voice and face of the company. Their words carry weight. That's why their role must shift from merely achieving targets to offering science-based advice.

Unfortunately, high attrition and uneven training often limit this potential. A well-trained field staff member can become an agronomic advisor — diagnosing pest issues, suggesting Integrated Pest Management (IPM) strategies, and guiding farmers on the timing and safety of sprays.

This requires investment:

Regular training on pest and disease identification

Exposure to sustainable practices like rotation, threshold-based sprays, and tank mix compatibility

Equipping them with digital tools — tablets, pest detection guides, and soil health testing kits

Incentives should also change — rewarding not just volumes sold, but farmer satisfaction, correct usage, and yield improvements in their territory.

Technology as an Enabler

Digital technology is a game-changer for agrochemical outreach. Weather-based spray advisories, geotagged demo plots, mobile apps with dosage calculators, and even drone-assisted scouting are no longer futuristic — they are real tools, available today.

Digital technology is a game-changer for agrochemical outreach.

By integrating data from weather, soil, and pest forecasts, we can offer hyper-local, personalized recommendations to farmers. Many startups in India are already working in this space, and agrochemical companies must explore partnerships or invest in building such capabilities in-house.

Importantly, digital tools also create feedback loops. When farmers log issues or successes, that data can shape future product development and more responsive customer support.

Why This Matters for Business

Some may ask: Why invest in all this? Isn't selling product our primary job?

Here's the truth — a farmer who trusts your advice will always come back. In a market flooded with similar-sounding brands and generic formulations, trust becomes the biggest differentiator.

Also, with increasing scrutiny on pesticide residues and environmental impact, companies that promote correct usage and stewardship will face fewer regulatory hurdles.

A farmer-first strategy is not a social responsibility add-on — it is a business imperative. It drives loyalty, protects brand reputation, and builds long-term growth.

Solving Problems, Not Just Selling Products

The agrochemical industry in India has made enormous contributions to food security and yield enhancement. But to remain relevant and respected, we must evolve.

Are we selling bottles, or are we solving problems? That's the question every agrochemical company must ask itself.

Those who align themselves with the true needs of the farmer — knowledge, trust, and outcomes — will shape the next chapter of Indian agriculture. And it's a chapter worth writing, together.

ACTOSOL® CARBON FARMING

A BALANCED SUSTAINABLE SOLUTION FOR INDIA'S SOIL HEALTH, CROP YIELDS, AND CLIMATE COMMITMENTS

By Rajni Shaleen Chopra
Group Editor, ATG Group

Loss of carbon in soils, the fourth largest storehouse of carbon is equally in peril as increasing in air. actosol addresses to rebalance both storehouses - Daman Walia, President/CEO, ARCTECH Inc.

An Opportunity for GOI

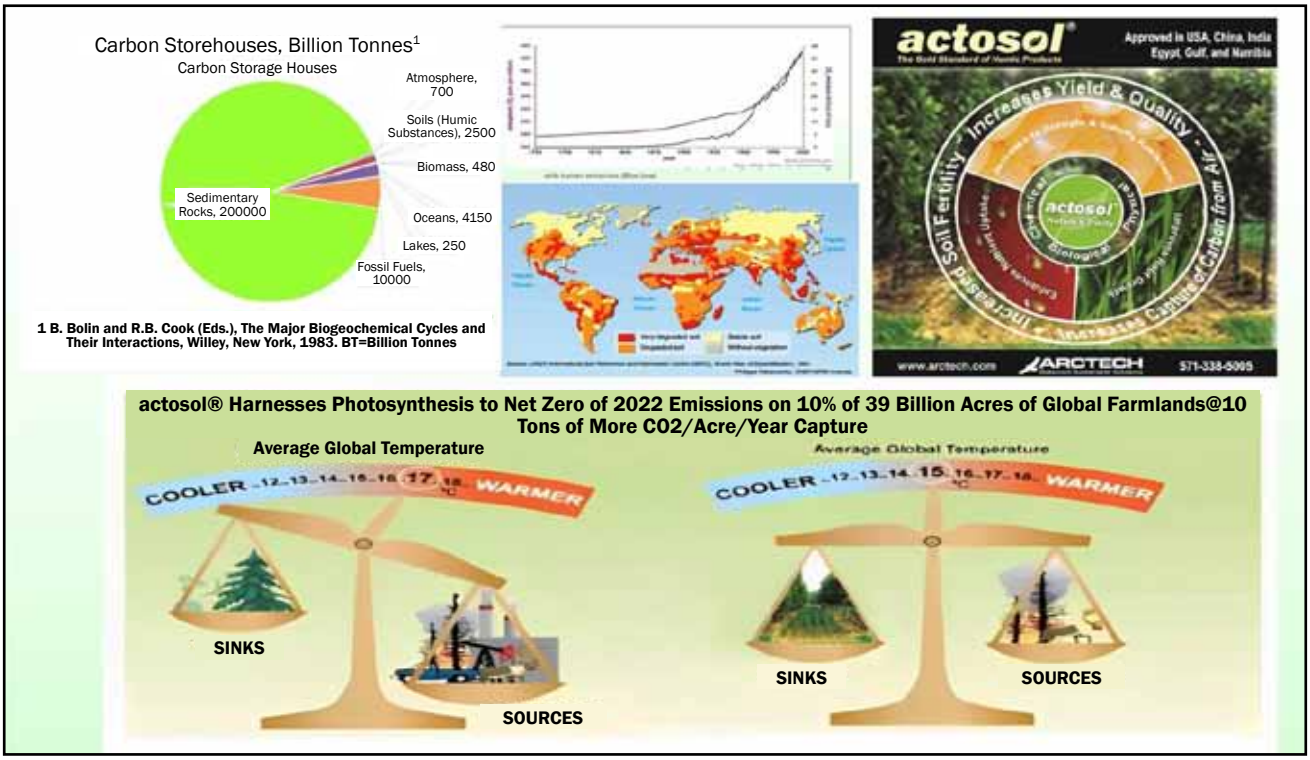
GOI can support farmers in becoming carbon farmers, improving the efficiency of fertilizers, agrochemicals, seeds, and increasing soil health, crop yields, and quality while increasing income and contributing to meeting India's commitment per the UN Paris Agreement to address global climate change on environment and even agriculture already experiencing adverse impacts and threatening food supply.

The Role of Soil in Carbon Storage

India is the third biggest emitter of CO2 after the USA and China, even though its per capita emission is still one of the lowest at 2.1 tonnes per person per year, compared to in USA at 14.3 and China at 8.4 tonnes. Soils are the fourth largest carbon storehouse in the form of long-term stable humic substances after sedimentary rocks, fossil fuels, and oceans; the fifth largest storage is the air. Carbon storage in India's soil, as well as globally, is alarmingly decreasing, while it is increasing in the air, eventually contributing to climate change and adverse impacts on agriculture. The most practical, fast-track, and economical value generation approach is to rebalance carbon storage in soil and air. It is a nature-based solution that facilitates photosynthesis to increase the growth of plants and their roots, thus increasing the capture of CO2 from the air. How it works:

The State of Indian Farmlands

India has the second largest farmlands comprising 325 million acres, but 60% of the land is degraded due to erosion, salinity, alkalinity, and deficient secondary and Micronutrients. A newspaper



from India recently headlined 'Farmers Are Toiling On Decaying Soil.' Indian scientists at IARI report that crop response to fertilizers fell continuously from about 25 kg of grain yield per kg fertilizer during the 1960s to 8 kg during the 1990s (Kapur, 2011) Note: https://cwss.in/Journal/Complete_jurnal/Vol.13-No.3__6.pdf. They attribute this reduction in crop response to fertilizer to a decrease in soil organic matter. Leadership and experts in India are making a case for the urgency of improving soil health, as well as addressing the increasing adverse impacts of climate change.

Promise of Actosol Carbon Farming in Haryana

The use of Actosol organic humic fertilizer offers the opportunity to enable plants to increase the uptake of carbon dioxide from the air and sequester up to 10 tons per acre per year in the soil while improving soil health and increasing crop yield by 20%+ and quality, notably increasing protein.. The use of Actosol is proving effective worldwide, including in India, by 10,000 + farmers. Proving out on increasing crop yields, nutritional content, particularly protein. for accelerating seed germination and the efficiency of granular fertilizers. Accelerating remediation of soils rendered barren due to high salinity in Haryana and for establishing sustainable, robust trees and ornamentals on the Mumbai-Nagpur highway.

Approved for use as organic fertilizer per the GOI NPOP as an equivalent to USDA NOP and now allowed in FCO as Biostimulant by the GOI Ministry of Agriculture. It is allowed per USEPA FIFRA for combining with agrochemicals as an UV protectant and adjuvant for improving their efficiency. Crop Science Forum of I H S Markit awarded it for improving delivery and efficiency of the granular fertilizers.

Call to Action

We are requesting the establishment of a policy and mandate for carbon farming farmers and funding with $10 million to facilitate fast-tracking carbon farming, using Actosol on 25,000 hectares of farmlands in various regions of India, and building the expertise of the KVKs to support the rapid ramp-up of carbon farming. In the near term, by 2030, meet its 30% reduction commitment per the UN Paris and, going forward, achieve net zero with the use of its land in its tradition of soil-centric agriculture with ancient wisdom and modern technology, while boosting the economy of all its stakeholders.

GOI should allow companies to pay CSR funds to farmers to farm carbon to offset their emissions in India, which otherwise require costly mitigation measures and/or substitutions to costly approaches

Actosol Use in India, Increasing Crops Yields, Farmers Income, Organic Matter and Soil Health.

Application	% Yield Increase	Income Gain X	Organic Carbon Increase, %	Observation
A. Crop-Cereals (Soyabean, Grains Pulses, Oil Seeds)	32.5	4 - 5 x	From 0.30 to 0.35	Better and Uniform Germination Increase in Root mass - 35% Increase in Green Part - 25%
B. Horticulture Vegetables (Tomato, Onion)	22.2	7-8 x	From 0.36 to 0.72	Test Weight of harvested Crop - 22% increase Flower Drop Reduced by 32% Number of Fruits per - 35%
Fruits Grapes, Banana, Pomo	16.5	8-9 x	From 0.35 to 0.65	Bunch Weight Increase by 15% 15 days Early Harvest
C. Landscaping (Samrudhi Expressway)	NA	NA	From 0.24 to 0.48	Survivals Rate Increased to 92% from 70% No. of Stems Increased from 7 to 13, 2X No. of Leaves Increased from 78 to 706, 10X No. of Flowers from nil to 167

Note:
1. In the above Actosol was used Biostimulants, Seed Coating, Fertilizer Coating.
2. Organic Matter is 1.72 times Organic Carbon

Benefits of Actosol use at KVK Baramati, India

By using Actosol, Krishi Vigyan Kendra (KVK) in Baramati, Maharashtra, has increased organic matter in sugarcane and fruit farm soil from lows of 0.1 to 0.5%, which is still alarmingly low in fertility. Organic matter in fertile soils needs to be between 3 to 8%, preferably as high as 25%. Actosol use at KVK Baramati increased sugarcane and fruit tree yield by 20%.

Benefits of Actosol use at Virginia, USA

At a Virginia, USA, farm, Actosol use over a period of 10 years resulted in soil organic matter increase from 1% to 7% while increasing crop yields by 20-50% of wheat, soybean, and sorghum.

He chisel plows straw along with Actosol, and it mulches in the soil in a few months. At this farm, 1 kg of fertilizer as water-soluble liquid produces 60 kg of food and an income gain of 15X. On average, a 0.5% increase in organic matter amounts to a net 10 tons of additional CO2 captured per acre per year by transferring it from the air to the soil.

Trees should also be encouraged to be planted on farmlands both for carbon capture and added income. *Trees on 10% of the acre of trees capture up to 6 tons of CO_2 and release 4 tons of oxygen annually.* Trees should be planted on the buffer areas of farmlands so they will be managed by the farmers instead of catching fire in forestlands. It offers farmers the opportunity to increase their income by planting income-producing trees and receive additional CO2 credits by establishing a tree canopy of 30% or more, even by planting on only 10% of the land, as per the UN Clean Development Mechanism. Additionally, farmers can mulch crop residue straw (low in water-soluble solids), amounting to almost two tons per acre, along with Actosol for increasing organic matter and carbon storage, rather than burning and polluting. This approach of both increasing organic matter in soils and carbon capture by trees on farmlands offers the potential of 14 tons per acre per year of carbon farming.

GOI Ministry Framework for Voluntary Carbon Markets in the Agriculture Sector dated January 2024, which is based on adopting management practices and covering crops. It increases the cost of crop production then the benefit realized. . A meta-analysis by academics of the University of Nebraska based on 77 multiyear applications at farmlands reports that the management and cover crops approach only result in less than 1 ton of CO2 per acre per year. They report that, although management practices such as no-till are somewhat lower in cost than cover crops, the resulting value from carbon credits is less or marginal.

Whereas carbon farming, on average, results in the capture of 10 tons of CO2 per acre per year, durably stored in the soil as useful organic matter, enabling the adoption of management practices that generate higher revenues from carbon credits. On Feb 20, 2024, the EU Commission announced carbon farming as the #1 EU-wide certification scheme for carbon removals.

Policy Recommendations for GOI

The Ministry of Agriculture should establish a carbon farming policy and validate the carbon credits of its existing KVKs to guide farmers to adopt carbon farming and validate measuring the increase of organic matter in soils with existing soil testing protocols and enable GOI to register its reductions on the UNFCCC registry.

Opportunity for Increasing Income of Farmers, Emitters, and GOI

We also request that the Ministry allow companies to pay CSR funds to farmers to farm carbon to offset their emissions in India, which otherwise require costly mitigation measures and/or substitutions to costly approaches. Emitter companies may be allowed to register on UNFCCC Trading Platform: https://unfccc.int/climate-action/united-nations-carbon-offset-platform. GOI may allow them to offset 50% of their emissions and trade 50% on the global platform such as: https://carboncredits.com/ .

To meet India 's commitment to reduce about 30% emissions by 2030 or one billion tons, by Actosol carbon farming on 200 million acres of agricultural land in India will sequester two billion tons per year. This is almost double its commitments to the UN Paris Agreement. Trading one billion tons can result in almost $70 Billion per year exportable revenues. If GOI taxes @5% will result in $3.5 Billion every year in tax revenues. Farmers increase income, Emitters make money while reducing their carbon emissions and government increases tax revenues. Below is a Business Case :

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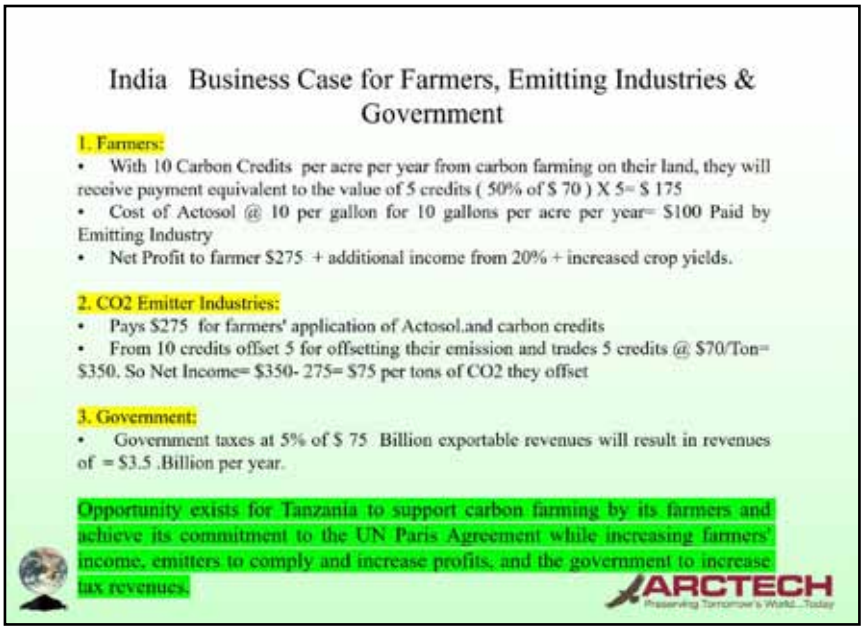

IIT ROPAR VISION FOR A TECH-ENABLED FUTURE

India's agriculture sector is navigating a critical phase, balancing the need for growth with sustainability, inclusiveness, and technological advancement. While the sector supports over 50% of the population, its sub-20% contribution to GDP underscores the urgency for transformative change. Conventional approaches have reached their limits.

About the **AUTHOR**

Prof Rajeev Ahuja is Director, Indian Institute of Technology, Ropar

Transforming Agritech: A Vision Anchored at IIT Ropar

IIT Ropar's agritech vision is rooted in creating a self-reliant, scalable, and digitally enabled ecosystem for Indian agriculture. With over 150+ deeptech startups, INR 137+ crores of direct and indirect agritech investments, and 5000+ individuals trained across India, the institute has laid a nationwide foundation for technology-led agri-skilling and innovation.

ANNAM.AI, a Center of Excellence (CoE) in Agriculture at IIT Ropar, es-

tablished under the visionary support of the Ministry of Education as part of the Rs 990 Cr initiative to set up three CoEs in Agriculture, Healthcare, and Sustainable Cities, is a transformative step towards innovation and sustainability. With an allocation of Rs 311 Cr, this CoE aims to revolutionize Agriculture by leveraging cutting-edge technologies and interdisciplinary research. The CoE focuses on driving advancements in sustainable agricultural practices, fostering R&D, and supporting technology-based solutions to address critical challenges in agriculture. This initiative is set to position IIT Ropar as a leader in creating impactful solutions that contribute to national and global agricultural innovation. As part of its current mandate, ANNAM is driving five flagship initiatives that are setting new benchmarks in agricultural AI.

