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KrishiJagruthi KhetiPuraskar

EXCLUSIVE INTERVIEW

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Director General,

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KhetiValah
Global Agri Magazine

Volume : 03 | Issue : 01

Founder's Note

Dear Readers,

At the outset, I convey my sincere thanks for your continuous support and encouragement to KhetiValah Magazine. With your blessings, we are now upgrading our publication into KhetiValah Global Agri E-Magazine, with a broader vision and global outlook.

This edition brings a curated collection of articles from esteemed authors and experts representing the diverse agricultural ecosystem. As this is our first global edition, we have given preference to the experienced authors of knowledge-driven content. From the next issue onwards, we plan to introduce dedicated sections such as Millets Zone, AgriStudent Corner, AgriQueen (Women in Agriculture).

I am immensely thankful to all our authors for their valuable contributions. I extend special gratitude to the Honourable Director General of CIRDAP, Dr. P. Chandrasekara, for sharing his vision, experience, and roadmap through an exclusive nterview. His mentorship and support strengthen our mission.

On the KhetiValah mission front, we are progressing well. The establishment work of two KhetiKendra centres has begun, and they will be ready for inauguration in the coming months. Our KhetiValah Dialogue Global Series has successfully reached its 50th session, and www.kvdialogue.com is now live, and www.khetivalah.com has been updated with all 15 KhetiValah Mission initiatives.

We sincerely thank Shri C. N. Shiva Prakash, MD, KAPPEC, Karnataka, for the opportunity to conduct the KrishiJagruthi & KhetiPuraskar event at Town Hall, Bengaluru, celebrating agri-entrepreneurship and honoring impactful contributors from Karnataka, in the presence of the Honourable Agriculture Minister Shri N. Chaluvarayaswamy, Chief Guest of the event.

We were honoured to have met the Honourable Chief Minister of Meghalaya, Shri Conrad K. Sangma, and discussed collaborative opportunities for a Centre of Excellence in honey farming—from awareness and training to entrepreneurship and api-tourism. We look forward to creating a meaningful impact in Meghalaya under his visionary leadership.

Another notable milestone in our journey is our entry into the Northeast through KhetiValah Dialogue, Assamese version—KhetiSanglap, which is now running successfully. My sincere thanks to the Assamese team and contributors.

Join us in building a "Wealthy and Healthier Globe."
Jai Bharat!

Regards,
Lakshman K
Founder & CEO of KhetiValah

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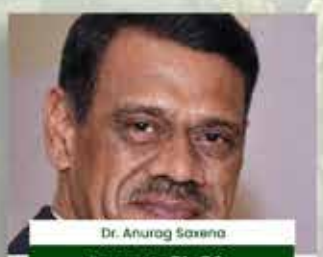

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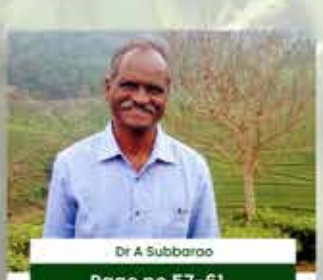

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KhetiValah Founder Meets Meghalaya Honorable CM Shri Conrad K. Sangma; COE for Honey Project Presented in North Garo Hills, Meghalaya

Shillong, Meghalaya: In a meaningful step towards strengthening rural livelihoods and advancing sustainable agriculture in Meghalaya, the Founder of KhetiValah had the honour of meeting the Honourable **Chief Minister of Meghalaya, Mr. Conrad Kongkal Sangma.** During this interaction, KhetiValah presented its key initiatives and shared a detailed concept note and presentation on the proposed Centre of Excellence (CoE) for the Honey Project in North Garo Hills.

The meeting reflected a shared vision of empowering rural communities through agriculture-led development, with a special focus on creating scalable and sustainable livelihood opportunities in the state.

Centre of Excellence for Honey: A Vision for Rural Prosperity

The proposed Honey COE in North Garo Hills is designed as a high-impact rural development initiative aimed at building a strong ecosystem around beekeeping and honey value chains in Meghalaya. The project envisions Meghalaya emerging as a model state in the apiculture sector by connecting awareness to impact—from training and skill-building to enterprise development and market linkages.

Key focus areas of the project include:

- Strengthening Meghalaya's rural livelihoods through income generation and community-based models
- Promoting women-led entrepreneurship, enabling women to become micro-entrepreneurs and leaders in the honey value chain
- Supporting sustainable agriculture through pollination, improving crop productivity and ecological balance

- Positioning Meghalaya as an Apitourism hub, showcasing honey farming, biodiversity, and rural experience to visitors

The initiative is planned not only as a production-driven programme but as a comprehensive development model that integrates training, entrepreneurship, branding, and long-term sustainability.

Exploring Wider Opportunities in Agriculture

Besides the honey production initiative, the meeting also deliberated on exploring other opportunities in agriculture where KhetiValah can contribute through innovation, knowledgesharing, and grassroots engagement.

The interaction provided valuable insights into the Honourable Chief Minister's vision for Meghalaya's agricultural growth, rural development, and the future of farmer-centric programmes.

KhetiValah team members were inspired by the Chief Minister's forward-looking approach and deep commitment to the state development. The leadership and clarity of vision showcased during the meeting reaffirmed the importance of strong governance in creating lasting rural transformation.

KhetiValah Dialogues: Meghalaya Edition "KhetiKobar" from February 2026

As the first step towards an intense involvement in the state's agricultural development, KhetiValah is planning to launch KhetiValah Dialogues – Meghalaya Version, titled "KhetiKobar", in February 2026.

KhetiKobar
KhetiValah: Whispering Fields of Meghalaya

This platform will serve as a collaborative dialogue series to connect farmers, rural government stakeholders, entrepreneurs, experts, and development partners. Its objective is to identify and create meaningful opportunities where KhetiValah can drive impact aligned with the Meghalaya Government's vision for uplifting agriculture and rural livelihoods.

Gratitude and Acknowledgements

KhetiValah expresses its sincere gratitude to the honourable **Chief Minister, Mr. Conrad Kongkal Sangma** for graciously sparing the time from his busy schedule to meet and interact with its team.

KhetiValah also extends heartfelt thanks to honourable **MLA, Mr. Rupert Momin** (Kharkutta, Meghalaya) for arranging and supporting this valuable meeting. Special appreciation is also conveyed to **Mr. Babu Bhuyan,** whose invitation and efforts played a key role in making this visit possible and successful.

This engagement marks an important milestone for KhetiValah in Meghalaya, strengthening collaboration and advancing sustainable rural development initiatives.

Next-Generation Digital Transformation in Agriculture: What's Really Cooking from Lab to Field?

Dr. Shaik N. Meera
Director, ICAR–ATARI
Hyderabad

Dr. Shaik N. Meera
Director ICAR–ATARI
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Dr. Shaik N. Meera is an Indian agricultural scientist and digital agriculture specialist currently serving as Director of ICAR – Agricultural Technology Application Research Institute (ATARI), Zone-X, Hyderabad under the Indian Council of Agricultural Research (ICAR). He has over two decades of professional experience in agricultural extension, digital technologies, and impact-focused innovation in agri-food systems. Dr. Meera's work spans digital agriculture, ICT-enabled extension, value-chain development, and frontline technology dissemination. He has led numerous large-scale projects in India and internationally, including a stint as Senior Technical Expert (Digital Agriculture and Extension Systems) with the International Fund for Agricultural Development (IFAD) where he helped design digital strategies across rural value chains in multiple regions

Abstract

Agriculture stands at a decisive historical inflection point. While scientific advances in genetics, agronomy, and mechanization have delivered impressive gains over past decades, the sector today confronts a convergence of challenges—climate volatility, resource degradation, labour scarcity, fragmented markets, and widening productivity gaps across regions and farm sizes. Digital transformation has emerged as the most powerful integrator capable of navigating this complexity. Yet, despite unprecedented technological maturity, outcomes on the ground remain uneven.

Drawing on global evidence, emerging technologies, and more than two decades of field-level engagement across research, extension, and policy systems, this article critically examines what constitutes the next generation of digital transformation in agriculture. It distinguishes what is genuinely transformative from what is merely fashionable and argues that the future of agricultural digitalization will be determined less by tools themselves and more by governance, institutional design, and delivery capability—by how decisively innovation moves from laboratories, pilots, and dashboards to farmers' fields and livelihoods.

1. Agriculture at a Systemic Turning Point

Agriculture has always evolved through technological leaps—domestication, irrigation, mechanization, chemical inputs, and improved genetics. Each phase addressed a dominant constraint of its time. Today, however, agriculture is no longer constrained by a single bottleneck. It is constrained by systemic complexity.

The modern agrifood system must simultaneously feed a growing population, adapt to climate change, reduce environmental footprints, ensure farmer profitability, and meet rising consumer expectations for quality, traceability, and sustainability. The Food and Agriculture Organization estimates that global food production must increase by nearly 60 percent by 2050, even as climate variability intensifies and natural resources become scarcer.

In this context, digital transformation is often described as the "fourth agricultural revolution." Yet unlike earlier revolutions, digital agriculture is not defined by a single breakthrough technology. It is defined by integration—the integration of data, decisions, actors, and scales.

The central question today is no longer whether digital tools exist. They do. The deeper question is whether these tools are being assembled into functioning systems that measurably reduce farmer risk, increase resilience, and improve productivity at scale.

2. A Personal Lens: From Early SMS to AI Dashboards

My own engagement with digital agriculture did not begin with artificial intelligence, satellites, or real-time dashboards. It began in the early 2000s, when sending an SMS advisory to a farmer felt revolutionary. Connectivity itself was the innovation. Many of us believed—perhaps somewhat naively—that faster information flow would automatically translate into better farming outcomes.

Agri Facts

- Gypsum is widely used to reclaim sodic soils by improving infiltration and reducing sodium effects.
- Soil salinity is measured as EC (dS/m); sensitive crops show yield loss even at moderate EC levels

Two decades later, the tools are extraordinary. We speak confidently about AI-driven advisories, digital twins, precision farming, climate models, and predictive analytics. Yet when I walk through villages, sit with farmers, or review extension outcomes, a sobering question keeps returning: if our digital tools are so powerful, why does farmer risk still feel so familiar?

This question has shaped much of my recent reflection and writing. The answer, I believe, lies not in technology gaps but in how we have chosen to deploy technology.

3. From Digitization to True Digital Transformation

A persistent conceptual error in agricultural discourse is the conflation of digitization with transformation. Digitization refers to converting analog processes into digital formats—online records, mobile apps, dashboards. Digital transformation, by contrast, implies a fundamental redesign of how decisions are made, how value is created, and how accountability is enforced.

Many agricultural systems today are digitized but not transformed. Data is collected extensively through satellites, sensors, surveys, and apps, yet decisions often remain fragmented, delayed, or disconnected from field realities. Farmers receive advisories, but these are frequently generic, untimely, or economically unviable.

True transformation occurs only when digital systems alter the structure of decision-making—shifting agriculture from reactive, intuition-based management to anticipatory, evidence-driven operations. This shift requires not just technology, but institutional change.

4. The Technological Convergence Behind Next-Generation Agriculture

The next generation of digital agriculture is not being driven by a single invention, but by the convergence of several mature technologies.

At the foundation lies the Internet of Things, which has quietly transformed farms into continuous data-producing environments. Soil moisture sensors, micro-weather stations, livestock trackers, and crop health monitors generate real-time signals that reveal spatial and temporal variability previously invisible to farmers and extension systems.

Artificial intelligence and machine learning sit atop this data layer, converting raw signals into insights. Predictive models now forecast pest outbreaks, nutrient stress, irrigation needs, and yield outcomes with increasing accuracy. Peer-reviewed studies consistently show that AI-driven decision systems can reduce input use while maintaining or increasing yields, particularly under climatic uncertainty.

Remote sensing—through satellites and drones—extends this intelligence across landscapes and regions. Vegetation indices, evapotranspiration estimates, and canopy temperature maps enable early stress detection long before damage becomes visible.

At the operational end, robotics and precision machinery translate digital insights into physical action—spot spraying instead of blanket application, selective harvesting instead of mass removal, and reduced soil compaction through controlled traffic farming.

Meanwhile, blockchain and distributed ledger technologies are reshaping post-harvest systems by enabling traceability, certification, and transparent transactions. Increasingly, these systems underpin carbon accounting, sustainability claims, and emerging climate finance mechanisms.