IIT Ropar is developing affordable, scalable digital solutions to empower smallholder farmers, using AI, remote sensing, and machine learning to boost productivity, support informed decisions, and drive sustainable agriculture. A few of the key technology areas developed by IIT Ropar's ANNAM include innovations such as an AI-Powered Pest Intelligence Platform for early infestation detection, a Soil Health Digital Twin to guide sustainable fertigation, a Weather-Adaptive Irrigation Planner, and a Crop Yield Estimation Engine utilizing satellite data and machine learning. The Smart Farmer Advisory Chatbot, powered by LLMs and vernacular interfaces, delivers personalized, accessible agronomic advice. IIT Ropar is bridging the digital divide in rural India while demonstrating the power of human-centric AI.

Beyond this, IIT Ropar, through its Technology and Innovation iHub -AWaDH, a DST-supported Technology Innovation Hub under NM-ICPS, serves as the applied research and field deployment arm of IIT Ropar's agritech mission. Bridging lab-to-land transitions, AWaDH ensures that high-impact innovations developed at IIT Ropar are contextually adapted, locally manufacturable, and economically viable for India's rural and farming communities and has

invested 17Cr+ in direct investment to a portfolio of 150+ startups that have externally raised 120Cr+, making it with a valuation of over 1600Cr.

From conducting a pan-India Smart Agriculture Surveys supported by the Office of Principal Scientific Advisor to Govt of India, that captured data from diverse agro-climatic zones, enabling the development of localized solutions, to launching and deploying several high-impact technologies, including MoooSense, a wearable livestock monitor co-developed with CIBR for real-time health diagnostics; Digital Entomologist, an AI-driven pest and biodiversity tracker; NanoAqua, an IoT-based nanobubble water purification system for canals and ponds; and Soil Spectra, a portable, non-invasive soil health scanner. Each of these solutions is characterized by affordability, ease of use, and local manufacturability, making them especially relevant to India's 86% smallholder farmers. Focusing on "lab-to-land" adaptability, IIT Ropar is fostering grassroots resilience through innovation.

IIT Ropar's vision of Skilling Bharat in Technology Assistive Agriculture

As India aspires to lead in smart and digital agriculture, building a future-ready workforce is critical. At the heart of this transformation is IIT Ropar's commitment to skilling youth in emerging domains such as Cyber-Physical Systems (CPS), IoT, AI, and Machine Learning. Through pioneering programs and infrastructure, the institute is shaping the next generation of agri-tech innovators.

The AI4AgriTech initiative and the "Artificial Intelligence for All" and Chanakya Fellowship programs equip students, researchers, and entrepreneurs across graduate to faculty levels with deep-tech competencies for real-world agricultural challenges. These are strengthened by AI Hackathons and Internship Carnivals, offering hands-on exposure to innovation in CPS and precision farming.

To extend access and localize innovation, NMICPS labs powered by IIT Ropar have been established across institutions nationwide under the NM-ICPS

mission, enabling educational institutes to engage in IoT, smart irrigation, and automation. Programs like AI4AgriTech, the Internship Carnival, and AI Hackathons offer immersive, hands-on experiences in agri-tech problem-solving. The Joy of Computing Lab model has expanded to rural schools and ITIs, sparking early interest in computational thinking. Through this integrated skilling ecosystem, IIT Ropar is building a national platform for capacity building and innovation, empowering India's youth to drive the next wave of agricultural transformation rooted in technology, inclusivity, and sustainability.

IIT Ropar Building Agritech Startup Ecosystem

At IIT Ropar, the cultivation of a thriving AgriTech startup ecosystem is enabling a new wave of innovation-led transformation across India's agriculture sector. The institute has supported over 150 startups, including 80+ in AgriTech, spanning AI/ML, drone farming, climate-smart tools, and water tech. These ventures have collectively reached a valuation of Rs 1600+ crore with multiple technologies transferred and commercialized.

Flagship initiatives such as SPRINT-Strategic Program for Research Innovation and Next-Gen Tech Commercialization (for grassroots innovation) and SAMRIDHI- Strategic Acceleration for Market, Research, Innovation & Development: a Holistic Initiative for ICPS Startups (for growth-stage support) provided targeted mentorship, funding, and market access. Strategic collaborations, like DRONAGIRI with IIT Tirupati, Water Innovation Challenge with HDFC Bank, SWACH with FICCI, and PRAGATI with Puri Oil Mills & MeitY Genessi and others, have received support from 220+ partners, including the Investment community and partners like Seafund for ASAP as direct investment commitment of 10Cr to international partners like ESG Weise, United People Global, and others, demonstrate IIT Ropar's cross-sector leadership.

With 12+ CPS Labs, training over 5,000 learners, and 15+ technologies commercialized, IIT Ropar's integrated model, combining deep-tech R&D, grassroots engagement, and entrepreneurship, is redefining rural development and agricultural modernization in India. Through inclusive skilling, deep-tech R&D, and entrepreneurial support, IIT Ropar is setting benchmarks for a tech-powered agricultural future and emerging as a national leader in scalable rural development and inclusive growth.

As India approaches its centenary in 2047, the vision of a climate-resilient, digitally managed, and socially inclusive agricultural Bharat is already taking shape, seeded, nurtured, and scaled by IIT Ropar. This is not just India's agricultural renaissance; it is a global model in the making

To unlock the next phase of agricultural growth, we must embrace an integrated model of technology-led transformation, policy standardization, and farmer-centric innovation. At the forefront of this shift is IIT Ropar, through its pioneering Agritech initiatives, Annam.ai – Centre of Excellence in AI for Agriculture supported by the Ministry of Education, Government of India, and IIT Ropar Technology and Innovation Foundation (Agriculture and Water Technology Development Hub), under the aegis of the Department of Science and Technology's National Mission on Interdisciplinary Cyber physical Systems (NM-ICPS).

National Recognition Strengthening IIT Ropar's Innovation Leadership

The exceptional work at IIT Ropar in advancing deeptech solutions for agriculture, water, and rural development has garnered prestigious national and international recognition, significantly enhancing the institute's stature as a hub of translational innovation. From winning the Innovation Program Leadership Award by the Indian Chamber of Food and Agriculture to being awarded the BHARAT Incubator Award by the Entrepreneurs Association of India, IIT Ropar's contributions are now widely acknowledged across academic, corporate, and development circles.

These accolades, including the Biodiversity Conservation Award at CASCA25, the Best Incubator Awards by CII and Ludhiana Angels, and multiple honors for skilling, livelihood, and startup development, demonstrate a transformative role in building impactful, inclusive, and scalable innovations rooted in India's rural realities.

A Vision for the Next Decades: The Future of Indian Agriculture

As the nation eyes global leadership in sustainable food systems, technologies like AI, IoT, blockchain, and satellite-based advisories will be essential for reducing crop losses, increasing productivity, and ensuring transparency from soil to shelf.

At IIT Ropar, this future is not a distant dream; it is unfolding now. Through transformative platforms like ANNAM.ai, the Ministry of Education-supported Centre of Excellence in AI for Agriculture; AWaDH, the DST-backed Technology Innovation Hub for rural water and agriculture systems; and PI-RAHI, India's pioneering initiative to integrate AI and robotics for horticulture intelligence, the institute is driving a new wave of innovation rooted in real-world needs.

The recent ANRF-PAIR initiative (Partnerships for Advanced Interdisciplinary Research) will form a national backbone for interdisciplinary research and strengthen the scientific ecosystem in northern India, while the 11 cutting-edge Centres of Excellence at IIT Ropar power deep-tech capacity across AI, CPS, quantum sensing, water sustainability, and more.

SUSTAINABLE SOLUTIONS FOR MODERN FARMING

To accelerate agricultural growth in India, the focus must shift towards enhancing productivity, promoting sustainable practices, and leveraging modern technology. This includes the adoption of advanced farming techniques, crop diversification, improved market access, and the widespread implementation of environmentally sustainable methods. Achieving this vision will require significant investment in research and development, rural infrastructure, and farmer education. India's agricultural sector stands at a crucial juncture where modernization and sustainability must progress in tandem. A comprehensive, multi-pronged strategy is essential to boost productivity, safeguard farmer welfare, and build long-term environmental resilience

Here's a more detailed look at how to accelerate agricultural growth in India:

Adopt New Technologies: The adoption of new technologies in agriculture is influenced by various factors, including socioeconomic conditions, geographic location, crop type, and access to irrigation. Modern farming increasingly relies on advanced technologies such as precision machinery, high-yield seed varieties, targeted fertilizer and pesticide application, and innovations like genetic engineering. These tools play a vital role in boosting agricultural productivity by preventing soil degradation, conserving water, and reducing chemical inputs. Technologies like GPS, sensors, AI, and drones further enhance efficiency by enabling precise resource management. As a result, farmers can achieve higher yields, improved crop quality, and lower production costs.

Enhancing Soil Health: The widespread, indiscriminate use of fertilizers and pesticides has severely degraded soil health, posing a persistent challenge to sustainable agriculture. To address this, efforts must focus on improving the soil's physical structure and microbiological activity. This includes developing targeted chemical interventions that supply essential macro- and micronutrients while minimizing environmental impact. Special attention is needed in arid and semi-arid regions where soils are more vulnerable and productivity gains more critical

Strengthen Water Management and Irrigation: Agriculture remains the largest consumer of water in India. However, limited water availability is creating growing competition among agricultural, industrial, and domestic sectors. To address this challenge, integrated water resource management at the river basin level is essential, promoting synergy across multiple sectors. Supply augmentation should focus on rainwater harvesting, aquifer recharge, and the restoration of traditional water bodies such as wells and ponds. Equally important is demand-side management through the adoption of efficient irrigation techniques like drip and sprinkler systems. These efforts must be supported by a nationwide water literacy movement and robust regulation of groundwater use. Ultimately, a conjunctive approach—leveraging rainwater, river water, groundwater, seawater, and treated wastewater—will be critical to ensuring sustainable and equitable water use.

Develop Efficient Agricultural Markets: The economic well-being and long-term sustainability of the farming sector depend on providing reliable and profitable avenues for selling agricultural produce. Market reforms should be guided by the principles of demand and supply and closely aligned with production planning, rather than relying predominantly on government-led support mechanisms. Strengthening the link between consumption patterns and supply chains is essential for fostering the resilience and sustained growth of farming communities. To empower farmers and improve their market access, the formation of Farmer Producer Organizations (FPOs) should be actively encouraged. These collectives enhance farmers' bargaining power and facilitate better integration with markets. Additionally, the promotion of e-market platforms can enable direct connections between farmers and buyers, reducing dependency on intermediaries and ensuring fairer prices for producers.

Agri-Credit and Crop Insurance: Reform in these areas is crucial to boosting productivity on small farms. Farmers who often depend on informal moneylenders need access to easy, affordable credit through formal channels. Additionally, crop insurance systems must be overhauled to provide timely and effective risk protection. Policymakers must develop innovative solutions that strike a balance between the stability of the financial system and the practical needs of farmers.

Promote Value-added Processing: Supporting the development of food processing industries can increase the production of value-added products, which not only boosts profitability but also enhances export potential by meeting diverse market demands. This can stimulate economic growth, create jobs, and strengthen the agricultural sector by turning raw materials into higher-value goods.

By aligning policy, science, and community action, India can transform its agriculture sector into a powerful engine of rural prosperity, food security, and national development

Policy Reforms: To boost India's share in global agricultural trade, targeted policy reforms are essential. These reforms should focus on simplifying export procedures, providing incentives for high-quality produce, ensuring compliance with international standards, and investing in modern infrastructure. Establishing clear and consistent quality control mechanisms will boost global confidence in Indian agricultural products, thereby enhancing competitiveness and export volumes.

Shift Towards High-Value Agriculture: Diversification into high-value crops such as fruits, vegetables, floriculture, and dairy can increase farm incomes and create employment. These crops offer better returns per unit of land and are more resilient to price volatility compared to staples.

To accelerate agricultural growth in India, we must embrace a holistic approach that combines innovation, sustainability, and inclusivity. This means investing in modern technology, strengthening infrastructure, ensuring timely access to credit and markets, and empowering farmers—especially women and smallholders—with knowledge and resources. At the same time, we must prioritize environmental resilience and climate-smart practices to secure the future of farming.

About the **AUTHOR**

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EMPOWERING INDIAN AGRICULTURE

The growth of Indian agriculture is crucial not only for the nation's economy but also for the livelihood of 65% of the nation's population. Several factors, ranging from technology and government policies to market reforms and environmental sustainability, can contribute to the advancement of Indian agriculture.

Technological Innovation, Soil Health Management, Regulatory Framework and Adoption

The adoption of modern farming practices such as precision agriculture, can help increase yield and reduce waste. Drones and IoT sensors can help farmers monitor crop health, manage irrigation, and optimize use of inputs. How-

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Ms Komal Shah Bhukhanwala is Director, SML Limited and SUMIL Industries

ever, more fundamental to increasing quality yield, is the adoption of reducing inputs, while increasing yield and improving and correcting soil health.

Soil health is a complex subject involving various chemical and biological processes. Many challenges faced in crops across the country, are due to an underlying soil health problem. It is estimated that about 95% of soils will be degraded by 2050. Correcting soil health and providing advanced sustainable technology in the form of high nutrient use efficiency fertilizer, microbials and bio stimulants can significantly impact yields across farms. Cost benefit ratios, which assess input costs against farm income, can no longer serve alone, as the measure of agri inputs. Regulations to understand and approve the advances in soil health management, are a must to allow farmers access to these solutions.

Automation in planting, weeding and harvesting can help reduce labor costs and increase productivity.

Cold Storage and Warehousing

Approximately 30% of agricultural produce in India is lost due to inadequate storage. While cold storage capacity has been growing, there are still regional disparities and gaps in infrastructure. Focus should also be on increasing shelf life of fruits and vegetables through sustainable solutions and better soil health management practices. Sustainable net-zero cold storage solutions should be promoted for long-term infrastructure support.

Financial Support and Credit Availability

Strengthening agricultural credit systems, offering low interest loans, and having insurance against crop failures would provide farmers with the financial stability to invest in modern farming techniques.

Subsidies and Incentives

The government can play a vital role by providing targeted subsidies for fertilizers, seeds, and machinery. Subsidies directed towards promoting sustainable

Combining technological advancement, educating farmers for sustainable practices, better infrastructure and supportive policies will increase the contribution of agriculture in terms of GDP growth

soil health management can incentivize farmers for adopting practices to ensure long term farm productivity. While sustainability remains a topic for corporate offices and conferences, providing incentives to farmers for adoption of net-zero practices, reduction of green house gas emissions, reduction in the use of water, reducing water pollution, and increasing carbon sequestration. can enable farmers to adopt long term solutions faster.

Policy Reforms, Farm Laws, Market Reforms and Government Support

Policies and creating and facilitating local markets for nutrient dense foods can reform farm productivity and quality, strengthen the food value chain and give farmers better bargaining power. Farm laws aimed at providing farmers with better market access, facilitating the establishment of private markets, can empower farmers longer term.

Climate Smart and Sustainable Agricultural Practices

Climate change poses the biggest threat to agriculture and has already impacted agriculture with unpredictable rainfall patterns, floods, droughts and extreme temperatures. Developing climate-resilient farming practices such as balanced low input nutrition management, efficient irrigation, rain water harvesting, can mitigate climate stress and empower farmers for the oncoming challenges. Agroforestry needs to be promoted, while increasing land under forest development, to increase carbon sequestration. Rice cultivation uses 43% of global irrigation water. Paddy cultivation in Inda, which has an area of around 44 million hectares under cultivation, needs to be carried out under drip irrigation, to not only save water and prevent ground water depletion, but also eliminate methane emissions which occur due to the use of water in paddy cultivation.

Skill Development and Education

Providing farmers with access to training in modern sustainable practices, pest management, soil health management, reducing inputs and improving efficiency, will be key to long term productivity of Indian agriculture. Dedicated portals for accurate and scientific information can empower farmers. Government education portals for sharing best practices by crops, mitigating climate change, educating farmers about climate change, and training them on leap frogging on advanced solutions to be producing food in the face of climate change, will enable farmers to prepare for worsening climate adversities.