5. Evidence from the Field: What Has Actually Changed?

The credibility of digital agriculture rests on outcomes, not promise. Encouragingly, evidence is accumulating across regions.

Large-scale studies in Europe and North America show that precision nutrient management reduces nitrogen fertilizer use by 10–30 percent without yield penalties, with parallel reductions in greenhouse gas emissions. Sensor-based irrigation systems routinely deliver water savings of 20–40 percent in water-stressed regions.

In Asia and Africa, mobile-based advisory platforms combined with localized weather and crop models have improved farmer decision-making, particularly in pest and disease management. A 2023 meta-analysis in Agricultural Systems reported yield gains of 8–15 percent among smallholders using integrated digital advisory services, with stronger income effects when advisories were linked to input and market access.

One insight emerges consistently from these experiences: impact is highest when digital tools are embedded within institutional delivery systems—extension services, cooperatives, FPOs, or contract farming arrangements. Stand-alone apps rarely deliver sustained value.

6. Why the Lab-to-Field Gap Persists

Despite technological maturity, the translation of digital innovation from laboratories to farmers' fields remains uneven. This gap is not primarily technological; it is systemic.

Many solutions are designed from a tool-first perspective—asking what technology can do, rather than what decision needs to improve. Farmers do not need more information; they need fewer, better decisions.

Pilots dominate innovation culture. Pilots are safe, fundable, and reportable. But agriculture does not change through pilots. It changes through patient, often unglamorous institutionalization.

Digital initiatives also frequently bypass extension systems instead of strengthening them, creating parallel advisory channels that compete for farmer attention but lack continuity and trust. Accountability remains diffuse;when a digital recommendation fails, responsibility dissolves into the system.

Until these structural issues are addressed, digital agriculture will remain impressive on screens and modest in fields

7. The Smallholder Imperative

Globally, more than 80 percent of farms are small or marginal. These farmers face the highest exposure to climate and market risks. Any serious digital transformation must therefore be inclusive by design.

Affordability, local language interfaces, offline functionality, and integration with trusted institutions are not optional features; they are foundational requirements. Experiences across India, Africa, and Southeast Asia show that digital tools gain traction when embedded within cooperatives, FPOs, or public extension networks—where technology amplifies human relationships rather than replaces them.

India Focus: From Digital Pilots to Digital Public Infrastructure

India stands at a unique moment in its agricultural digital journey. With over 140 million farm holdings, most of them small and marginal, the country cannot rely on fragmented apps or isolated pilots. Scale, diversity, and

climate risk demand system-level digital solutions.

What distinguishes India globally is its emerging Digital Public Infrastructure (DPI) approach to agriculture—bringing together land records, farmer identity, crop data, weather intelligence, and market platforms on shared digital rails. Initiatives such as the Digital Agriculture Mission, AgriStack, e-NAM, PMFBY analytics platforms, and integrated state-level systems signal a shift from project-based digitization to platform-based governance.

The decisive opportunity now lies in connecting these digital rails to last-mile institutions—Krishi Vigyan Kendras, extension departments, FPOs, cooperatives, and agri-entrepreneurs—so that data translates into timely, trusted decisions at the farm gate. For India, success will not be measured by the number of dashboards created, but by whether farmers experience lower risk, better prices, and more predictable incomes.

8. Institutional Transformation: The Missing Layer

Perhaps the most under-discussed dimension of digital agriculture is the transformation required within institutions themselves. Digital systems redistribute power. They expose inefficiencies, make performance visible, and demand accountability. Unsurprisingly, they often face quiet resistance—not because people oppose technology, but because technology challenges comfort.

In one of my earlier reflections, I posed a simple diagnostic question: if a digital system makes a wrong recommendation tomorrow, who is accountable? When no one can answer this, digital transformation has not occurred.

Leadership must therefore focus on redesigning organizations—not just adopting tools. Roles must be redefined, incentives aligned with outcomes, data allowed to flow across silos, and impact rewarded over activity.

9. Emerging Frontiers: What Is Truly Next-Generation

What is genuinely new in the next phase of digital agriculture is not sharper images or more complex algorithms, but tighter feedback loops.

Edge computing will bring intelligence closer to the field. Digital twins will allow farmers and policymakers to simulate decisions before taking risks. Bio-sensing will detect stress before symptoms appear. Climate analytics will increasingly guide not only advisories, but finance and insurance.

Equally important is a philosophical shift—from technology as a product to digital systems as public goods. The future belongs to interoperable platforms, shared standards, and governance frameworks that prioritize farmer value over vendor lock-in.

10. Rethinking Success: From Dashboards to Outcomes

Over the years, I have grown cautious of impressive dashboards. They often display activity density rather than outcome integrity. Numbers move. Slides look good. But farmers' risk profiles remain unchanged.

The real test of digital transformation is simple: did decision-making improve, did risk reduce, did incomes stabilize, and did trust increase? If these answers remain unclear, the system is not yet working.

Agri Facts

- Zinc deficiency is one of the most common micronutrient issues in intensively farmed soils.

Digital tools must therefore be judged not by adoption metrics, but by lived outcomes

Digital Direction for Khetivalah: Where the Conversation Must Go Next

As India's agricultural transformation accelerates, the digital discourse must move beyond celebrating tools to questioning outcomes, governance, and farmer value.

The next phase of digital agriculture must shift from technology-centric narratives to farmer-centric system design, from isolated innovations to interoperable platforms, and from pilot success stories to institutional adoption at scale. Extension systems, universities, and producer organizations must become active digital actors—not passive recipients.

Khetivalah can play a vital role by curating evidence, field experiences, and honest assessments of what works and what does not—helping shape a digital agriculture narrative that is grounded, accountable, and deeply connected to farmers' realities.

Conclusion: What's Cooking Is a Choice

After two decades, my conviction is clear. Digital transformation in agriculture is not inevitable. It is a choice.

A choice to move beyond pilots.

A choice to redesign institutions.

A choice to treat farmers not as users, but as decision-makers.

A choice to govern integration rather than celebrate fragmentation.

What is truly cooking globally is a growing realization that agriculture must be managed as a living, data-enabled system—one that learns, adapts, and remains accountable to those who farm the land.

The next decade will not remember who built the most elegant digital product. It will remember who had the courage to make digital agriculture work where it matters most—on the ground.