Women in Agriculture

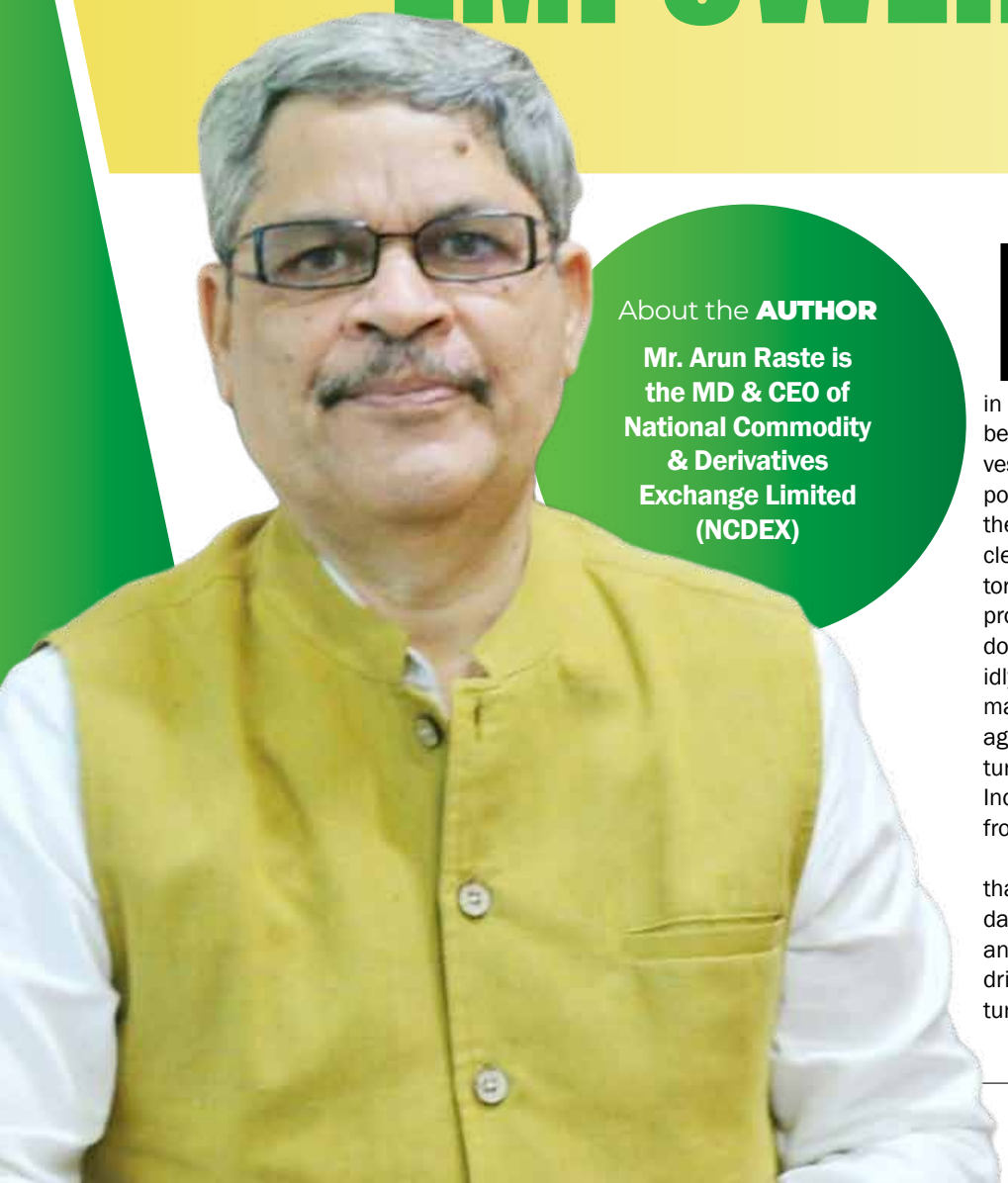
Empowering women farmers is critical to enhancing agricultural productivity. Educating women farmers, supporting women led FPOs, supporting women led agri producers and small businesses can further lead to stronger productivity across the country.

Multi-Pronged Approach Required

For Indian agriculture to grow and thrive, a multi-pronged approach is necessary. With the right investments in innovations, supporting regulatory framework, India can build a more resilient and thriving agriculture eco-system that benefits farmers, consumers and the economy as a whole.

A REFORM BLUEPRINT FOR INDIAN AGRICULTURE

FROM PROTECTION TO EMPOWERMENT



About the **AUTHOR**

Mr. Arun Raste is the MD & CEO of National Commodity & Derivatives Exchange Limited (NCDEX)

Post Independence India's agriculture sector has made significant progress in achieving food security and attain self-sufficiency in several key crops. This change has been caused by decades of public investment, assured procurement, and policy backing. However, as we look to the future, it is becoming increasingly clear that the current status of the sector, rooted in outdated subsidy, targeted procurement and protection model, does not meet the challenges of a rapidly changing economic aspirations, climatic conditions, and realities of global agricultural trade. The share of Agriculture in the Indian GDP is going down and India's agricultural needs to move away from current policy structure.

The future requires a new approach that embraces market signals, dynamic data, and also that climate resilience, and digital innovation are leveraged. To drive this change, India needs a structured and strategic realignment within

government Ministries, like Agriculture, Finance, Science and Technology, and departments like Commerce, Departments of Food and Consumer Affairs, Food Processing and MSME.

While the erstwhile Planning commission and the new avtar Niti Ayog have lacked in envisaging needs of consumers, imports and coordinating with the afore-mentioned agencies, the Cabinet Secretariat can possibly do it. This will help. balance productivity with sustainability, empower farmers through strong institutions and robust markets, and shift Indian agriculture from a subsistence model to a thriving growth engine and change must occur in five key areas:

1. Judicious Resource Usage: Reforming Incentives for Efficiency

Indian agriculture has long struggled with distorted input pricing, especially regarding free or underpriced power, water, and fertilizers. While these subsidies aimed to protect farmers, they have unintentionally promoted inefficient practices and long-term ecological harm, such as groundwater depletion and nutrient imbalance. Moreover, in the name of farmers, others are getting major benefits of these subsidies. The need is to replace price subsidies with Direct Benefit Transfers (DBT). This will allow farmers to make resource choices based on their agronomic needs and market conditions. States that have tested DBT models for power and fertilizer have already noticed a shift toward more sustainable input use and diverse crop options, besides efficiency in use of funds.

2. Market-Driven Production: From Subsistence to High-Value Farming

While much of India's agriculture still focuses on a few staple crops, leading to surpluses in some areas and shortages in others, this imbalance has negatively impacted both farmer incomes and nutritional health. As a country we need to consider potential linked planning and shift toward diversified production systems that respond to demand. Encouraging farmers to grow oilseeds, pulses, fruits and vegetables, and livestock, along with clear price signals and post-harvest support, will create more stable incomes and lessen regional ecological pressures.

If we can empower farmers, not only will we ensure self-sufficiency, but farmers will add to Viksit Bharat goal so much that we may aspire to advance it from 2047 to 2037!

3. Technology & Sustainability: Scaling Climate-Smart Solutions

The government needs to recognise region-specific diversification strategies and also the fact that we can't be self-sufficient in all crops, given our low yields. Therefore, the leap in productivity must come from technology, precision, and data, not just land and labour. Lab to land period should be shortened to enhance yields. Also included real-time advisories through AI, satellite mapping for weather risks, drone-assisted delivery of inputs, and IoT irrigation systems.

Embracing climate-smart practices, such as heat-resistant seeds, efficient water use, and markets for crop residues, can enhance long-term resilience. Developing markets for crop residues and carbon credits will not only help solve the stubble burning issue but also create additional income opportunities for farmers.

Our national goal should be to ensure that every smallholder, can access affordable and locally relevant innovations, promoting Agri-tech Inclusivity through FPOs or cooperatives.

4. Price Risk Management: Transitioning to Market-based Tools

Farmers in India wrestle with significant price volatility, often lacking the tools to handle it. While minimum support prices offer some relief, their coverage is limited and cannot address price swings for all crops or regions. Market-based tools, such as regulated commodity derivatives, offer a more sustainable and inclusive solution. Through regulated exchanges, farmers and FPOs can hedge prices, discover transparent benchmarks, and improve cropping strategies.

Gradually adopting price risk management tools, supported by training and simplified onboarding, will help Indian farmers move from being passive price takers to informed price participants and eventually price setters, marking a true shift from protection to empowerment.

5. Modern Market Infrastructure: From Fragmented Local Mandis to an Integrated National Agri Grid

A fragmented market system, with uneven access, inefficient logistics, and limited transparency is a bane for farmers. This not only mean income loss to farmers, but also is a national loss. There is instant need to upgrade physical markets with compulsory WDRA registered scientific warehousing, and investment in facilities for testing, logistics, and cold chains. Creating digital connections that link farmers to national markets is equally important. This includes modernizing APMC mandis, expanding warehouse facilities registered under WDRA and treating them at par with APMC Mandis. On financial front incentivising and promoting electronic negotiable warehouse receipts to improve liquidity and reduce post-harvest distress sales will help farmers.

A Shared Vision for Agri-Transformation

Indian agriculture must shift from a policy-focused safety net to a blueprint based on efficient resource use, responsiveness to market demands, climate resilience, and digital inclusion. We need:

- A system where farmers are efficient producers, informed decision-makers, and active market participants.
- A rural economy that is competitive, climate-smart, and sustainable.

ACCELERATING SUSTAINABLE GROWTH IN AGRICULTURE

Decades of indiscriminate use of chemical fertilizers and pesticides have come at a significant hidden cost, one that is now threatening the very sustainability of Indian agriculture.

India Needs to Rethink Input-Intensive Agriculture

The real cost of chemical agriculture is not just in the farmer's ledger—but in our soil, water, health systems, and future food security. Rational regenerative farming is essential to counter the challenges of low productivity and profits of farmers. If the farm profits are not increased in the short term, there is a fear of growing unrest in our food production systems. The problem is not the absence of technology but the delay in reaching them on a priority basis to farms.

About the **AUTHOR**

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The Way Forward: From Chemicals to Biologicals

Transitioning to biofertilizers, biopesticides, organic fertilizers and regenerative practices is not just environmentally sound – it's economically and strategically urgent. Governments, agri-tech companies, and civil society must act now:

- Incentivize sustainable inputs via subsidies and insurance benefits to farmers
- Educate farmers on bio-inputs and integrated practices
- Invest in microbial technologies by way of research, extension, regulatory/policy support
- Shift research and extension priorities toward soil health, food quality/safety, fermentation, plant-microbiome interaction, agroecology etc.

The following are some of the reasons for shift with cost and future action plan:

1. Depletion of Soil Health

- Chemical overuse disrupts soil

biology

- Continuous use of urea and DAP has led to micronutrient deficiencies, soil acidification, and organic matter depletion.
- Declining productivity per unit of input, especially in intensively farmed states like Punjab, Haryana, and parts of Maharashtra. There is extensive soil fatigue which is primarily due to imbalanced use of fertilizers.
- India's NPK usage ratio is often skewed (e.g., 6.5:2.5:1 instead of the ideal 4:2:1), especially due to subsidized urea (N).
- Excessive urea (N) use leads to:
  - o Soil acidification
  - o Nitrate leaching into groundwater
  - o Depletion of micronutrients (e.g., Zn, B)
- Low K application in most states despite crop demand

Cost: Reduction in soil health is directly proportional to reduction in yields. Cost per kg of yield increases which makes farming unsustainable.

Action plan – We cannot adopt the failed Sri Lankan experiment but use Biochar and organic fertilizers to improve the efficiency of chemical and microbial fertilizers. Like we are adopting alcohol for blending our fuel similarly organic must be blended with chemical fertilizers [packed separately but sold as kits] to improve their efficiency which can be done with technology. Working on soil fatigue is the only way to come out of this vicious cycle. Rebuilding 1% organic matter in soil with technology and improving the nutrient supplementation by adopting soil test-based fertilizer recommendation.

2. Water Contamination and Overuse

- Nitrate leaching from urea pollutes groundwater, causing blue baby syndrome and cancer in high-risk zones (e.g., Malwa region of Punjab).
- Pesticide run-off contaminates rivers and ponds, harming aquatic life.
- Heavy use of water-soluble fertilizers promotes excessive irrigation, worsening water scarcity.

Cost: Billions spent annually on rural water purification and health care.

Action plan – If urea cannot be rationed see that it is sold in a way that doesn't promote excess use. Coupling with organic and biofertilizers must be done. 30% use efficiency should be a benchmark for doing so. Partially reducing subsidies on manufacturing should be seriously considered. Carbon sequestration must be incentivized by enacting farmer friendly carbon credit policy at the earliest. Carbon build-up can only help in improving the water holding capacity of soils which is very important for water deficit areas.

3. Pest Resistance and Pest Resurgence

Comparison with Other Countries (2023 Data)

Country	Fertilizer Use (kg/ha)
China	~340–370 kg/ha
EU (avg.)	~150–170 kg/ha
Brazil	~210 kg/ha
India	~135–140 kg/ha
Africa (avg.)	~20–25 kg/ha

- Over time, pests develop resistance to synthetic pesticides, demanding higher doses or newer molecules.
- Broad-spectrum insecticides kill natural pest predators, causing secondary pest outbreaks.
- Farmers enter a pesticide trap, with rising costs and diminishing returns.
- Farmers face a double whammy of rejection due to residues for export

Cost: Farmers spending up to Rs 8,000–Rs 15,000 per acre on pest control alone. In horticulture it is almost 2x or 3x. Even after spending such huge amounts farmers are unsure of returns to the levels desired.

Action plan – Integrate the biological technologies in POP as they do not depend on ETL levels of pests. The earlier biopesticides are used, the better it is for the farmers since there are no MRL's and therefore no preharvest interval. The issue of resistance development is also remote as the modes of action are multiple and complex. We need biopesticide actives at a rapid pace which can only happen with public investments and policy shifts to attract private investments

Goal	How Microbes Help
High Yields	Promote root growth, nutrient availability
Soil Health	Improve organic matter, fix N, mobilize P, restore microbes
Cost Savings	Reduce need for synthetic fertilizers and pesticides
Food Safety	Residue-free produce; meets export & organic standards
Sustainability	Eco-friendly, reduces carbon and chemical footprint



in research and development. It takes at least 3 to 5 years to develop and launch biopesticide. India has the necessary know how and manpower in biotech. It is time we used it to the best of our advantage and even export. Time is running fast, and India cannot afford any delay.

4. Human and Animal Health Hazards

- Pesticide exposure is linked to neurological disorders, reproductive harm, cancers, and developmental issues in many cases to long term exposure.
- Farm workers and rural women face the greatest risk due to poor handling and lack of PPE.
- Residues in food and water are often above safe limits, posing chronic health risks to consumers.

Cost: Hidden public health burden, especially in rural hospitals and cancer belts.
Action Plan – Use biopesticides in POP. Promote research in the public and private domain and simply the guidelines for provisional registrations further. India can take the lead and develop PLI plans for mass scale production facilities. IPM has to be promoted for every acre of cropped area.

5. Food Safety and Export Rejection

- Chemical residues above permissible levels in fruits, vegetables, and grains lead to export rejections and reputational loss.
- Growing consumer demand for safe, residue-free, and high value organic produce in both domestic and export markets is unmet.

Cost: Missed premium markets and declining trust.
Action Plan - Develop and support the GAP practices and certifications leading to increase in exports. Plan for implementation of FSSAI standards for domestic markets specially in packed food which would then trickle down to fresh produce by promoting packaging/branding.

Transitioning to biofertilizers, biopesticides, compost, and regenerative practices is not just environmentally sound, it's economically and strategically urgent

6. Economic Unsustainability for Farmers

- Chemical input prices have risen 3x to 5x in the last 10 years, increasing debt among smallholders.
- Despite higher input use, profit margins are shrinking due to soil fatigue and yield stagnation.
- Government spends over Rs 1.5 lakh crore annually on fertilizer subsidies, crowding out investments in innovation, water management, and extension.

Cost: Fiscal strain + declining incomes for farmers.
Action plan – Promote biofertilizers and organic fertilizers with every bag of chemical fertilizer. Co packing would help as Neem coated urea. This would improve the fertilizer use efficiency as almost 70% of the nutrients are wasted, which can be easily replaced with biofertilizers and organic fertilizers in current packing.

7. Environmental and Climate Damage

- Fertilizer production and use release nitrous oxide, a potent greenhouse gas.
- Soil degradation and deforestation linked to pesticide-intensive monoculture contribute to climate vulnerability.
- Heavy pesticide use threatens pollinators like bees, vital for food crop productivity.

Cost: Long-term loss of biodiversity, ecosystem services, and climate resilience.
Action Plan – Develop and implement a plan to have at least 40% of quality biologics in toolbox of the farmer wrt input cost of cultivation
The way forward is the shift from chemicals to biologicals.

Integration with Other Technologies

- Can be combined with:
  - Mobile advisory apps
  - Drone spraying
  - Precision irrigation
  - Lab soil tests & GIS mapping

Visual Guide: Application Methods

- **Seed Treatment** – Coat seeds with microbial slurry
- **Soil Application** – Mix with compost or FYM before sowing
- **Drip Irrigation** – Apply through fertigation
- **Foliar Spray** – Spray biopesticides during crop stage

Celebrating HORTICULTURE DURING AMRIT KAL

India's horticulture production has seen a remarkable rise from 25 million tonnes (Mt) in 1950-51 to 354.74 Mt in 2023-24, including approximately 207 Mt of vegetables and 113 Mt of fruits. This production has positioned India as the second-largest producer of fruits and vegetables in the world, accounting for over 10% of global production. Export earnings from the horticultural commodities and their value-added products have reached Rs 312 billion, with additional Rs 60 billion generated from the crude drugs, herbal extracts, and finished products derived from medicinal and aromatic crops, highlighting the rising global demand for India's horticultural produce and products.

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support through missions like National Horticulture Mission (NHM), Rashtriya Krishi Vikas Yojana (RKVY), along with targeted Research & Development and dissemination of technological advancements have played a pivotal role in this progress. With a growing population, rapid urbanization, raising incomes, evolving dietary preferences, and escalating impacts of climate change, there is an urgent need to unlock the full potential of horticultural crops. These crops are crucial for ensuring nutritional security, economic empowerment, and sustainable livelihoods in the years ahead. Accelerating the growth of this sector is not just a necessity but a strategic imperative for India's transformation into a developed nation by 2047, as envisioned by the Hon'ble Prime Minister, Narendra Modi during the 10th Governing Council Meeting of NITI Aayog.