Agri Facts

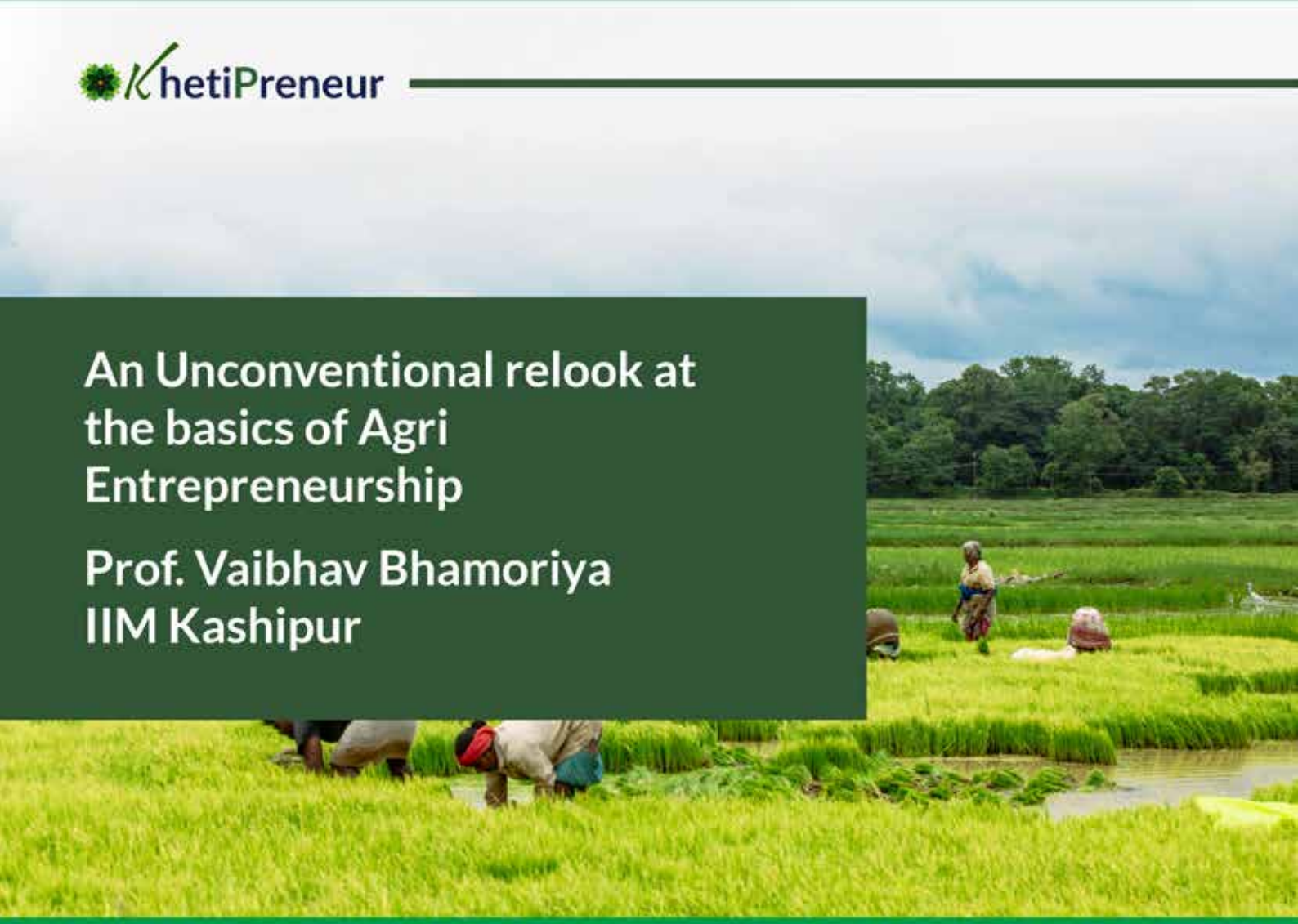
- Nitrogen losses happen through volatilization, leaching, and denitrification—not all applied N reaches the crop.
- Split application of nitrogen improves efficiency compared to single heavy basal application in many crops.

Author's Note

This article draws on more than two decades of engagement with agricultural research, extension, digital innovation, and policy systems, as well as reflections shared through professional platforms and field interactions. The views expressed are personal and intended to contribute constructively to the evolving dialogue on the future of agriculture.

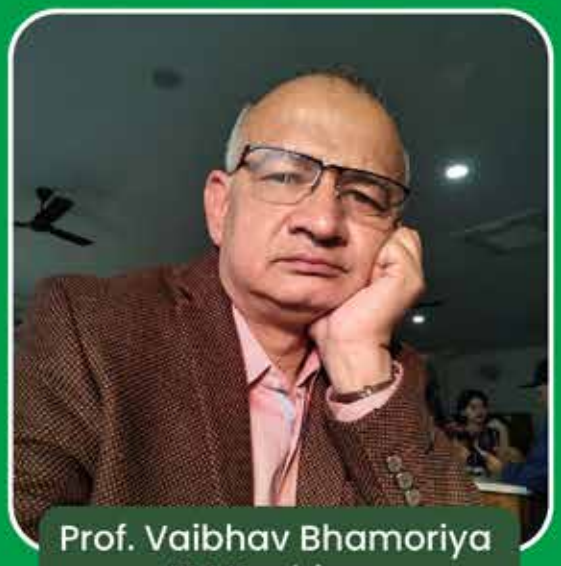
Agri Facts

- Phosphorus availability is highest in a moderate pH range; extreme acidic or alkaline soils reduce P uptake.
- Band placement of phosphorus often improves uptake more than broadcasting in many soils.
- Too much phosphorus can induce zinc deficiency, especially in cereals and maize systems.



An Unconventional relook at the basics of Agri Entrepreneurship

Prof. Vaibhav Bhamoriya
IIM Kashipur



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Prof. Bhamoriya's academic and professional interests lie at the intersection of agriculture, markets, institutions, and policy, with a strong emphasis on how technology and organizational innovation are reshaping agribusiness ecosystems. He has been actively involved in teaching, research, and capacity building related to entrepreneurship in agriculture and allied sectors.His work reflects a deep engagement with ground realities of rural India, combining empirical insights with strategic and managerial perspectives. Prof. Bhamoriya has contributed to curriculum development, executive education, and policy discussions aimed at strengthening agri-entrepreneurship and sustainable agribusiness models. His scholarship and teaching continue to influence students, practitioners, and policymakers working towards resilient and market-orientated agricultural .