Drivers of Horticulture Growth in India

Consumer demand: A marked shift in food consumption patterns has resulted from rising incomes (Rs 21,962 in 1983 to Rs 99,404 in 2022-23) and growing urbanization (from 23% in 1983 to 37% in 2023). Consumers now demand diverse, fresh, and nutritious food, with a significant rise in the consumption of fruits, vegetables, dairy, and meat. Increased health awareness, especially among the urban populations, is driving this dietary diversification. Consumption of horticultural products has increased about 2-3 times.

Economic opportunity: Horticulture offers high returns per unit area and income from fresh, value-added and processed products. It also generates off-farm opportunities in value-addition, processing, logistics and act as an engine of growth for rural diversification and employment. India's export potential is raising, for instance, the floriculture sector has witnessed a compound annual growth rate (CAGR) of approximately 10%.

Government programs and schemes: Centrally sponsored initiatives under the Mission for Integrated Development of Horticulture (MIDH), including schemes like the National Horticulture Mission

As India moves toward 2047, accelerating horticulture during "Amrit Kal" is requires for ensuring better nutrition, higher farm incomes, and climate resilience. By combining innovation with farmer-centric policies and strong market support, horticulture can become a pillar of rural prosperity and national growth

(NHM), Horticulture Mission for North East & Himalayan States (HMNEH), National Horticulture Board (NHB), Coconut Development Board (CDB) and Central Institute for Horticulture (CIH) facilitate holistic growth of the national horticulture sector. Besides this, several other commodity boards such as the Tea Board, Coffee Board, Spices Board and Coconut Development Board provide extension services, production support, and market/export promotion support to respective sectors. These initiatives collectively cover a wide range of crops including fruits, vegetables, root and tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, cocoa, and bamboo. The e-NAM platform, integrating about 1,410 markets and 3,979 Farmer Producer Organizations (FPOs), has enhanced price transparency and market access.

Genetic improvement through research and development: Plant breeding efforts have led to the development of 2,000 improved horticultural varieties with higher productivity, better nutritional quality and enhanced stress resilience across the agro-climatic zones. Biotechnological tools have potential for genetic improvement of horticultural crops. Plant tissue culture offers disease-free planting material and government initiated Clean Plant Programme (CPP) to ensure the availability of quality planting material. Modern techniques such as QTL mapping, genome sequencing, marker-assisted selection, genome wide association and CRISPR-Cas9 gene editing have accelerated the identification and precise improvement of desired traits. Genome editing projects have been initiated in 17 horticultural crops to improve 34 key traits, targeting climate resilience and nutritional enhancement. Advances in whole genome sequencing, omics, and high-throughput phenotyping can accelerate the pre-breeding and speed breeding that are valuable for improving horticultural crops especially the perennials.

Digital tools in smart farming: Recent years have seen a strong push towards climate-smart horticulture and improved crop management practices, supported by digital technologies. Tools such as Artificial Intelligence (AI), Internet of Things (IoT), and market-driven data analytics are being leveraged to make horticultural systems more efficient, resilient, and responsive to changing the climatic and market conditions.

Agribusiness, post harvest management and value-chain infrastructure: Investments in cold chains, food processing, micro-irrigation, and protected cultivation systems (e.g., polyhouses, net houses) are significantly improving yields, product quality, and shelf-life. The expanding food processing sector and private sector engagement are reinforcing post-harvest infrastructure and value chains. Additionally, start-ups and agribusinesses are increasingly investing in logistics and integrated farm-to-fork models. There is a strong emphasis on processing, branding, and capacity building traceability, thereby transforming horticulture into a market-driven and employment-generating sector.

Challenges amidst acceleration

Despite its vast potential and expanding scale, the Indian Horticulture sector continues to face deep-rooted structural and operational challenges. Fragmented landholdings have declined from 2.28 ha in 1970-71 to just 1.08 ha in 2015-16, and a significant portion of agricultural land suffers from salinity (6.73 Mha), acidity (16.03 Mha), and poor soil fertility, which further constrain productivity. Concurrently, the average landholdings size is expected to decrease significantly to 0.6 ha from approximately 1 ha now.

While fruit and vegetable production

increased by 6.34% over the last decade, productivity rose by only 1.57%. India's average horticultural productivity continues to lag behind global benchmarks; for example, fruit yields (excluding banana and papaya) average just 12 t/ha compared to 22.4 t/ha in Indonesia, and vegetable productivity is 17 t/ha versus over 30 t/ha in the USA. Low yields in plantation crops, such as tea (2,500 kg/ha), coffee (810 kg/ha), and black pepper (325 kg/ha), reflect gaps in quality planting material, inefficient resource utilization, and limited technology adoption.

Climate change has intensified abiotic stresses and the prevalence and also resurgence of pests and diseases. Overuse of agrochemicals is contributing to pest resistance and environmental pollution. While weak biosecurity and surveillance systems further expose crops to invasive pests and diseases.

Postharvest losses remain alarmingly high, estimated at 4.82–11.61% for vegetables and 6.02–15.05% for fruits (NABCONS, 2022), largely due to inadequate cold chain infrastructure and inefficient logistics. Weak market linkages, price volatility, limited storage facilities, and inadequate farming infrastructure continue to undermine marketing and supply chains for high-value crops. As consumer demand and global competition increase, the lack of robust quality monitoring systems and compliance with international standards is a key barrier in enhancing export potential.

Moreover, the majority of small and marginal farmers have limited access to modern technologies like precision farming, IoT-based monitoring, soil mapping and drip irrigation due to high costs, low awareness and inadequate technical skills. Investment in R & D and agricultural extension remains low at 0.43 and 0.12% of AgGDP, respectively during 2022-23, which is far below the global benchmarks.

Way Forward in Horticulture sector as a Component to Viksit Bharat @2047

Despite the above challenges, India's Horticulture sector continues to register significant progress, with an estimated area of 29.09 Mha, production of 354.74 Mt,

and average productivity of 12.2 tonnes/ha in 2023–24 (MoA&FW, 2024). To the meet growing domestic demand, nutritional security, and export aspirations by 2047, the sector must aim for a projected area of 42.2 Mha, production of 777.7 Mt, and productivity of 18.4 tonnes/ha. Achieving these targets requires coordinated, multi-pronged strategies in the following domains:

I. Research, Innovation & Education

Accelerated breeding: Fast-track the development of climate-resilient, input-efficient varieties using tools like speed breeding, crop wild relatives, and participatory plant breeding.

Horticulture education hubs: Collaborate with agricultural universities to train youth in modern horticulture, post-harvest management, value-addition, and offer scholarships and mentorships to build skilled human capital.

Technology access and innovation: Launch farmer-centric AgriTech initiatives promoting IoT devices, weather sensors, precision horticulture tools, drones, and smart irrigation systems through dedicated innovation hubs.

Digital Knowledge Hub: Creating a centralized, multilingual digital platform for real-time dissemination of research updates, best practices, and advisories for farmers and extension workers.

II. Production Planning & Farmer Capacity Building

Crop zoning and diversification: Identify agro-ecological zones for introducing high-value crops and promote underutilized crops for crop diversification.

Climate-smart training: Roll out region-specific training programs and awareness campaigns to equip farmers with climate-resilient horticultural practices and stress-mitigation techniques.

Core working group: Establish a multi-stakeholder working group including government agencies, research institutions, private sector, and farmers to drive public-private partnerships and cluster-based development.

III. Infrastructure, Markets & Agribusiness Ecosystem

Infrastructure development: Strengthen cold chain logistics, set up processing units, and upgrade rural connectivity to improve farm-to-market efficiency.

Post-Harvest enterprises: Promote small-scale, farm-adjacent processing units for value- addition and local employment, especially through bio-based product manufacturing.

Support for Startups & FPOs: Empower agri-startups, cooperatives and FPOs to innovate through institutional, financial, and capacity-building support to expand market.

Market modernization and reforms: Modernize agricultural markets with upgraded infrastructure, digital payment systems, and e-marketing platforms to improve transparency and efficiency. Promote direct marketing, contract farming, and digital platforms to reduce intermediaries and improve farmer's margins.

Private sector partnership: Enable private investment in mechanization, storage, processing, and value chain integration through state-led policy incentives.

IV. Bio-economy and Sustainability

Bioenergy from residues: Utilize horticultural residues to produce bioenergy and industrial inputs using innovative technologies.

Bio-based economy: Promote plant-derived, eco-safe inputs for nutrition, plant protection, and soil health enhancement, driving a sustainable bio-based economy.

Monitoring and evaluation: Develop a robust monitoring and evaluation framework to track technology adoption, sustainability outcomes, and capacity-building impacts at local and national levels.

Sustainability fund: Establish a dedicated fund to promote organic farming, agroforestry, water-efficient farming, regenerative and conservative horticultural practices.

AGRICULTURE'S NEW ERA

The Shaktiman Legacy and the National Imperative

The time has come for a new revolution — one that blends mechanization, smart farming, policy reforms, and sustainability. As highlighted by recent insights from government initiatives, a unified, technology-driven, farmer-centric model is essential for future-ready agriculture. Within this transformation, Shaktiman — India's leading agri-machinery, implement manufacturer — emerges not just as a manufacturer but as a strategic enabler of this national shift.

At the core of India's agricultural challenge is the need to modernize farming practices, reduce labor dependency, and improve productivity per hectare. Mechanization and smart farming are no longer optional but essential. However, with India's overall mechanization rate still hovering around 40–45%, regional disparities continue to hold back progress.

With government programs like the Sub-Mission on Agricultural Mechanisation (SMAM) and Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) have laid important foundations, execution at the last mile remains key.

Specialized Mechanization

This is where Shaktiman's Hi-Tech Farm Solutions division becomes a transformative force. Shaktiman's Hi-Tech Farm Solutions, a forward-looking platform within Shaktiman, focuses on driving specialized mechanization in critical crop segments that are typically underserved. It promotes cutting-edge technologies tailored for crops like Sugarcane, Paddy, Fodder (Silage), and Tree Pruning Solutions, Cotton as well as Self-Propelled Boom Sprayers designed for high-efficiency plant protection.

Among the standout innovations under this platform is the launch of the Sugarcane Harvester 3737 TejasUltra. This machine has revolutionized sugarcane harvesting not only in India but also in international markets. It represents a historic milestone. Initially, India used to import sugarcane harvesters from Brazil; later, Shaktiman designed and developed the first-ever machine in India, tailored to Indian farming requirements. More notably, Shaktiman spearheaded the export of this harvester to Fiji, laying the foundation for expansion into countries such as Mexico, Brazil, Philippines, Vietnam, Sierra Leone, Guadeloupe, Colombia, Tanzania, Sri Lanka, Nigeria, Mauritius, Réunion Island, and Guatemala. This remarkable journey demonstrates how indigenous engineering excellence, backed by a deep understanding of farmer needs, can create global footprints.

Mr. Hasmukh Gohil, Managing Director and Mr. Ashwin Gohil, Chairman, Tirth Agro Technology Private Limited. "SHAKTIMAN"

Visionary Leadership

This success is attributed to the visionary leadership of Mr. Ashwin Bhai Gohil (Chairman) and Mr. Hasmukh Bhai Gohil (Managing Director), whose unwavering focus on innovation and farmer-centric thinking has made Shaktiman a household name in rural India.

We have played a pioneering role in introducing mechanized sugarcane harvesting to India and beyond. Shaktiman stands for Indian agricultural progress, offering top-quality equipment, implements, and services. This philosophy resonates with Shaktiman's guiding purpose of "Making Agriculture More Economical®".

End-To-End Mechanization Solutions

This is more than a tagline—it is a long-term mission that's redefining how farming is done. Shaktiman offers end-to-end mechanization solutions: from Seedbed Preparation, Planting & Sowing, Crop Management, Harvesting to Post-Harvest Management. This integrated approach

has impacted the lives of over a million farmers in India and globally, empowering them to farm more profitably, efficiently, and sustainably.

In paddy cultivation, the Paddy Master 3785, a high-capacity harvester suited for Indian terrains, offering speed, precision, and reduced grain loss. Combined with mechanized rice transplanters, these technologies help farmers cope with labour shortages and climate uncertainties, ensuring timely sowing and harvesting.

The use of Self-Propelled Boom Sprayer Protektor 600 is another critical innovation in modern farming. These machines ensure uniform chemical application over large areas, helping conserve water and pesticides while significantly reducing operator fatigue. With their high ground clearance and advanced spray control systems, they are perfectly suited for row crops like cotton, maize, Paddy, soybean and many other Multi Crops. Today, when farmers think of efficient spraying, the name that comes to mind is Protektor—a trusted solution from Shaktiman.

In the silage and fodder management space, offers mobile Silage balers that convert green fodder into compact, storable, and transportable feed for dairy animals. With livestock playing a vital role in farm income for over 70 million households, this mechanization creates food security not only for people but also for the animals they depend on.

Mechanized Fruit Harvester cum Tree Pruning

One of the most specialized interventions of Shaktiman's Hi-Tech Farm Solutions is in Tree Pruning Solutions. Recognizing the challenge of managing orchards, vineyards, and plantation crops, Shaktiman offers mechanized pruning tools that improve cutting precision and plant health, reducing the risk of disease while enhancing fruit quality and yield. These machines are built to global standards but adapted for Indian crop systems.

Mechanization in Cotton

India is one of the world's largest producers of cotton, yet a significant portion of its cotton cultivation continues to rely on manual labour, making the process time-consuming, inefficient, and costly. Shaktiman's Hi-Tech Farm Solutions is transforming this scenario through a robust portfolio of cotton-focused mechanization machinery—culminating in the development of India's first indigenous Cotton Picker 1437. This pioneering innovation is designed to enhance productivity, reduce drudgery, and support farmer prosperity by offering a reliable, cost-effective, and locally adapted alternative to manual cotton harvesting.

About the **AUTHOR**

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KrishiUdan, Shaktiman's Flagship Brand Experience

Further amplifying this outreach is KrishiUdan, Shaktiman's flagship brand experience centre, which showcases cutting-edge agricultural technologies to the farming community.More than just a showroom, KrishiUdan serves as a live interface—where farmers, dealers, students, researchers, and policymakers can interact with the full spectrum of mechanization solutions, witness live demos, and engage in hands-on learning. This initiative plays a pivotal role in building awareness, trust, and aspiration among rural audiences, reinforcing Shaktiman's farmer-first approach to technology dissemination.

This emphasis on capacity building is complemented by Shaktiman's broader initiatives, including the L.S. Gohil Learning & Development Academy in Rajkot and regional farmer training camps. Shaktiman's Hi-Tech Farm Solutions exemplifies how industry can lead this change: by understanding crop-specific pain points, offering fit-for-purpose technology, and nurturing the knowledge ecosystem that sustains it.

Redefining Agriculture
Strategic Imperatives for Sustainable Growth

Accelerating the growth of Indian agriculture is not just desirable—it is imperative. The future of Indian agriculture lies in accelerating growth through a combination of strategic accelerators. One of the foremost strategies is diversification—from cereal-dominated production to high-value commercial crops like fruits, vegetables, pulses, and oilseeds. Diversification not only increases farm income but also enhances nutritional security and optimizes use of resources. In many regions across the country, farmers have shifted to commercial crops cultivation as major agricultural activities and their source of income.

Technology is continuing to reshape Indian agriculture through precision farming, drone applications, mobile-based advisory services, and satellite-based crop monitoring. Real-time access to information empowers farmers to make informed decisions about sowing, irrigation, fertilization, and marketing. To unlock the full potential of these advancements, it is crucial to scale up their adoption across regions and crop segments.

FPOs – A Powerful Strategy

More than 80% of Indian farmers are small and marginal, owning less than two hectares of land. These farmers often face challenges in accessing technology, quality inputs, credit, capital, and markets. Aggregating them into Farmer Producer Organisations (FPOs) has emerged as a powerful strategy to overcome these constraints and achieve

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economies of scale. Building on India's successful history of cooperatives and inclusive models, the FPO approach can enhance farm-level efficiency and collective bargaining power.

The Food Processing Industry is a key driver of agricultural growth, creating forward linkages that connect farmers to value-added markets through partnerships with food hubs, food parks, start-ups, and corporates, thereby ensuring better price realisation, income stability, and reduced market risks. It also drives the development of essential Agri-infrastructure—cold chains, packaging, and logistics, benefitting the entire Agri-value chain, and enabling wider market access—both domestic and export-oriented. In essence, the food processing sector serves as a strategic enabler for turning "Producers" into "Processors" and "Farms" into "Food Factories".

Access to timely and adequate credit is a key enabler of agricultural productivity. Schemes like Kisan Credit Card (KCC) with Interest Subvention and Jansamarth Portal as well as e-NWR integration with banks are helping farmers transition into the formal credit ecosystem. e-NWR (Electronic Negotiable Warehouse Receipt)-based pledge financing is gaining momentum, allowing farmers to avoid distress sales post-harvest. Innovative Credit models tapping the potential across the Agri Value Chain and new-age scientific and progressive farming is the intervention needed to accelerate growth in these areas.

Kisan Samriddhi Rin, Agri & Food Enterprise Loan

Understanding the importance of these emerging trends towards the growth of agriculture sector, State Bank of India has two innovative products – "Kisan Samriddhi Rin (KSR) and Agri & Food Enterprise Loan (AFEL). While KSR is a tailor-made product for meeting the production credit requirement of scientific and progressive farmers, AFEL provides credit at attractive rates to meet all types of funding requirements of Agri entities across the Agri/Food Value Chain.