Introduction

I first became aware of entrepreneurship in the field of agribusiness when I got to know about AMUL. Today the definition of entrepreneurship is different from those times. While a cooperative effort or a producers' company may be entrepreneurial, few consider it as entrepreneurship. This makes me take an unconventional re-look

at agri-entrepreneurship or agpreneurship. Agpreneurship is neither new as a career choice in the real world especially in rural contexts nor as a domain in research literature. However what agpreneurship means today is transforming and is probably set to transform at a very fast rate. Let's deconstruct this into small parts and connect the dots.

Agribusiness at a Crossroads: Technology, Platforms, and the Crisis of Definition

Agriculture is today not only a necessity for food security but also for nutritional security of nations and to fulfill the needs of hedonistic socialization as well as social needs of humans, societies and civilizations. Agribusiness is the domain that concerns itself with the production, trade and consumption of agricultural commodities and products, broadly speaking. However, we are increasingly experiencing and poised to see the explosion of agribusiness composed of services. Agriculture has seen a rapid uptake of technologies transforming it into a knowledge-based precision-oriented activity from a physical effort based general risk-averse activity. We have in the past two decades seen the rise of consumer faced monopolies where agribusiness is a platform for rapid growth, expansion and diversification of business. We also witnessed the increased push of the government towards resilient agriculture for the future and active promotion of ZBNF, sustainable agriculture, collective agricul-

ture, focus on ag-insurance and income-insurance for the farmers amongst traditional productivity and distributive income targets. Having a unified definition of agpreneurship is therefore challenging and daunting. This translates into challenges towards focusing ag-policy and government support on ground as well

Why Conventional Entrepreneurship Logic Is Necessary—but Insufficient—for Agpreneurship

To start with we may assume agrpreneurship to be a special form of entrepreneurship more similar to entrepreneurship in any other domain. The need for identification of an opportunity and to take risk is a must but the ability to structure a business and find a market is the cornerstone to success. Those with skills of either piling up or padding up valuations get the support of less aware investors whereas those with execution skil-sets deliver value to the investors and continue to grow. A good idea backed by a hard-working team and ability to reformat the venture to enlist the support of experts

incubator selectors, government support mechanisms and finally corporate vision are the stand out. This may be a limited general recipe for a successful enterprise and hence desirable for an entrepreneur but this may often not be enough for an agpreneur. Conventional agpreneurs in the past required excellent execution skills that were based on an ability to stay within the traditional boundaries of agri-markets and institutions. More importantly execution that reduced cost while creating a new order without a direct confrontation with the original or status-quo was often the smart way to long-term survival. It was considered that an entrepreneur and their enterprise required to survive for 7 years to ensure that they had seen all cycles of agribusiness and be confident that they could survive and look towards thriving in the market. What was a foundation to all this was the need to claim to serve the millions of farmers even while making a profit based on dealing with the top 2-5% of the farmers or 10% of the commodity in a region.

When Agriculture Became Strategic Rather Than Subsistence

In 2011 when I joined IIMA as a faculty at the Centre for Management in Agriculture I wanted to kickstart the culture of agpreneurship and the easiest way was launching an elective course on Agri-Entrerpreneurship. My course content was also centered on the same. However in a decade and a half almost everything about Indian markets and rural areas has changed. The average Indian rural household stopped reports a less than 50% dependence on agribusiness for income for more than a decade now. It is increasingly difficult to find a household which has no source of income apart from farming. The rural institutions are no more constituted by members who are always focused on farming or agri-commodites alone. The scenario has changed , the strategic nature of agriculture and agribusiness have never been so clea

in commercial terms before in markets. For rural businesses the volumes for deriving cost advantages are brought in by agribusiness, as much as the salience of policy makers and implementers too but now probably without the burden of having to provide a bulk of the income to the so called poor farmers. More efficient ways of working and governing had to be devised. Organizational and institutional structure and governance changed over the last decade and more. Efficiency still has a virtue but technology enabled lower cost of execution has meant more competition than ever before pushing prices down and the focus on effectiveness for margins and profits. This is where the agpreneur of 2026 is different from that of 2011 when I started trying teaching agpreneurship.

Agri Facts

- Shade nets reduce heat load but too much shading reduces yield due to low photosynthesis.
- Hydroponics performance depends heavily on nutrient solution pH and EC, not just adding nutrients.

From Farms to Platforms: The Emergence of the 2026 Agpreneur

The agrpreneur of 2026 can build a hyper localized business but use technology and new age hustle-like management methods to try out new things. Only now they don't have to be apologetic about trying new things. They are building platforms to create agglomerations of users of products and services and even competitors are collaborating for keeping markets and serving customers for better satisfaction (terminal value) and more profits as an instrumental value. The successful agpreneur is rooted today in the ground realities to the extent never before, and is keying-in into a new ecosystem seeking support of knowledge-based support and service providers. The successful entrepreneur is able to structure medium term opportunities into a platform creation that allows them to create and capture value constantly making profit cycles shorter and agribusiness more sophisticated, data-driven, analytical and yet ever more behavioral. The agpreneur in 2026 is faced with consumers in markets who are exhibiting behavioral change like never before and are more informed too. This means to be successful there is no alternative to creating value and trying to capture it in a hyper competitive space. Today it also means that the agpreneur is trying to unlock opportunities for behavioral pricing by unlocking new consumption models that allow value capture and a enhanced experience of agri commodities, products and services. The agpreneur today also is building supply chains which are non-conventional and are more diverse to hedge fraility with all round income against traditional seasonal incomes. The agpreneur today is trying to change farming to ensure the desired quality at mass to enable customer loyalty on one hand and quality production and product at the other hand. The agpreneur is not a risk taker but one who manages risks in a collaborative manner to create a beneficial risk-return logic for most agents in the value chain. The agpreneur today has to keep an eye on the future to be nimble to keep the platform of congregated users consistent while capturing value across the value chain and especially at the customer end as incomes have continued to increase catapulting millions out of poverty to unleash the magic of consumption in markets. The agpreneur today is one who can match the production under resource squeeze with the explosion of consumption today.

Agri Facts

- EC shows total salts but cannot detect which nutrient is missing—imbalances can still occur at "correct EC."
- Root-zone oxygen is critical in hydroponics; low oxygen leads to root stress and disease.
- Cocopeat quality varies widely—high sodium or chloride can reduce seedling growth.

The dynamism of agpreneurship is only starting to make itself explicit from being implicit for decades. The future holds even more promise of opportunities with an ever increasing mass of consumers with income streams that allow them to purchase and express their preferences for the first time before markets become mature. This volatility can be incredibly profitable and treacherous at the same time. The future holds the promise of deployment of accurate robots and other technologies that allow precision application of inputs and remedies to unlock maximizing productivity thereby eradicating the necessity of using too much land.

The future holds the promise of artificial and curated intelligence that shall allow more and more producers to identify with profitable supply chains allowing them premiums that they have never been entitled to resulting in their changing behavior as well. The future holds the burned of saving the planet through sustainable choices which seems to be the limited factor for the future along with limits of water , land, seeds and germplasm. The future also holds the promise of management that the agrpreneur shall have to focus on being amoeba – flexible and resilient to navigate through changing behavior of producers, supply chains and customers all. Agpreneurship today is therefore not about risk taking but managing risk today and for the long term future in a way to allow building platforms and capturing short term value as and when the agpreneur can create value. To sum it up the most exciting phase of agpreneurship is yet to happen but the moot question remains – at what level are we prepared or not prepared to embrace the change and master businesses.

Disclaimer:-

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KrishiJagruthi – From Awareness to Prosperity

Town Hall, Bengaluru hosts a Landmark Agri-Entrepreneurship event

Bengaluru, Karnataka | Thursday, 12th June 2025 | 9:00 AM – 2:00 PM

Town Hall, Bengaluru became the centre of rural innovation and agricultural transformation as **"KrishiJagruthi – From Awareness to Prosperity"** programme was successfully conducted on **Thursday, 12th June 2025,** from **9:00 AM to 2:00 PM.** Organised in association with **KAPPEC (A Government of Karnataka Enterprise),** the event was designed as a powerful workshop cum celebration, focused on strengthening agri-entrepreneurship, promoting rural innovation, and creating awareness about key agricultural initiatives and government schemes.

With an overwhelming response from across the state, the programme recorded participation of 1150+ attendees from all the districts of Karnataka, making it one of the most impactful gatherings for an agri-enterprise event in recent times.

A Strong Platform for Agri-Etrepreneurship & Rural Innovation

KrishiJagruthi reflected the mission of KhetiValah—to transform farmers from cultivators to innovators and agripreneurs. The event aimed at empowering rural entrepreneurs with the right knowledge, exposure to modern technology, and direct linkages to investors (Niveshaks), for creating sustainable and scalable agri-business ecosystems.

The event served as a unique platform where farmers, entrepreneurs, District Resource Persons (DRPs), bankers, government officials, and sector experts came together with a shared vision of driving rural prosperity through enterprise development.

Chief Guest & Distinguished Dignitaries

The event was graced by Shri **N. Chaluvarayaswamy, Hon'ble Agriculture Minister, Government of Karnataka,** as the **Chief Guest,** whose presence added immense value and encouragement to the agripreneurs and stakeholders present.

The organisers expressed sincere thanks to **Shri C. N. Shiva Prakash, Managing Director, KAPPEC Ltd., Bengaluru,** for giving an opportunity to conduct the KrishiJagruthi & KhetiPuraskar event at Town Hall, Bengaluru,

for celebrating agri-entrepreneurship and honouring the impactful contributors across Karnataka.

The dignitaries and guests who participated in the programme included:

Shri N. Chaluvarayaswamy, Agriculture Minister, Government of Karnataka

- **Shri N. Chaluvarayaswamy,** Hon'ble Agriculture Minister, Government of Karnataka (Chief Guest)
- **Shri C. N. Shiva Prakash,** Managing Director, KAPPEC Ltd., Bengaluru
- **Shri Mohammed Paravej Banthanal,** Director, Watershed Development
- **Sri M. Venkateshwarlu,** Vice Chancellor, Tumkur University, Tumakuru
- **Shri Prakash Chandra Dash,** General Manager, NABARD, Bengaluru
- **Shri M. Bhaskara Chakravarthy,** Convenor, SLBC, Bengaluru
- **Shri Rajendra Gopal Kulkarni,** Manav Charities, Bengaluru
- **Shri Lakshman K,** Founder & CEO, KhetiValah, Bengaluru

PMFME Scheme: Driving Rural Enterprise Growth

A key focus of the event was the PMFME (Pradhan Mantri Formalisation of Micro Food Processing Enterprises) Scheme, which is enabling rural entrepreneurs to establish and scale up the micro food processing enterprises across Karnataka.

In his address, the Hon'ble Agriculture Minister stated that the Government of Karnataka has allocated ₹206 Crores for the current financial year to promote agri-entrepreneurship through the PMFME scheme. He further explained that its beneficiaries can receive a combined subsidy of up to ₹15 Lakhs, including ₹6 Lakhs from the Central Government and ₹9 Lakhs from the State Government, for supporting the entrepreneurs with financial strength and structured assistance.

The Minister emphasised that this initiative is an appropriate solution to address unemployment and build self-reliant rural communities, with complete handholding and guidance extended

under the dynamic leadership of KAPPEC MD, Shri C. N. Shiva Prakash.

KhetiPuraskar – Celebrating Excellence in Agriculture

A major highlight of KrishiJagruthi was the KhetiPuraskar Awards, presented to the individuals and institutions who played a significant role in implementing the PMFME scheme and driving the agri-enterprise success.The awardees were felicitated by the Chief Guest and dignitaries with certificates and mementos, acknowledging their contribution and impact.