Indian agriculture remains largely rain-fed, making it vulnerable to climate variability. Per Drop More Crop initiative under Pradhan Mantri Krishi Sinchayee Yojana encourages farmers to adopt water-efficient irrigation methods like drip and sprinkler systems. Sustainable farming through organic and natural practices is another key area that requires focused attention and scaling. These methods not only preserve soil health and reduce chemical dependency but also enhance long-term productivity, environmental resilience, and consumer health.

The country is witnessing a surge in AgriTechs and Agri Start-ups that are revolutionizing traditional agricultural practices across the entire value chain. To sustain and scale their impact, these start-ups require robust ecosystem support in the form of access to capital, mentorship, research collaboration, regulatory facilitation, and greater integration with public and private sector initiatives. Technology incubators like those at ICRISAT, ICAR-NAARM, ICAR-IIMR in Hyderabad, and NABARD are playing a vital role in supporting and nurturing Agri-entrepreneurs.

GOI has launched several transformative initiatives viz., 10,000 FPO Scheme, Digital Agriculture Mission, Agri Infrastructure Fund (AIF), Pradhan Mantri Formalisation of Micro Food Processing Enterprises Scheme (PMFME) and PM KUSUM focused on reaping the benefits of Collectivization, Digital Technology, improved Agri infrastructure, formalization of Food processing, and promotion of renewable energy solutions. Objective of these initiatives is to enhance productivity, improve farmer incomes, and make agriculture more resilient and market oriented. Such policy support from Govt through strategic existing and future interventions, need further expansion for accelerated growth of Agriculture sector.

Prosperous Nation, Prosperous Farmers

As we work towards a *Viksit Bharat*, it is essential that we place our farmers at the centre of this development, because a prosperous nation begins with prosperous farmers. And therefore, to accelerate agricultural growth in India, a holistic and multi-pronged strategy is essential. Integrating climate resilience through climate-smart practices, efficient water management, and renewable energy solutions like solar pumps are critical in building long-term sustainability.

Promoting data-driven policymaking by leveraging platforms like AgriStack can help deliver customized services and timely interventions to farmers. Strengthening the research-extension ecosystem will ensure that innovations from institutions like ICAR reach farmers faster and more effectively. Establishing strong forward linkages—through investments in export facilitation, product branding, and quality certification—can unlock global market potential. Together, these strategic actions can transform Indian agriculture into a more productive, resilient, and inclusive growth engine for the nation.

GREENSTAR FERTILIZERS LIMITED
HELPING FARMERS PROSPER

Greenstar Fertilizers Limited is a leading manufacturer and marketer of fertilizers in India. During 2011 Greenstar Fertilizers Limited, a private limited company had acquired the phosphatics manufacturing assets of SPIC located at Tuticorin in Tamil Nadu, an enduring fertilizer brand in India, bringing it a significant strength in phosphatics. Greenstar also imports fertilizers for sale in India. The company is also a brand launch platform for organic and inorganic fertilizers that stand up to its tough quality certification process.

Driven by our purpose to maintain soil health, improve crop productivity and to increase the standard of living of the farming community, this business also serves as a platform for the launch of customizable water-soluble fertilizers, organic fertilizers, micronutrients, secondary nutrients, bio fertilizers, plant growth regulators and plant bio stimulants. As a leading marketer, we ensure that we supply quality fertilizers and speciality products for the rural farming community.

Range Of Agricultural Services

To lead a transformation of the food system through climate neutrality, regenerative agriculture, and prosperity of the farming community, Greenstar offers a range of agricultural services such as soil testing, training programs, publishing SPIC Pannai Cheithi a bi-monthly farm journal and a dedicated 24 /7 customer service through Spic Agricultural Services (SAS). Spic Agricultural services is a pioneer in farmer care and support services in terms of core values, interactive experiential learning, farmer-friendliness, networking and farmer centred consultancy services in the country.

In an effort to provide Indian farmers with specialized agricultural inputs based on soil types and climatic trends in any particular region, Greenstar has stepped up its soil testing services through its mobile and static soil

labs. Our soil testing laboratory is well equipped with modern devices for the analysis of macro and micronutrients, organic carbon, soil texture, water purity etc., A fully fabricated mobile soil testing van with all the necessary advanced equipment regularly visits farmers in rural villages of Tamil Nadu, Andhra Pradesh, Telangana and Karnataka for providing soil and water sample testing services. Analytical results are provided on the spot to advise the farmers on corrective measures for improving soil health and enhancing crop productivity.

Greenstar regularly organizes farming and entrepreneurial skill based residential and outreach training programmes for farmers with the help of eminent subject matter specialists. These training sessions help farmers to learn, acquire specific skills and integrate modern agricultural methodologies with enterprise training related to sustainable agriculture.

Residential training programs are well supported by an exhibition hall that showcases the symptoms of crop damage due to pests & diseases, germplasm of paddy varieties, traditional agricultural implements, model integrated farming systems and a medicinal garden to educate the farmers on the range of crops, its benefits & their commercial scope. These programmes enable farmers to take advantage of new agriculture opportunities, manage risks and market their farm produce more effectively.

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HYFUN: INDIA'S GLOBAL FACE OF FROZEN POTATO INNOVATION

As a Global Leader in Frozen and Ready-to-Cook Potato Products—from French Fries and Patties to Hash Browns—HyFun is redefining food innovation on the world stage. With a presence in over 40 countries and trusted by QSR giants. HyFun represents India's rise as a hub for premium, value-added food manufacturing.

From Seed to Shelf: Built for Quality, Rooted in Purpose

What gives HyFun its competitive edge is its fully integrated Seed-to-Shelf model—ensuring consistent quality, sustainability, and full traceability across the value chain. At the heart of this model is HyFarm—its Agricultural Business Unit - designed to unite traditional farming wisdom with precision technology while uplifting India's smallholder farmers.

HyFarm: Where Technology Drives Transformation

Partnering with over 7,000 smallholder farmers across 35,000 acres in North Gujarat, HyFarm is set to scale to 30,000+ farmers by 2028. But this is about more than scale—it's about im-

"What began with just 200 farmers is now a thriving community of over 7,000 — a testament to the trust we've built, and the transformation we're driving. At HyFun growth has never been just about numbers. It's about empowering farmers, advancing agriculture with science and technology and creating a profitable & sustainable future."

— Mr Haresh Karamchandani, MD and Group CEO, HyFun Foods

pact.

By integrating farmers into a high-quality, globally compliant supply chain, HyFarm delivers:

- Quality seed and soil-health-based nutrient plans
- Real-time digital advisory via FarmOji
- Field-level demonstrations of regenerative techniques
- Transparent, assured payments that drive farmer trust and product integrity
- Farmers are now unlocking higher quality and better prices—thanks to real-time grading tech that sees what the eye can't and delivers precision right at harvest.

The result- Lower input costs, smarter decisions, and potato yields that meet global processing standards.

Banaskantha to the World: India's High-Value Potato Cluster

The districts of Banaskantha, Mehsana, and Sabarkantha offer ideal conditions for French Fry-grade potatoes. This 90,000-hectare Agri-cluster—anchored near HyFun' s world-class processing plants—now produces over 2.7 million MT of potatoes annually, forming one of India's most ambitious farm-to-fork value chain models.

HyFarm is turning this into a replicable model—one that balances productivity, climate resilience, and farmer inclusion.

Tech with Purpose: Smart Farms, Smarter Futures

HyFarm' s digital-first ecosystem transforms fragmented farmlands into precision-powered production zones:

- **FarmOji App**: Multilingual, mobile-based guidance on soil health, crop plans, pest control, weather alerts, and market transparency
- **HarvestEye (UK):** AI-driven tuber grading brings precision to quality and power to the farmer. It ensures every potato is accurately sized and defect-free, maintaining premium standards — while giving farmers full transparency, faster results, and greater trust in every harvest.
- **IoT Sensors**: Enable smart irrigation and nutrient management—saving up to 35% water and reducing fertilizer costs
- **Cold Chain Digitization**: Ensures traceability from farm to factory, minimizing post-harvest losses and improving raw material flow

"HyFarm exists to prove that the future of Indian agriculture lies in dignity, not dependency. Our purpose is to unlock prosperity for smallholder farmers—by equipping them with the tools, tech, and trust they need to thrive in a global value chain."

— Mr Soundararadjane, CEO, HyFarm

A Climate-Smart, Farmer-First Vision

HyFarm is rooted in a regenerative, inclusive philosophy that promotes:

- Low-input, high-output farming
- Efficient water and soil management practices
- Crop diversification and climate-adaptive techniques

By embedding sustainability in every stage, HyFarm empowers farmers to grow more with less, building a future that is profitable, resilient, and dignified.

HyFun' s Growth Engine: Global Demand, Local Prosperity

With a current processing capacity of 1.58 lakh MT—set to scale to 3.10 lakh MT—HyFun is India's largest manufacturer and exporter of frozen potato products. Nearly 75% of its output is exported to high-growth markets across Southeast Asia, the Middle East, Japan, and the U.S.

Domestically, HyFun' s partnerships with leading QSRs and food innovators ensure farmers stay connected to premium, predictable demand.

Vision 2030: Scale with Impact

HyFarm' s 2030 roadmap is focused on transformation at scale:

- Deepening relationships with 30,000+ smallholder farmers
- Scaling FarmOji and IoT solutions across micro-regions
- Advancing climate-resilient seed development
- Expanding cold chain infrastructure and post-harvest automation
- Launching experience centres to spotlight India's potato leadership to the world

More Than a Model—A Scalable Movement

What sets HyFarm apart isn't just its scale or technology—it's the power to uplift farming communities, transform rural economies, and deliver global quality, plot by plot, village by village.

This is more than farming. It's a movement—toward climate-smart agriculture, inclusive prosperity, and world-class Agri-systems led by India.

As HyFarm continues to bridge grassroots realities with global ambitions, it sets a new benchmark for the future of food—tech-powered, farmer-first, and proudly Indian.

INDIAN AGRICULTURE ON FAST TRACK

Strategies and Success Stories

Agriculture remains the backbone of India's economy, employing about 50% of the workforce and contributing approximately 16-17% to the national GDP. Despite its significance, Indian agriculture faces numerous challenges such as low productivity, fragmented landholdings, outdated technology, inadequate infrastructure, climate vulnerabilities, and fluctuating market prices. To accelerate growth in this vital sector, a multifaceted approach integrating technological innovation, policy reforms, infrastructure development, and sustainable practices is essential. This write-up explores strategies to boost agricultural growth in India, supported by notable success stories.

1. Embracing Technology and Innovation

- **Digital Agriculture and Precision Farming:**

The adoption of digital tools like mobile apps, remote sensing, and data analytics can revolutionize farming practices. Precision agriculture allows farmers to optimize inputs such as water, fertilizers, and pesticides, thereby increasing yields and reducing costs. For example, companies like AgriDigital and CropIn have developed platforms providing real-time data, weather forecasts, and crop health monitoring, enabling farmers to make informed decisions.

- **Mechanization and Modern Equipment:**

Encouraging the use of modern machinery such as tractors, harvesters, and drip irrigation can significantly improve productivity. The government's Kisan Tractor Subsidy Scheme has facilitated access to affordable machinery, especially for smallholders.

- **Biotechnology and Improved Seeds:**

Development and dissemination of high-yielding, pest-resistant, and climate-resilient crop varieties can boost productivity. The success of Bt cotton in India exemplifies how biotechnology can transform crop yields and farmers' incomes.

About the **AUTHOR**

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2. Strengthening Infrastructure and Market Linkages

Rural Infrastructure Development:
Improving rural roads, storage facilities, cold chains, and transportation reduces post-harvest losses and ensures timely market access. The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) aims to enhance irrigation infrastructure, thereby stabilizing production.

- **Market Reforms and Farmer-Producer Organizations (FPOs):**

Strengthening FPOs can empower farmers to negotiate better prices, access credit, and collectively market their produce. The National Agricultural Cooperative Marketing Federation of India (NAFED) has played a crucial role in marketing agricultural produce.

- **E-NAM Platform:**

The Electronic National Agriculture Market (e-NAM) connects farmers directly with buyers across India, promoting transparent pricing and expanding market reach. Since its inception, e-NAM has facilitated better price realization for farmers.

3. Policy Reforms and Financial Inclusion

- **Crop Insurance and Credit Facilities:**

Affordable credit through schemes like Kisan Credit Card (KCC) and comprehensive crop insurance schemes such as Pradhan Mantri Fasal Bima Yojana help farmers manage risks and invest in productivity-enhancing inputs.

- **Land Reforms and Consolidation:**

Encouraging land consolidation can reduce fragmentation, enabling mechanization and efficient resource utilization.

- **Subsidies and Incentives:**

Targeted subsidies on fertilizers, seeds, and machinery should be linked with sustainable practices to prevent overuse and environmental degradation.

4. Promoting Sustainable and Climate-Resilient Practices

- **Integrated Farming Systems:**

Diversifying cropping patterns and integrating livestock, aquaculture, and agroforestry can enhance income stability and resource use efficiency.

To realize India's full agricultural potential, policymakers, researchers, private sector players, and farmers must collaborate closely

- **Water Management and Conservation:**

Adopting rainwater harvesting, drip irrigation, and efficient water management practices can mitigate climate change impacts and conserve vital resources.

- **Organic Farming and Soil Health:**

Encouraging organic farming and soil health management improves productivity while preserving ecosystems.

5. Enhancing Research, Education, and Extension Services

Agricultural Research and Innovation:
Investing in research institutions like IARI (Indian Agricultural Research Institute) can develop innovative solutions tailored to local needs.

- **Farmer Education and Extension:**

Strengthening extension services ensures that farmers are aware of new technologies, practices, and market trends. Digital extension platforms can reach remote areas more effectively.

Success Stories Demonstrating the Potential

1. High Drip Irrigation Adoption
Israel has become a global leader in water-efficient and precision farming techniques. Indian farmers, especially in water-scarce regions, have adopted drip irrigation and soil moisture sensors inspired by Israeli practices. Pilot projects in states like Gujarat have shown promising results, increasing water efficiency and crop yields.

2. Madhya Pradesh's Collective Farming Initiatives:
The state's Kisan Sathi program promotes the formation of FPOs, enabling small farmers to access credit, inputs, and better markets. This collective approach has led to increased incomes and reduced exploitation by middlemen.

3. Organic Farming in Sikkim:
Sikkim has achieved a 100% organic state status by promoting organic cultivation and eco-tourism. This initiative has improved soil health, reduced chemical dependency, and opened new revenue streams through organic exports.

4. The Success of Bt Cotton:
Since its introduction in 2002, Bt cotton has revolutionized Indian cotton farming. Yield per hectare has increased, pesticide use has decreased, and farmers' incomes have improved significantly in states like Maharashtra and Gujarat.

Comprehensive Approach

Accelerating growth in Indian agriculture requires a comprehensive approach that combines technological adoption, infrastructure development, policy reforms, sustainable practices, and capacity building. Success stories like Bt cotton, organic farming in Sikkim, and FPOs in Madhya Pradesh exemplify how innovative strategies can lead to increased productivity, higher incomes, and sustainable development.

Embracing digital technology, improving market access, promoting sustainable practices, and fostering a culture of innovation will be crucial in transforming Indian agriculture into a more productive, resilient, and inclusive sector in the coming decades. This holistic effort can ensure food security, rural prosperity, and environmental sustainability, ultimately driving India's growth story forward.

INDIA'S CORN CURVE

TRACKING THE GROWTH, GAPS & GAINS

Kharif 2025 Signals a New Growth Chapter

As Kharif 2025 approaches, corn is firmly positioning itself as one of the most dynamic crops in Indian agriculture. A mix of shifting farmer economics, government policy tailwinds, and evolving pest and input management strategies is driving this transformation. Insights from our detailed farmer panel study and expert conversations across major corn-growing states reveal strong signals: corn acreage is poised to rise, seed and input decisions are becoming sharply strategic, and the industry is aligning fast to meet new demands and constraints.

Acreage Expansion – Measured Momentum in Corn Acreages

Farmers across Western and Northwestern India—particularly in Maharashtra, Madhya Pradesh, and Rajasthan—are expected to increase corn acreage by 4–9% in Kharif 2025, with some expert estimates pegging national growth between 8–10%. The push is largely driven by disappointing returns from cotton, soybean, and pulses, alongside strong corn prices and ethanol-linked demand.

In contrast, Uttar Pradesh, Telangana, and Karnataka are likely to maintain current acreage levels. Here, expansion is restricted by land saturation, fewer viable crop alternatives, and seed supply constraints. While farmer sentiment could have supported a 15% jump in area, limited availability of high-quality seed is a real bottleneck.

Seed Preferences: Performance driven choice

Seed selection is becoming increasingly data-driven and performance-oriented.

Corn may be the crop of the moment—but its future will depend on the strategic choices we make today

Farmers are showing growing confidence in high-performing hybrids from Bayer, Pioneer, and Advanta. Bayer maintains stronghold positions in Uttar Pradesh and Karnataka, while Pioneer and Advanta are gaining acceptance in regions like Telangana, expanding beyond their traditional zones. However, Syngenta's share appears to be declining in some key districts—possibly due to market fatigue or inconsistent hybrid performance, signalling a strong preference among farmers for localized trial results and peer validation over legacy brand presence.