Top 3 Best Performing Banks (loans sanction and disbursement)

Canara Bank

- **Canara Bank –** Sanctioned: 2168, Disbursed: 2077

SBI

- **State Bank of India –** Sanctioned: 1206, Disbursed: 1005

- **Karnataka Vikas Grameena Bank –** Sanctioned: 869, Disbursed: 775

Top 3 Best Performing Districts

- **Mr Shivanagouda S Patil** (Belgaum) – Sanctioned: 832, Disbursed: 771
- **Mrs Seetha M. C** (Bengaluru Urban) – Sanctioned: 455, Disbursed: 408
- **Mr K. Mallikarjun (Haveri) –** Sanctioned: 450, Disbursed: 417

PMFME Top 9 DRPs(Based on Loan Sanctions & Disbursement)

- **Mr Ashwin Kumar HV** (Mandya) – 229 sanctions | 217 disbursements
- **Mr Suraj Shetty** (Udupi) – 225 applications | 213 disbursements
- **Mr Praveen Pujari** (Bagalkot) – 201 sanctions | 183 disbursements
- **Mr Sujay Bhat** (Uttar Kannada) – 188 sanctions | 179 disbursements
- **Mr Basavaraj KD** (Davanagere) – 181 sanctions | 172 disbursements
- **Mr Abhishek B** (Bengaluru Urban) – 156 sanctions | 145 disbursements
- **Mr Basappa Muddol** (Dharwad) – 149 sanctions | 130 disbursements
- **Mr Shravan Kumar P V** (Hassan) – 146 sanctions | 136 disbursements
- **Mr Premdas** (Bidar) – 145 individual + 3 Group (FPO) sanctions | 130 disbursements

PMFME - Top 9 Beneficiaries

- **Mr Kiran Kumar P G –** VINAYAKA AGRO TECH, Tumakuru
- **Mr Narayana Hegde Gadikai –** Nelasiri Farmer Producer Company Ltd., Uttar Kannada
- **Mr Mahadevaswamy. M –** Avvas Oil Mill, Mysuru
- **Mrs Shambavi Ashwathpur** – Go Nutrition, Belagavi
- **Mr Dhanraj –** Sriyansh Agro Products, Bidar
- **Mr Mahadevi Itnal** – Pure Nature, Bagalkot
- **Mr Vijaya Basavaraj Aiholli** – Vijaya Karadantu, Bagalkot
- **Mrs Shilpa Mantagani –** Gaurishankar Food Industries, Haveri
- **Mr Krupa. T –** Davanagere & Chitradurga District Regional Co-op Organic Farmers Association Fed., Davanagere

Technical Sessions: Knowledge, Market Access & Finance

The event also featured expert-led technical sessions that strengthened the practical understanding of beneficiaries and aspiring entrepreneurs. Key discussion areas included:

- Benefits of the PMFME scheme for establishing Micro Food Processing Enterprises
- Marketplace opportunities for KAPPEC's PMFME beneficiaries
- Good Manufacturing Practices (GMP) for quality production
- Branding and Packaging requirements for effective marketing (KAPPEC)
- Leveraging banking and financial assistance for enterprise establishment
- Agri Export initiatives by KAPPEC

These sessions provided the participants with actionable insights on enterprise setup, compliance, marketing, product quality, and expansion opportunities.

Gratitude to the Teams behind the Success

Shri C. N. Shiva Prakash,
Managing Director,
KAPPEC Ltd., Bengaluru,

During the programme, Shri Lakshman K, Founder & CEO, KhetiValah, expressed his heartfelt gratitude to the entire KAPPEC leadership and team for their continuous guidance and support in making KrishiJagruthi a grand success. He especially thanked Shri C. N. Shiva Prakash (MD, KAPPEC) for his encouragement and strong leadership. He acknowledged the dedicated efforts of the KAPPEC team members Mr Shiva Kumar, Mr Chandrakumar, Mr Arvind Kare, Mr Vihnesh, and Mr Naveen Kumar H R and their coordination and commitment in conducting the event seamlessly.

He also appreciated the tireless work of all District DRPs across Karnataka for their grassroots-level efforts in PMFME implementation. He extended sincere thanks to the entire KhetiValah team for their strong support in planning, mobilising participation, and ensuring smooth conduct of the event

From Awareness to Prosperity: A Strong Message for Karnataka

Sri M. Venkateshwarlu
Vice Chancellor, Tumkur University, Tumakuru

KrishiJagruthi 2025 emerged as a milestone initiative that not only promoted awareness of government schemes but also highlighted the inspiring stories of rural change makers and entrepreneurs across Karnataka. With 1150+ participants, strong institutional support, and recognition of achievers through KhetiPuraskar, the event reinforced the idea that agriculture is no longer limited to cultivation—it is evolving into a powerful area for innovation, enterprise, and prosperity. The event concluded with renewed confidence among participants, to take a giant leap in Karnataka's journey towards building a vibrant and sustainable agri-entrepreneurship ecosystem.

Development and Promotion of Agri Businesses and Producer Collectives: ni-msme the Catalyst

Dr. Shreekant Sharma
Director, SEE
National Institute for Micro, Small and MediumEnterprises (ni-msme)
Hyderabad, India

Mr. Gudela Devan Sai
Faculty Associate, SEE
National Institute for Micro, Small and Medium Enterprises (ni-msme)
Hyderabad, India

Landscape of MSME Development

Micro, Small and Medium Enterprises (MSMEs) form the backbone of most developing and emerging economies, playing a crucial role in employment generation, value creation, and inclusive growth. Within this broad MSME landscape, Agri-based enterprises and producer collectives occupy a strategic position due to their direct linkage with food security, rural livelihoods, and natural resource management. Globally, there is a growing recognition that agriculture must move beyond subsistence production and integrate enterprise thinking, value chains, and collective action to remain viable and competitive

In India and many agrarian economies, producer collectives such as Farmer Producer Organizations (FPOs), cooperatives, Self-Help Groups (SHGs), and clusters have emerged as key institutional mechanisms to aggregate small producers, improve bargaining power, enable market access, and foster entrepreneurship. However, the success of such models depends heavily on institutional support systems that can provide capacity building, enterprise orientation, policy alignment, and ecosystem linkages.

ni-msme's Impact

The National Institute for Micro, Small and Medium Enterprises (ni-msme) has played a transformative role in strengthening the MSME and Agri-entrepreneurship ecosystem through its integrated mandate of training, research, policy support, and enterprise development. With several decades of experience in entrepreneurship promotion, ni-msme has emerged as a catalytic institution that bridges agriculture with MSME frameworks, enabling the transition of traditional livelihood activities into structured, market-oriented business enterprises.

The institute's impact extends beyond programme delivery to fostering systemic change in how agriculture and allied sectors are perceived and practiced. By embedding entrepreneurial thinking, value-chain perspectives, financial literacy, governance, and managerial capabilities into its interventions, ni-msme has empowered farmers, rural youth, women entrepreneurs, and producer collectives to move from production-centric models toward enterprise-led growth pathways. Its capacity-building initiatives emphasize sustainability, scalability, and resilience, ensuring that enterprises are equipped to respond to market dynamics and external risks.