The underlying trend is clear: farmers are no longer loyal to labels, but to results.

Weed Control: Laudis Stands Tall Amid Regional Weed Pressures

Weed pressure remains a critical challenge in corn, though it varies by geography. Cyperus rotundus dominates in the North, while Rottboellia cochinchinensis causes significant problems in the South. The first 30 days after sowing (DAS) remain the most crucial weed control window.

During this phase, **Tembotrione** has become the default solution. Bayer leads the segment with over 60% market share, with BASF trailing behind. Farmers typically rely on a single herbicide spray early in the season, reflecting both cost-efficiency and strategic timing.

Fall Armyworm: Still a Threat, But Smarter Management

The Fall Armyworm (FAW) continues to be a major threat—especially in Uttar Pradesh, Maharashtra, and Karnataka. However, farmer responses are evolving. Most spraying activity is now concentrated in the 20–70 DAS window, closely aligned with pest infestation peaks.

Farmers are increasingly adopting a tiered insecticide approach: starting with generics like Emamectin for early-stage control and escalating to premium molecules like Rynaxypyr and Spinetoram as pest pressure intensifies. Though insecticide usage remains fragmented, companies like FMC, Crystal Crop, and Syngenta are seen as consistent value providers.

Importantly, generic insecticides now command nearly one-third of the value share, signaling a shift towards cost-effective precision pest control.

A Point to Ponder: Is India's Corn Push Sustainable?

Despite the momentum, a deeper question looms over India's corn narrative—how long can this expansion sustain, and at what cost?

The original policy push for corn expansion was aimed at reducing paddy acreage, especially in water-stressed regions, as paddy is both surplus and highly water-intensive. However, on the ground, corn is not replacing paddy. Instead, it is increasingly displacing crops like cotton, soybean, and pulses—crops where India already faces domestic shortfalls and import dependency.

This shift raises red flags for India's

broader food balance sheet. Cotton and soybean are both strategic crops for rural livelihoods, textiles, and edible oil security. Corn's rise, if not carefully managed, could aggravate existing supply gaps in these critical segments.

Moreover, seed availability, market infrastructure, and pest dynamics continue to challenge the scalability of corn. The real question for agri-input players and policymakers alike is: can India create a balanced corn economy that supports both farmer income and national agri-security goals?

Conclusion: A Crop in Transition

India's corn story in 2025 is one of transformation—but also of worry. The crop is clearly evolving from a commodity to a strategic choice, driven by market and policy signals. Yet the broader sustainability of this growth depends on addressing input bottlenecks, protecting crop diversity, and aligning incentives with long-term food security. For agri-input companies, the focus should be on targeted support and smarter solutions. For policymakers, it's time to rethink the corn push—to fix one issue without creating new ones.

About Q & Q Research Insights

It is an award-winning boutique market research firm specializing in agriculture across India and 10+ APAC countries. This article draws on insights from Q&Q's long-standing panel of more than 2,000 corn farmers in India. The farmer panel tracks agronomic practices, input usage, crop performance, and cost of cultivation (COC) through multiple field visits during the Kharif season.

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FAST FORWARD FOR INDIAN AGRICULTURE

STRATEGIES, INNOVATIONS, OPPORTUNITIES

To unlock the true potential of Indian agriculture, a multi-pronged strategy involving technology, policy reforms, infrastructure development, and sustainable practices is essential.

1. Adopting Technology and Precision Agriculture

Technological innovation is a key driver of agricultural transformation. Precision farming, powered by GPS, drones, and data analytics, enables farmers to apply the right inputs at the right time and place, minimizing waste and maximizing productivity.

Example: In Punjab and Haryana, farmers are using drones for spraying pesticides and monitoring crop health. Startups like Fasal and CropIn are helping farmers make data-driven decisions using weather forecasts, soil data, and market trends, resulting in higher yields and reduced input costs. Expanding access to these tools through government and private sector collaboration can significantly enhance productivity, especially for smallholder farmers.

2. Infrastructure Development and Market Linkages

Poor rural infrastructure, especially roads, storage facilities, and irrigation, limits the efficiency of the agricultural value chain. Expanding rural roads under the Pradhan Mantri Gram Sadak Yojana (PMGSY) has improved market access, but much more needs to be done in storage and cold chain development. Example: In Maharashtra, the Farmer Producer Organizations (FPOs) supported by NABARD have established collective cold storage units, allowing farmers to reduce post-harvest losses and get better prices by avoiding distress sales. In addition, initiatives like eNAM (National Agriculture Market) have improved price discovery and market transparency. Strengthening these digital platforms and connecting them

with more mandis can further streamline agricultural trade.

3. Improving Access to Credit and Insurance

Many Indian farmers face barriers to formal credit, relying heavily on informal moneylenders. Strengthening institutional credit mechanisms and crop insurance schemes is essential for de-risking agriculture.

Example: The Pradhan Mantri Fasal Bima Yojana (PMFBY) has provided insurance coverage to millions of farmers, yet issues remain regarding claim settlements and awareness. Simplifying processes and leveraging technology like satellite imagery can make insurance schemes more effective and trustworthy.

Microfinance institutions and agri-fintech startups such as Samunnati are bridging the credit gap for small and marginal farmers, facilitating investment in better seeds, tools, and technologies.

4. Promoting Crop Diversification and Allied Activities

India's over-dependence on rice and wheat, particularly in the Indo-Gangetic Plain, is leading to soil degradation and water stress. Encouraging crop diversification into pulses, oilseeds, and horticulture can reduce risks and improve income stability.

Example: In Karnataka, farmers shifting from paddy to millets have seen reduced input costs and better resilience to erratic rainfall. The government's Year of Millets 2023 campaign also helped raise awareness and market demand for these climate-resilient crops.

Promoting allied activities such as dairy, poultry, and aquaculture offers additional income sources. The White Revolution is a testimony to the power of diversification, transforming India into the world's largest milk producer.

5. Land Reforms and Consolidation

Fragmented landholdings remain a serious barrier to agricultural efficiency. Most Indian farmers own less than two

hectares of land, limiting the use of mechanization and economies of scale. Land leasing reforms, digitization of land records, and enabling cooperative farming can help consolidate land use without affecting ownership. Andhra Pradesh and Madhya Pradesh have made progress in this area, facilitating smoother land transactions and secure leasing arrangements. Moreover, states should promote custom hiring centers where smallholders can rent modern farm equipment on a pay-per-use basis, reducing the cost burden.

6. Boosting Agricultural Research and Extension Services

Agricultural research institutes like ICAR (Indian Council of Agricultural Research) have played a major role in increasing food production. However, the outreach of research findings to farmers remains limited. Strengthening the Krishi Vigyan Kendras (KVKs) and involving private players in extension services can bridge the knowledge gap.

Example: In Maharashtra, Agrochemicals Literacy Training Program by Biome Innovative Learning Foundation is educating farmers on integrated pest management and organic farming, leading to lower input use and better soil health and enhancing livelihood by increasing profit through consumer preferred residue-free and organic yield.

Increased investment in R&D, particularly in climate-resilient crops and regenerative agriculture, is vital in the face of changing climate patterns

7. Policy Reforms and Governance

Long-pending reforms in agricultural marketing and input subsidies are necessary to create a competitive and transparent ecosystem. Rationalizing subsidies and redirecting them toward infrastructure and innovation can yield better outcomes.

Example: The Direct Benefit Transfer (DBT) model for fertilizer subsidies ensures that benefits reach the intended farmers directly and reduces leakages.

Moreover, policy consistency is critical. Frequent export bans or MSP changes can create uncertainty, discouraging private investment and innovation in the sector.

8. Empowering Women and Youth in Agriculture

Women contribute significantly to farm labor, yet lack recognition and access to credit, land, and training. Recognizing women as farmers in policy and extending special schemes to support them is key. Simultaneously, making agriculture attractive to youth through agri-entrepreneurship programs and agri-tech innovations can rejuvenate the sector.

Example: Initiatives like Agri-Clinics and Agri-Business Centres (ACABC) are empowering rural youth to offer professional services and start agribusinesses, creating employment while boosting agricultural services.

Holistic Approach Essential

Accelerating the growth of Indian agriculture is both an economic necessity and a moral imperative. A holistic approach that combines technology, infrastructure, inclusive policies, and sustainable practices can revitalize the sector. With coordinated efforts from the government, private sector, and civil society, Indian agriculture can transition from subsistence to sustainability, from stagnation to self-sufficiency, and from vulnerability to vibrancy.

VIKSIT AGRICULTURE BY 2047

Accelerating Growth of Indian Horticulture

India's horticulture sector vital for Viksit Bharat by 2047, produces 362.08 million tonnes, surpassing food grains production since 2011-12. In past two decades horticultural scenario indicated 75% increase in area and 148% surge in production. Exports of fresh fruits and vegetables valued at 15,424 crores in 2023-24. There has been 47.3% growth in the volume of exports of fruits and vegetables between the period 2019-20 to 2023-24. The consumption rate also increases 2–6% for fruits and vegetables and projected to rise dramatically.

Business-as-usual (BAU) and high-income growth (HIG) scenarios estimate that the requirement may rise to 365 million tonnes of vegetables and 233 million tonnes of fruits by 2047, with HIG projections reaching 385–417 million tonnes and 252–283 million tonnes, respectively. Meeting this growing demand necessitates a well-planned, multi-dimensional strategy encompassing improved planting material, climate-resilient technologies, minimising input costs, supply chain strengthening, and enhanced post-harvest infrastructure. Recent initiatives and programs like clean plant program (9 clean plant centres covering 12 fruit crops), national mission on high yielding seeds (NMHYS), establishing gene bank for crops germplasm, enhancing climate resilience and ensuring food security though genome editing (15 horticultural crops) shall help in achieving the target.

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With Dr Kripa Shankar

Availability Of High-Quality Planting Material

Without disease-free, genetically superior and climate-adapted propagules, farmers cannot achieve consistent yields or tap into global markets. India needs to establish decentralized, well-regulated planting material hubs across its agro-climatic regions. Under clean plant program, these hubs must ensure that both public and private sector nurseries meet strict certification standards, and they should focus on developing and distributing disease free quality planting materials.

Land use planning, especially in the face of competing demands for urban expansion, industrial use and nutritional security, must consider the high return per hectare and nutrient dense produce offered by horticultural crops.

Challenges Posed By Climate Change

Climate change, through its increasing frequency of extreme weather events, directly affects horticultural productivity. Most horticultural crops are highly sensitive to temperature, humidity and rainfall variations, which affect yield and quality of produce and can trigger pests and diseases outbreaks or physiological disorders. It affects the activities of natural pollinators in the field/orchard. Breeding and deploying climate-resilient designer cultivars/varieties tailored to specific stress are essential. This includes drought-tolerant, salinity-resistant and pest-resistant genotypes developed using modern tools such as marker-assisted selection, speed breeding and genome editing. Biotic stress causes around 33% yield loss in India.

Pest and disease pressures are intensifying due to ecological imbalances and climate shifts. Integrated pest management (IPM) must be reinforced with newer tools such as artificial intelligence for pest prediction, sensor-based surveillance and drone-assisted pesticide application. Rapid diagnostic kits and real-time disease forecasting models will empower farmers to undertake timely and informed interventions.

Indian horticulture must develop and adopt international standards of production, processing and packaging and develop sea protocols

The Benefits of Mechanisation

Labour-intensive practices like training, pruning, harvesting and intercultural operations can be mechanised using precision tools and lightweight machinery as Indian holds around 75% as marginal to small farmers. The emergence of electric cutter and battery-powered pruners, especially in hilly and peri-urban areas, aligns with India's net-zero emission targets and will reduce drudgery and time costs for smallholders.

Pilot demonstrations and subsidised schemes will encourage adoption and overcome initial resistance from traditional farmers. Vertical farming and peri urban horticultural should be emphasized to tap the urban and metropolitan areas. AI, IoT, ML, drones and sensors will revolutionize horticulture by enabling precise monitoring of crop health, soil and climate in real time, harvesting and storage. It will also be ease in harvesting and post-harvest activities based on X-ray detection and imaging.

Post-Harvest Management

Around 6–15% post-harvest loss of fruits and vegetables are recorded due to poor handling, lack of storage and insufficient logistics. These losses represent not only food wastage but also economic inefficiency. Investments in grading lines, pack houses, cold chain infrastructure and transport are urgently required. Promotion of solar-powered cold storage in rural areas and government support through subsidy and viability gap funding can boost private participation and fill critical infrastructure gaps. Over 75% of fruits and vegetables in India are consumed fresh, there are ample scope for value-added products such as juices, dehydrated vegetables, frozen pulps, which can enhance income and reduce perishability. Encouraging micro food enterprises under and supporting FPOs to set up small processing units can generate rural employment and unlock new markets, especially in urban and export channels.

Pricing And Market Access

Pricing and market access are also major concerns. Unlike staple crops, most horticultural produce do not fall under the MSP regime. This exposes farmers to extreme price volatility. A differentiated price policy for horticultural crops, based on cost of cultivation and demand-supply dynamics, is needed.

The formation of price stabilization funds, futures markets for perishable horticultural crops and digital platforms for price discovery can enhance farmer confidence and market participation. India's share in the global fruit and vegetable export market remains below 2% despite being the world's second-largest producer.

Some major causes are suboptimal produce quality, long geographic distance raising the costs of logistics, delay in grant of market access by importing countries for certain products, stringent phyto-sanitary requirements imposed by some importing countries and delay in registration of enterprises in certain countries. Indian horticulture must develop and adopt international standards of production, processing and packaging and develop sea protocols.

Investments in R&D

Investments in horticultural research need to be substantially scaled up. National Agricultural Research System institutions under ICAR and state agricultural universities must focus on climate-smart production, resource use efficiency, protected cultivation and genetic improvement. Collaboration with global research centres and private research and development firms can expedite the transfer of innovation to field level.

SAFEGUARDING INDIA'S DAIRY SECTOR IN GLOBAL TRADE

India stands at a pivotal juncture as it negotiates a comprehensive Bilateral Trade Agreement (BTA) with the United States. As President of the Indian Dairy Association (IDA), I remain steadfast in my commitment to safeguarding the interests of the 80 million small and marginal farmers who form the backbone of our nation's dairy sector.

India's Unique Dairy Model: A Grassroots Success

India's dairy industry is not only the largest in the world by volume but also one of the most inclusive and community driven. Unlike many developed countries, our growth has not relied on government subsidies. Instead, it is powered by millions of rural households—predominantly women—who depend on dairy for both nutrition and income. Milk, in rural India, is more than a commodity; it is a lifeline.

Risks in Global Trade Negotiations

As India and the US work to double bilateral trade to $500 billion by 2030, the US push for greater market access in dairy presents a significant challenge. The American dairy sector is characterized by heavy subsidies and industrialized practices, creating an uneven playing field for our smallholder farmers. The recent re-imposition of a 26% tariff on Indian imports by the US has already impacted our export sectors, highlighting the risks of liberalization without adequate safeguards.

Strategic Use of Non-Tariff Barriers

Recognizing these challenges, the Indian government is wisely considering the use of WTO-compatible non-tariff barriers (NTBs) to protect our dairy sector. These measures—rooted in legitimate food safety and cultural sensitivities, such as the use of non-vegetarian feed in American cattle—will help India maintain

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its sovereign right to regulate food imports that do not align with our public health and cultural standards.

IDA's Strategic Focus Areas

As we navigate these negotiations, the IDA urges a multi-pronged approach:

- **Dairy as a Sensitive Sector:** Dairy must remain excluded from tariff concessions and protected by NTBs where necessary.
- **Boosting Export Competitiveness:** We should leverage global trade disruptions to expand Indian dairy exports to Asia, the Middle East, Africa, and emerging markets like Russia and Mexico.
- **Enhancing Productivity:** Investments in better breeding, feeding, and farmer support programs are essential for long-term competitiveness.
- **Securing Farmer Income:** It is vital to ensure that 70-80% of the consumer price continues to reach farmers through cooperatives and local value chains.

Key Issues for Sustainable Growth

At the recent Dairy Industry Conference in Patna, I highlighted the urgent need to reduce milk production costs through improved breeding, feeding, and circular economy practices. Policymakers must recognize that the price paid to farmers is not inflationary; it is their rightful income. Our supply chain's strength lies in the fact that 80-85% of the consumer rupee reaches the producer.

Crossbreeding, alongside preserving indigenous cattle, is vital for a sustainable future

Long-term infrastructure investment—across both cooperatives and the private sector—is crucial, especially in underrepresented regions like Eastern India. I also called for a reduction in the high GST on ghee and other dairy products to stimulate consumption, and for buffer stocking of skimmed milk powder (SMP) and white butter to manage seasonal fluctuations and stabilize milk prices.

Global and Domestic Market Dynamics

The global dairy market is projected to grow from USD 991.5 billion in 2024 to USD 1,505.8 billion by 2033, driven by health consciousness, technological advancements, and rising demand in emerging markets. India's dairy sector continues to thrive, with 11.9% value growth in Q4 FY25, supported by strong rural consumption, festive demand, and innovative value-added products.

Protecting Quality and Consumer Trust

The recent surge in paneer adulteration cases is deeply concerning. The IDA fully supports the Food Safety and Standards Authority of India's (FSSAI) proactive consultation on regulating dairy analogues. Clear labelling bans on loose sales, and restrictions in HoReCa establishments are essential to protect consumers and uphold industry integrity. All stakeholders must collaborate to promote traceability, certification, and consumer education.

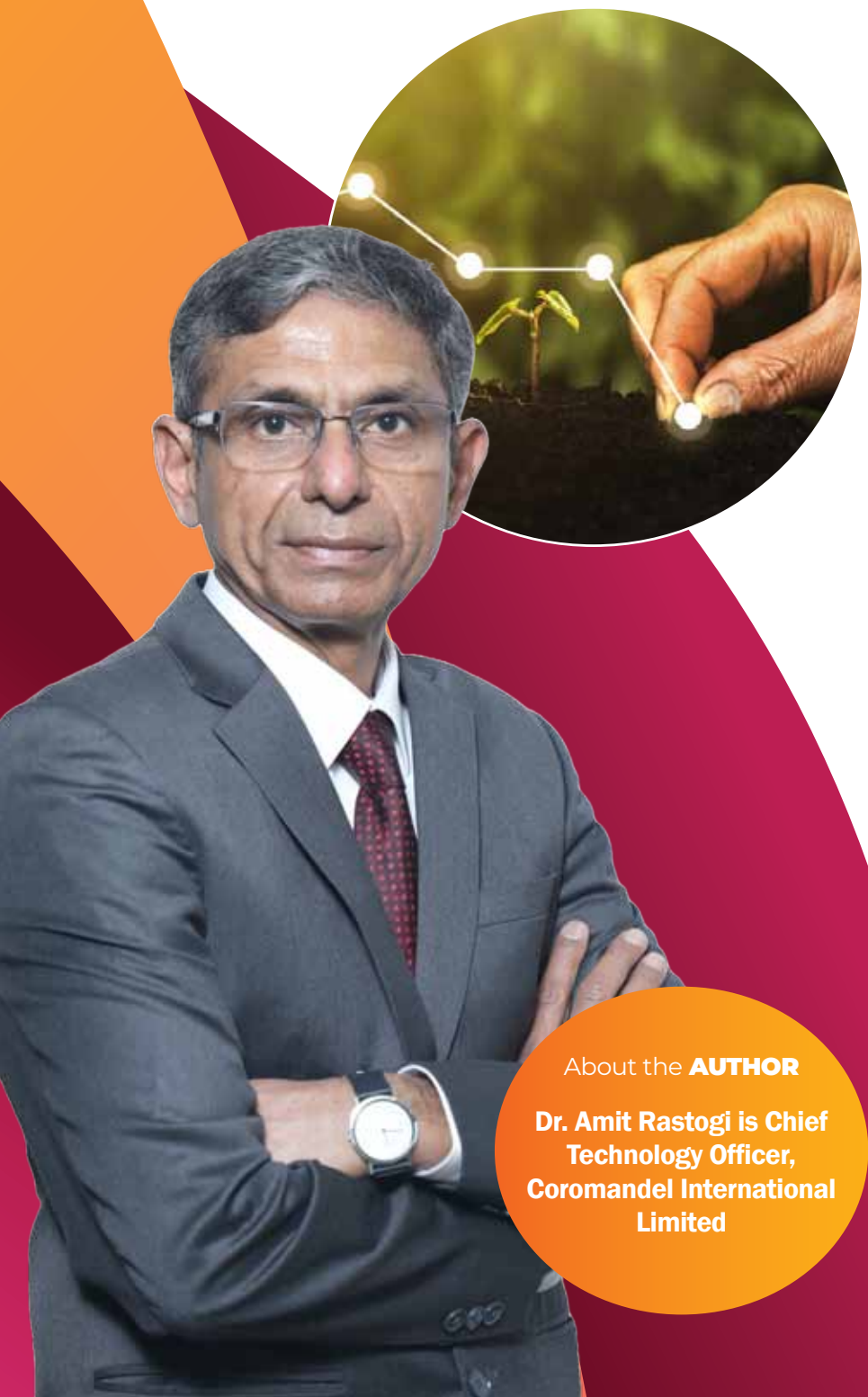
Commitment to Sustainability and Innovation

At the National Conference on "Dairying: A Sustainable Approach for Transforming Livelihoods and Health" in Raipur, I emphasized the need for enhanced productivity through genomics, nutrition, and management. Crossbreeding, alongside preserving indigenous cattle, is vital for a sustainable future. The enthusiasm of farmers, students, and experts at such events showcases the sector's vibrancy and potential.

A Call for Collective Action

India's dairy sector is at a crossroads. By protecting our unique model, investing in productivity, ensuring fair farmer incomes, and upholding quality standards, we can secure a robust, inclusive, and future-ready industry. Let us work together—industry, government, and consumers—to ensure that Indian dairy continues to nourish livelihoods, health, and national pride.

REDEFINING INDIAN AGRICULTURE



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According to NITI Aayog Working Group Report on Demand and Supply projections for Crops (2024), the demand in 2047-48 for foodgrains, vegetables, fruits, sugar, and oilseeds, under the high-income growth scenario, is expected to grow to 415-437 million T, 385-417 million T, 252-283 million T, 44-45 million T, and 31-33 million T respectively. Food demand is expected to increase at the annual rate of 3.07% under accelerated economic growth.

The report states that the gross cropped area is expected to increase annually only at the rate of 0.45%, mainly through increase in cropping intensity. Hence, according to the NITI Aayog report, the additional production to meet the increased demand can only come through yield improvements. Thus, bridging the current yield gap in most crops offers the best way to accelerate growth in food production.

Bridging the Yield Gap

In another NITI Aayog working paper (02/2023), the importance of deploying frontier technologies in agriculture for improving productivity, efficiency, food quality, food safety, profitability, and sustainability is highlighted. According to this paper, one of the key benefits of innovative technologies such as digital, GPS, UAV, sensors is better decision making in production and marketing.

The NITI Aayog paper states that the diffusion of frontier technologies for transformation of agriculture is extremely low, with emerging agri start-ups taking the lead in this direction. This article attempts to present a model by which frontier technologies can

Service providers who provide comprehensive services need to work within the farms and share the risk burden of farmers

be deployed on a large scale to bring about accelerated growth in Indian agriculture.

Input Management for Yield Maximization

During farming, the farmer must make many decisions regarding the application of inputs such as seeds, water, fertilizers, and pesticides. Often, these decisions are based on traditional practices rather than on the current growing conditions of his farm. Furthermore, the decisions regarding seeds, fertilizers, and pesticides are influenced by recommendations from neighbouring farmers or input retailers, which may not be appropriate for his farm.

Sometimes, the approach adopted by farmers towards input management is guided more by the desire for risk minimization rather than yield maximization. Even if the farmer takes optimal decisions regarding the type and quantity of inputs to be applied, application of these inputs may be sub-optimal because of dependence on manual labour, harsh weather conditions, or wrong timing. Therefore, there is clearly a need for providing farmers with customized input management service which encompasses all aspects – type, quantity, timing, and application.

Role of Agri Start-ups

Many agri start-ups have emerged that address one or two of the aspects of input management - sensors for management of irrigation water, advisory services for plant nutrition, diagnostics services for diseases and pests, spraying services for agrochemicals etc. Very few of these start-ups provide comprehensive input management under one roof. Also, very few of the start-ups work within the farms; rather, their offerings are primarily apps or products.

In this model, the farmer continues to bear the entire risk associated with decisions related to application of inputs – seed, water, fertilizers, and pesticides - as no single entity is responsible for all areas. Clearly, a business model which provides holistic services for management of inputs is needed.

Input Management Services

Yield improvement through deployment of innovative technologies related to application of inputs in farms can be made possible by companies that take the responsibility of complete input management. This business model will require 'in-the-farm' presence by the service provider rather than remote guidance through apps.

These companies will need to employ a data-based approach that will allow development of highly accurate predictive AI/ML models for assessing the impact of variables such as weather, soil quality, biotic and abiotic stresses for arriving at customized strategy for inputs required in the farm.

Accurate predictive models based on high-quality data will increase the level of certainty in agriculture. Highly accurate predictive AI/ML models for taking and implementing decisions inside the farm will allow the service provider to offer some sort of guarantee for the expected yield. This will lead to risk sharing between the farmer and service provider and thereby reduce the risk burden of the farmer.

Examples

This model for comprehensive input management services is being adopted by some fertilizer and pesticide companies on B2B2F basis for large customers such as sugar companies, grower associations, exporters, and seed companies who work directly with large groups of farmers. It is considered as an additional offering to support the primary offering of products.

It is necessary to move to B2F basis so that the benefits of new technologies are available to larger number of farmers. This will be possible when large number of entrepreneurs take up Input Management Services as business opportunity. This will also lead to more employment opportunities in the formal sector for large number of agricultural labour.

The Road Ahead

As India travels on the high growth trajectory, the higher demand for food will have to be achieved through yield improvement as there is limited scope to increase cropped area. Deployment of modern technologies in farms will play a critical role in maximizing crop yields. Use of AI/ML can help with better decision making in farms about application of inputs and this will bring more predictability regarding expected yields.

CHALLENGES AND OPPORTUNITIES IN INDIA'S AQUAFEED REVOLUTION

A quiet revolution is happening in India's ponds, rivers, and fish farms—one that expands beyond output metrics and into sustainability, innovation, and economic viability. India is the world's second-largest aquaculture-producing country, with 14.4 million tonnes of fish produced in 2024 and projected to double to a whopping 28 million tonnes by 2033. But in addition to the huge numbers, the real question is how do we grow responsibly?

At the heart of this change is something that does not normally make headlines but has immense importance—aqua feed. Once seen as a simple input, it is now in the centre of how fish are produced, how farmers operate and how environments are supported. The Indian aquafeed market is expected to achieve USD 5.33 billion in just a few years, up from USD 4.27 billion in 2025. The global industry will also exceed USD 112 billion by 2032.

There is growing awareness of the science of feeding fish—not just for growth, but to enhance immunity, improve yield and lessen impact on environment. India is moving from traditional wet feeds to structured nutritionally balanced feeding systems.

Troubled Waters: What the Numbers Don't Show

Behind these promising trends is a complex reality that often goes unnoticed. For the two million smallholder fish farmers in India, every pond is like a battlefield, not just against climate and disease, but also against the hurdles that come from lacking infrastructure, high market volatility, and reduced profit margins.

Climate as an Unpredictable Adversary

Fish farmers operate in a changing environment where the seasons are become increasingly unpredictable. Rainfall regimes are erratic, water temperatures are warmer, and oxygen availability has an uncertain cycle. Changes in the stress landscape within aquatic ecosystems translates to stress on fish metabolism and fish immunity. This is not just a climate story, this is a livelihood story. Stress within aquatic ecosystems means less yield and higher uncertainty of income.

The High Cost of Staying Healthy

India's aquaculture sector bears an estimated annual loss of USD 2.5 billion due to disease outbreaks. Shrimp farmers are especially vulnerable, with rising risks linked to the adoption of high-density farming practices. With the ban on

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antibiotics, reliance on them is no longer an option. Fortunately, effective alternatives are emerging such as Antimicrobial Peptides, Bacteriophages, and Quorum sensing inhibition technologies offering reliable and sustainable disease management solutions.

Profit Margins Under Siege

Feed comprises up to 60% to 70% of operating costs, so global market shocks have made a significant difference. The U.S. recently raised its shrimp tariffs from 10% to 26%, which has already affected Andhra Pradesh's 300,000 shrimp farms. Falling prices, collapsing demand, and more debt have left many not wanting to stay.

Infrastructure: The Weakest Link

Programs like the Pradhan Mantri Matsya Sampada Yojana (PMMSY) are helping to fund hatcheries, training, and cold chains, but the benefits are not evenly distributed. Even with all of that incentive, certain remote areas still suffer real challenges affecting electrification, broken fish feed supply chains, inadequate access to monitoring and measuring water quality in real-time, which is key to good aquaculture science today.

Andhra Pradesh, despite being a leading player in India's domestic aquaculture sector, continues to lag in fostering strong public-private partnerships.

India's fish exports require urgent focus, particularly in building robust technology infrastructure for value-added species. There remains a visible gap in scaling up exports and ensuring competitiveness. Moreover, in the shrimp sector one of India's key export categories price volatilities is a growing concern that needs strategic policy and market interventions.

Turning the Tide: How Innovation Is Creating New Possibilities

Amidst the chaos, there is an abundance of optimism. Advancements in feed formulations and on-farm management practices are providing small and mid-scale farmers with a new toolbox—and a new hope.

Consider Bio Guru 3F Pro, a novel feeding supplement that incorporates prebiotic bacteria to promote fish immunity. Consider also the increasing adoption of alternative sources of proteins—such as insect meal, fermented soy, and microalgae—providing feed formulators with exciting tools to increase the sustainability of aquaculture feeds.

There is a clear need for deeper collaboration between the government and private enterprises to extend infrastructure and technological support to fish farmers in the state

We are also seeing advances in precision aquaculture. Real time monitoring through IoT sensors and machine learning platforms, such as FarmMOJO, are demonstrating measurable benefits—5 to 10% increases in yield, 10 to 30% reductions in feed costs. In an industry so attuned to margins, these metrics are important.

Further upstream, closed-loop systems—like Biofloc and Recirculating Aquaculture Systems (RAS)—are demonstrating what is possible, even in water-stressed areas. Although capital intensive, closed-loop systems provide effective reduction on water usage, disease movement, and antibiotic dependency. These states—including Haryana, Odisha, and Uttar Pradesh—stand out as contributing states benefitting from subsidy provision.

Collectively, these advancements are enabling aquaculture to shift from volume to value—from uncertain survival to scalable success.

Feeding Growth, Fueling Resilience

India's aquaculture sector is changing from a commodity mindset to one built on innovation, science, and farmer prosperity. The change will depend on how we view feed as an expense to being a driver for health, profit, and sustainability.

We need to strengthen infrastructure. Policy must include much more. Small farmers need access to education and affordable tools. But we can see a pathway forward and it is encouraging.

If India can take its centuries-old aquaculture heritage and blend it with 21st-century science and policy coherence, it will not just be a leader in volume but will be setting a global standard for sustainable, inclusive and intelligent aquaculture.

ACCELERATING Agricultural Growth

India's agriculture sector stands at a crossroads. Valued between $580–650 billion, it has grown at an impressive 5% annually over the past six years. Yet, with the right interventions, this growth could accelerate by another 1–2 percentage points, unlocking greater prosperity for millions of farmers.

The Ground Reality

Despite such remarkable progress, over 95% of Indian farmers still depend on traditional methods. Adoption of modern tools remains limited - only 2% use precision agriculture, and 4% leverage digital farming solutions. This stark gap between potential and practice presents a transformative opportunity.

These challenges are real. Nearly 30% of our farmland faces degradation, threatening long-term productivity. Rising input costs, unpredictable weather patterns and fragmented landholdings add to farmers' concerns. Yet within these challenges lie seeds of innovation and resilience.

The Foundation: Smart Crop Planning and Input Management

The foundation of agricultural growth lies in making informed decisions about what to grow, when to grow and how much to invest. Traditional guesswork often leads to market imbalances and income instability.

Modern crop planning, powered by real-time data on soil, weather, and market demand, enables farmers to align production with profitability. When farmers have access to this information, they can choose crops that match their land's potential while meeting market needs. This approach has shown remarkable results in several regions, with some areas reporting 21% yield increases and profit boosts of $800 per acre.

Alongside smart planning, balanced input management becomes critical. The government's Soil Health Card initiative, reaching over 140 million farmers, provides a strong foundation for this transformation. By combining soil testing with targeted fertilizer application, farmers can reduce input costs by 15% while maintaining or improving yields.

Blending traditional wisdom with modern science—like Direct Seeded Rice and integrated weed management—offers climate-smart, cost-effective solutions.

Technology as an Enabler

The barriers to technology adoption including lack of technical support, setup complexity and high costs should be addressed through farmer-friendly solutions. Technology should simplify farming decisions, not complicate them.

Artificial Intelligence applications in agriculture can boost yields by 20% while reducing input costs by 15%, according to studies by the National Academy of Agricultural Sciences. For farmers, this translates into practical applications such as pest prediction systems that alert them before infestations occur, preventing crop losses and reducing input use. Soil health analysis using rapid testing methods provides instant feedback on nutrient needs, while weather-based advisory services help optimize timing for planting, irrigation

and harvesting activities.

The success of these technologies depends on their accessibility. Voice-based interfaces and local language support ensure that even smallholder farmers can benefit from these advances. The focus must remain on creating solutions that work within existing farming systems rather than requiring complete overhauls of established practices.

Value Addition and Market Access

Increasing agricultural output is only part of the solution. To truly uplift farmer incomes, it's essential to add value to farm produce and connect farmers with more lucrative markets. Village-level primary processing helps minimize post-harvest losses, while quality certification empowers farmers to earn premium prices by assuring buyers of product standards.

Smart marketplaces that align supply with demand and offer transparent pricing enable farmers to make informed selling decisions. When paired with traceability systems, these platforms unlock access to export markets and value-added opportunities that were previously out of reach for smallholder farmers.

Integrating these market-access tools with production planning completes a cycle of informed decision-making. Farmers can align crop choices with market demand, optimize yields using data-driven insights, and tap into premium markets through digital platforms and certification frameworks.

Real-World Success

Mr. Bharat Dhamdhere, a progressive farmer from Bhimashet Village in Shirur, Pune District, from Maharashtra has been a proud participant in UPL's Shashwat Mithaas – Sustainable Sugar Program since 2022. Cultivating sugarcane on his 16-acre farm, he adopted regenerative agricultural practices with UPL's support, including high-quality cane sets from super-cane nurseries, scientific soil, water, and nutrient management, and advanced crop protection and nutrition through the Pronutiva program. Technologies like Zeba for improving water & fertilizer usage efficiency, Electron for set protection and germination, and Triskele for efficient weed control were implemented, along with digital tracking of field interventions for traceability. These efforts led to a yield increase of over 15%, while reducing water and electricity usage by 30% and fertilizer input by 25%. Mr. Dhamdhere now produces over 5 metric tons of additional sugarcane per acre, enhancing his return on investment and contributing more cane to the local sugar mill. His success has inspired many neighbouring farmers to join the program, showcasing a model of sustainable and profitable farming.

Accelerating Agricultural Growth: A Strategic Approach

Farmers aiming to scale their agricultural success should adopt a systematic, evidence-based strategy. Starting with small, practical steps—like soil testing and crop planning—builds confidence and delivers immediate benefits, laying the groundwork for more advanced practices.

Maximizing government support is key. Programs such as the Soil Health Card, credit schemes, and input subsidies reduce financial barriers and promote modern farming. The government's push for diversified subsidies and organic inputs presents new opportunities for progressive farmers.

Collective action through farmer groups enhances affordability and reduces risk. Shared input purchases, equipment, and training make advanced techniques accessible to smallholders, enabling scalable adoption. Blending traditional wisdom with modern tools creates resilient, high-performing farms.

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AGRICULTURE: NEW HORIZONS

PATHWAYS TO FARMER PROSPERITY AND NATIONAL GROWTH

Several persistent challenges continue to undermine agricultural productivity and farmer prosperity. A staggering 85% of Indian farmers are small and marginal, owning less than two hectares of land. Such fragmented landholdings make mechanization and achieving economies of scale difficult, reducing farm efficiency. Moreover, productivity levels for major crops in India remain below global standards, further exacerbating income disparities. Farmers also face an inefficient supply chain plagued by post-harvest losses, inadequate storage, and limited market access, all of which reduce profitability.

One of the most critical threats is climate change. The increasing frequency of erratic monsoons, droughts, floods, and rising temperatures is making farming more uncertain and risky. In tandem, high input costs and unpredictable returns have pushed many farmers into debt and financial distress. Without timely reforms and systemic interventions, the Indian agriculture sector risks falling into deeper distress.

To turn Indian agriculture into a growth engine for the economy and a source of dignity and prosperity for farmers, we must embrace technology, reforms, sustainability, and inclusivity.

1. Technological Innovation and Digitization

- Modern technologies have the potential to revolutionize Indian agriculture. Precision agriculture powered by GPS, drones, IoT sensors, and Artificial Intelligence (AI) can provide real-time data to help farmers make informed decisions about sowing, irrigation, pest control, and harvesting. These tools enhance productivity while reducing resource use.

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Organizations (FPOs) can empower small farmers by enabling collective bargaining for inputs and better access to markets.
- Investments in cold chains, storage facilities, and logistics infrastructure are critical for reducing post-harvest losses, especially for perishable produce. Additionally, well-regulated contract farming arrangements can offer farmers assured markets and stable incomes while reducing market-related uncertainties.

3. Sustainable and Climate-Resilient Practices

- Agricultural practices must evolve to address environmental and climate-related challenges. Crop diversification—shifting from water-intensive crops like paddy and sugarcane to pulses, millets, and horticulture—can reduce pressure on water resources while improving farm income.
- Organic and natural farming methods that minimize chemical inputs can command premium prices in both domestic and international markets. Adoption of climate-smart agriculture techniques such as zero tillage, agroforestry, and integrated pest management can further enhance resilience to changing weather conditions.
- The integration of renewable energy, especially solar-powered irrigation systems, can significantly reduce input costs and carbon emissions, contributing to a greener agricultural economy.

4. Policy and Institutional Reforms

- Strong policy frameworks and institutional reforms are essential for systemic change. Rationalizing input subsidies and transitioning

toward direct income support can improve the targeting of benefits and increase efficiency. Formalizing land leasing and ensuring tenure security will encourage long-term investments in land improvement and infrastructure.

- Reforming the Minimum Support Price (MSP) system by expanding its scope to include pulses, oilseeds, and millets can promote diversification and reduce over-reliance on rice and wheat. Water management policies, particularly in regions like Punjab and Haryana, must encourage efficient water use and regulate over-extraction of groundwater.

5. Empowering Farmers Through Education and Extension

- Empowering farmers with knowledge and skills is crucial for sustainable growth. Training programs on modern agronomy, digital tools, and market trends can help farmers make better decisions. Krishi Vigyan Kendras (KVKs) should be revitalized and strengthened to serve as effective grassroots-level knowledge hubs.
- Youth engagement is critical. Encouraging rural youth to view agriculture as a modern and rewarding profession can inject innovation and dynamism into the sector. Equally important is empowering women in agriculture by ensuring access to land rights, training, and financial services, thereby making agriculture more inclusive and equitable.

Public-private partnerships (PPPs) are indispensable to the future of Indian agriculture

6. Financial Inclusion and Credit Accessibility

- Ensuring that farmers have access to formal credit and insurance is key to building a resilient farming economy. Expanding institutional credit and reducing bureaucratic hurdles can help reduce dependence on informal lenders.
- Developing risk management tools, including crop insurance schemes and weather-indexed insurance, can protect farmers from climate and price shocks. Additionally, supporting agri-entrepreneurs and rural startups with seed funding, incubation, and market access can create localized value chains and employment.

The Agro Chem Federation of India (ACFI) strongly believes that public-private partnerships (PPPs) are indispensable to the future of Indian agriculture. Collaborations in infrastructure development, research and development (R&D), and international market access can bring in capital, efficiency, and innovation.

Joint ventures in seed development, farm machinery, biotechnology, and market logistics can fast-track modernization and create an enabling environment for long-term sectoral growth. With the right blend of technology, policy reform, financial inclusion, and institutional support, India can unlock the vast potential of its agricultural sector. Agriculture must not be seen only as a means of livelihood, but as a catalyst for inclusive economic growth, employment generation, and rural transformation. By accelerating Indian agriculture through integrated, farmer-centric, and sustainable pathways, the country can fulfill its dream of doubling farmer incomes, revitalizing rural areas, and emerging as a global agricultural powerhouse. Ultimately, prosperous farmers are not just vital for agriculture—they are essential to building a resilient, equitable, and thriving India.

BIO-AGRI TECHNOLOGY

Paving the Path to an Evergreen Revolution

India stands at the threshold of a transformative phase in agriculture—one that must harmonize productivity with environmental stewardship. With climate volatility, declining soil health, and resistance development among pests to different available modes of action, traditional models of agricultural intensification are no longer viable. The answer lies in a new paradigm: a sustainable bio-agriculture model, powered by cutting-edge bio-stimulant and biocontrol technologies.

This movement is central to realizing the vision of an Evergreen Revolution, one that is not only sustainable in output but also regenerative in approach. At the heart of this transition are science-led biological solutions that support productivity and plant health while maintaining ecological balance.

Biologicals: Nature Driven Tools for Resilient Agriculture

Biological solutions encompass bio-control agents, bio-stimulants, and bio-fertilizers—innovative inputs derived from naturally occurring organisms or substances. Bio-control agents target pests and diseases with minimal environmental impact , while bio-stimulants enhance plant metabolism, root growth, and resistance to abiotic stress like drought or salinity. The global Agricultural biologicals' market comprising of bio-control, bio-nutrition and bio-stimulants, assessed at US$ 8 billion in 2021, is expected to grow to US$ 19 billion in 2030, growing at a CAGR of 10.5% (Source: The Context Network report), driven largely by the growing demand for sustainable farming, and technological advances in bio-control and bio-stimulants[2].

These solutions are particularly suited for India, where over 85% of farmers are smallholders managing diverse cropping systems. Biologicals offer a path to low-residue, soil-friendly, and climate-smart farming that improves yields without compromising the environment or consumer safety.

Technology Transforming Bio-Ag

A wave of innovation is rapidly enhancing the effectiveness, reliability, and scalability of biologicals:

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Mr. Raju Kapoor is Director – Corporate Affairs, FMC India Pvt. Limited

- **Advanced Strain Discovery:** AI-powered microbial screening is enabling the discovery of potent strains tailored to specific geographies and crops.
- **Next-Gen Formulations:** Encapsulation and nano-carriers are extending product shelf life and stability, improving field performance across varied conditions.
- **Precision Delivery:** Drones and sensor-based sprayers now allow precise application, reducing dosage and optimizing field coverage.
- **Microbiome Engineering:** Insights into soil-plant-microbe interactions are allowing the development of customized consortia to support regenerative practices.
- **Digital Integration:** Farmers are being empowered through mobile apps, satellite imagery, and advisory platforms to make informed decisions on timing, dosage, and application methods for biologicals.

FMC's Role: Leading with Innovation and Integrity

As a global agricultural sciences company, FMC is committed to advancing sustainable agriculture through science-based, high-performance biological solutions. Our dedicated Plant Health platform integrates R&D, partnerships, and field validation to bring world-class innovations to farmers.

FMC delivers an integrated approach to sustainable crop protection, pairing biological solutions with synthetics to enhance farmers' yields. This approach helps boost productivity while supporting sustainable farming practices that meet increased regulatory and consumer expectations.

In India, FMC has launched differentiated bio-stimulants, which have been shown to improve soil health and productivity of crops. Soil health is a critical issue in India as the quality of the soil has been in decline, due to improper agricultural practices such as the injudicious use of fertilizers.

As FMC brings newer technologies to farmers, it also dedicates itself to ensuring they have the tools and resources to use them effectively. FMC is resourced to provide capacity-building, training programs, and demonstration initiatives that help farmers and extension workers understand the value of integrated biological solutions.

India's agricultural future depends not only on how much we produce, but how we produce it. Biologicals—if supported by science, policy, and awareness—can deliver productivity with resilience

Unlocking Global Innovation through Regulatory Reforms

To realize the full potential of bio-agriculture, India has a significant opportunity to evolve its regulatory ecosystem to be more enabling, science-based, and globally aligned. This will facilitate faster access to cutting-edge, sustainable technologies for Indian farmers.

We will need to address the following:

- Time-bound and risk-proportionate pathways for evaluating low-risk biologicals,
- Recognition of global data and making provisions / guidelines for allowing import of microbials based formulations and combinations, thereof.
- A central nodal authority for biologicals to coordinate between agencies under different regulatory frameworks (FCO, Insecticides Act, etc.), and
- Fast-tracking of biologicals in the regulatory pipeline, especially those with proven environmental and residue safety profiles.

By enabling the entry of globally validated products, India can benefit from decades of international research, reduce duplication of trials, and provide its farmers with credible, consistent, and effective solutions.

This would also help raise industry credibility, foster investment in Indian bio-R&D, and make the country a hub for innovation and export in the biologicals sector.

Towards a Sustainable Bio-Agri Model

To accelerate the shift toward sustainable agriculture driven by biologicals, the following strategic actions are critical:

1. Strengthen Research Ecosystems: Public and private investment must be directed towards cutting-edge biological research, incubation of start-ups, and translational science.
2. Create a Harmonized Regulatory Framework: India should adopt a progressive regulatory policy for biologicals, aligned with global benchmarks and responsive to industry innovation cycles.
3. Promote Farmer Awareness and Demonstration: Through phyigital extension services, field trials, and knowledge-sharing platforms, awareness about biologicals must be scaled rapidly.
4. Encourage Public-Private Collaboration: Partnerships across academia, government, and industry are essential to ensure that scientific advances are translated into accessible, scalable solutions.
5. Support Biologicals through Policy and Incentives: Include biologicals in state procurement, natural farming schemes, and sustainable agriculture missions, and offer incentives for bio-based IP development.

A New Green Frontier

Companies like FMC, with deep research capabilities and global exposure, have the technologies to bring the best of bio-innovation to Indian farms. A forward-looking regulatory environment and ecosystem support are essential to unlock this potential at scale. The Evergreen Revolution must be rooted in nature, powered by science, and carried forward by the collective will of industry, policymakers, and farmers.

TECH PUSH

A PARADIGM SHIFT TOWARD SUSTAINABLE FOOD SECURITY

Precision agriculture represents the cornerstone of technological transformation, utilizing satellite imagery, Geographic Information Systems (GIS), and Global Positioning Systems (GPS) to optimize field-level management regarding crop farming.

Monitoring soil health with advanced sensors provides ample opportunity for monitoring pH status, nutrient content, moisture detection, and organic matter composition in real-time, this allows for site-specific nutrient management and reducing fertilizer input in the field by 25-30%, while not compromising or even potentially increasing crop yield. Drones will help farmers detect pest infestations, nutrient deficiencies, and plant diseases through multispectral imaging quickly enough to avoid yield loss.

Protected cultivation: controlled environment revolution

Protected cultivation systems, such as polyhouses, shade nets, and climate-controlled greenhouses, are innovative methods of agricultural production. The systems provide ideal conditions for growing irrespective of fluctuations in external weather parameters and allow the crops to be produced even during the off-season with sufficiently higher yield levels and good quality of the produce. Innovative climate control mechanisms that provide automated ventilation, heating, cooling, and humidity management to enhance growing conditions, will increase value added and allow for precision growing. This observation is augmented when climate control mechanisms using automated systems with Internet of Things (IoT) sensors, enable real time monitoring of growing conditions and automated responses to variations in temperature, humidity, and light. when protected cultivation technology integrated

High-yield Tomato production under protected cultivation system using vertical trellising and mulch in a polyhouse environment

PUSA Greenhouse Vertical Farming System for smart urban farming

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with solar-powered systems, it becomes possible to eliminate major operational costs related to environmental control, enabling small and medium farmers to achieve greater economic viability, with potential cost reductions of up to 50–60%.

Smart Urban Farming

Smart urban farming is tackling food security issues in rapidly growing cities by using innovative solutions like vertical farming towers, rooftop hydroponic gardens, and automated growing facilities. These setups make the most of limited urban space by incorporating Internet of Things (IoT) sensors, artificial intelligence, and climate-controlled environments to boost productivity. With advanced LED lighting systems, they provide energy-efficient lighting that supports year-round production. Cities like Bengaluru, Pune, and Delhi etc, are home to smart urban farms that showcase impressive productivity, cutting down on transportation costs and delivering fresh, pesticide-free produce to consumer's just hours after harvest. These automated systems not only require less manual labor but also create significant job opportunities in urban areas, playing a vital role in enhancing sustainable food security and self-sufficiency in metropolitan regions.

Agriculture 4.0: Application of digital intelligence

Using the fourth agricultural revolution, trending agriculture is utilizing artificial intelligence, machine learning and big data in agriculture, integrating these digital technology components to make smart farming systems. Advancements in artificial intelligence imagery in monitoring crop situations are compiled using computer vision algorithms. Crop monitoring can provide insights into states of plant health, providing information to predict harvest timing, improving knowledge of resource use efficiency and effectiveness associated with inputs. Machine learning models are built with massive data sets from agriculture including weather patterns, soil conditions, and previous historical yield data providing information to assist in usage and utility around decision making with various growing models and agronomy.

Smart irrigation systems with soil moisture sensors and automated system control options with forecasting system use can enable 30% - 40% reductions in water consumption while ensuring crops can receive the appropriate amount of water to maximize plant hydration. Smart watering systems for crop requirements can ensure plants are hydrated without being over watered, which can cause stress to the plant and reduce productivity from a nutrient perspective.

Robotics for seed planting, weeding and harvesting can address identified labor shortages, from work efficiencies, and improve efficiencies from work processes, and work assignments. Autonomous tractors with GPS systems designed to guide operational applications in the field can provide productivity improvements; as examples, GPS guided tractors can be constructed to ensure a consistent working quality and reduce fuel consumption by an estimated 15% - 20%.

Table 1: Comparative analysis of Protected vs. Open field cultivation

Crop	Protected yield	Open field yield	Water savings (%)	Quality premium (%)	ROI timeline (months)
Tomato	250 t/ha	45 t/ha	45	25-30	18-24
Cucumber	190 t/ha	40 t/ha	50	35-40	15-20
Capsicum	85 t/ha	20 t/ha	40	45-50	20-26
Lettuce	25 t/ha	8 t/ha	55	60-70	12-16

FPOs can help by enabling collective technology adoption, which eases the financial burden on individual farmers while enhancing their bargaining power.

Biotechnology and Genetic Innovations

Modern biotechnology is revolutionizing agriculture with tools like marker-assisted breeding, genetic modification, and CRISPR gene editing, all of which are speeding up crop improvement.

By creating disease-resistant varieties through these innovative methods, we can slash pesticide use by 40-60% while still achieving impressive yields, even under stress.

Biofertilizers and biopesticides are fantastic sustainable options that replace chemical inputs, enhancing soil health and reducing our environmental impact. Microbial consortiums help make nutrients more accessible and boost plant immunity, cutting down the need for synthetic fertilizers by 20-30%.

Economic and environmental sustainability

Embracing technology can lead to impressive economic gains by boosting productivity, cutting costs, and allowing for premium pricing on high-quality products. Integrated technology solutions typically show a return on investment within 2 to 4 years, with net present values that can surpass initial investments by 200 to 300%.

On the environmental side, sustainability is achieved by using fewer chemicals, optimizing resources, and reducing the ecological footprint. Improved soil management practices also help with carbon sequestration, playing a vital role in combating climate change.

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