Through strategic partnerships with government agencies, development institutions, and international organizations, ni-msme has also contributed to strengthening enabling ecosystems for agri-businesses and producer collectives. This integrated and impact-oriented approach positions ni-msme as a key institutional driver of inclusive and sustainable Agri-enterprise development.

Bridging the Transformation

One of ni-msme's most significant contributions has been its role in bridging the longstanding divide between agriculture as a livelihood activity and agriculture as a business enterprise. Through structured Entrepreneurship Development Programmes, Training of Trainers initiatives, product-specific interventions, and cluster-based development approaches, ni-msme has enabled Agri-stakeholders to adopt enterprise-oriented perspectives. These interventions equip participants with practical understanding of value chains, market assessment, business planning, risk management, regulatory compliance, and access to institutional finance.

This bridging function is particularly critical for producer collectives such as Farmer Producer Organizations, cooperatives, and Self-Help Group–based enterprises, which often demonstrate strong production capabilities but face constraints in governance, branding, financial management, and market intelligence. ni-msme's capacity-building efforts focus on strengthening collective governance, professional

management, and market linkage strategies, thereby converting aggregation advantages into commercial viability.

By aligning agricultural production with MSME frameworks and market systems, ni-msme facilitates the transformation of producer collectives into sustainable agri-business entities. This approach enhances enterprise resilience, improves income realization, and supports long-term competitiveness within evolving domestic and global Agri-markets.

Recent Developments

In recent years, ni-msme has significantly expanded and diversified its Agri-entrepreneurship portfolio in response to evolving national priorities and global development imperatives. The institute's focus has progressively shifted toward allied agricultural sectors, value-added enterprises, inclusive entrepreneurship models, digital integration, and cluster-based development approaches. These initiatives reflect a strategic effort to align agriculture with emerging market opportunities, sustainability goals, and MSME-driven growth frameworks.

ni-msme has increasingly emphasized entrepreneurship in sectors such as apiculture, fisheries, food processing, herbal and AYUSH-linked products, and rural services, recognizing their potential for income diversification and employment generation. Parallelly, the institute has strengthened its commitment to inclusiveness by promoting women-led enterprises, supporting producer collectives, and building capacities among marginalized and rural communities.

Digital branding, market access, and professional management have also emerged as key focus areas, particularly for Farmer Producer Organizations and Agri-clusters.

Collectively, these recent developments highlight ni-msme's adaptive and forward-looking approach, demonstrating how institutional innovation can effectively respond to changing agricultural, technological, and market dynamics.

AYUSH Sector

Agri-entrepreneurship linked to the AYUSH sector has gained increasing relevance in the context of the expanding global wellness economy. ni-msme has contributed to this domain by enabling AYUSH doctors, students, and rural entrepreneurs to adopt entrepreneurship as a viable career pathway alongside professional practice. Through structured Entrepreneurship Development Programmes and enterprise-oriented capacity-building initiatives, ni-msme has supported the creation and strengthening of AYUSH-linked micro and small enterprises within the MSME framework.

These interventions focus on entrepreneurial orientation, business planning, regulatory awareness, branding, financial management, and market access, thereby equipping AYUSH professionals and aspiring entrepreneurs with the skills required to establish sustainable enterprises. By integrating entrepreneurship with AYUSH practice, ni-msme has facilitated the transition of traditional knowledge systems into organized, market-responsive agri-business and wellness enterprises at national and international levels.

Agri Facts

- Poor filtration is the biggest reason for drip emitter clogging—maintenance decides success.
- Scheduling irrigation using evapotranspiration (ET) can educe water waste compared to fixed-day watering.

Fisheries and Aquaculture Entrepreneurship Development Initiatives

Recognizing fisheries and aquaculture as critical components of agri-business diversification, ni-msme has collaborated with the National Fisheries Development Board (NFDB) to promote entrepreneurship in the fisheries sector. Through structured Entrepreneurship and Skill Development Programmes, ni-msme has supported fisheries-based enterprises by integrating technical knowledge with business planning, value addition, and market orientation.

These initiatives have enabled beneficiaries, particularly from marginalized communities, to view fisheries not merely as an occupation but as a scalable enterprise opportunity. By embedding fisheries entrepreneurship within the MSME ecosystem, ni-msme has expanded the scope of Agri-entrepreneurship to include nutrition-sensitive and high-growth sectors.

Honey Beekeeping Development Initiatives

Beekeeping has emerged globally as a low-investment, high-impact Agri-enterprise with strong linkages to crop productivity, biodiversity, and income generation. ni-msme's association with the National Beekeeping and Honey Mission (NBHM) and the National Bee Board reflects its commitment to promoting scientific, enterprise-oriented apiculture.

Through national, state, and district-level seminars and scientific beekeeping training programmes, ni-msme has strengthened capacities across the honey value chain. Building on this experience, the institute has proposed product-specific entrepreneurship development programmes focused on value-added honey and beehive products, reinforcing beekeeping as a viable MSME-linked agri-business.

Gender Inclusiveness

Gender inclusiveness is a critical determinant of sustainable Agri-entrepreneurship, particularly in contexts where women play a central yet often under-recognized role in agricultural and rural economies. ni-msme's collaboration with the International Labour Organization (ILO) through the Women's Entrepreneurship (WE) Check framework represents a significant institutional initiative to embed gender responsiveness within entrepreneurship promotion systems. Through this process, ni-msme undertook a structured self-assessment of its policies, programmes, and delivery mechanisms to identify gender gaps and implement targeted improvements.

The WE-Check initiative strengthened internal systems, training design, outreach strategies, and monitoring processes to enhance women's participation and leadership across entrepreneurship and agri-business programmes. As a result, ni-msme expanded women-focused interventions, improved accessibility of training, and strengthened mentoring and support mechanisms for women entrepreneurs. This institutional transformation has generated positive spillover effects across Agri-entrepreneurship initiatives, ensuring that women producers, SHG members, and rural entrepreneurs receive more inclusive, responsive, and sustainable enterprise support.

Promoting Producer Collectives

At the grassroots level, ni-msme's collaboration with the Society for Elimination of Rural Poverty (SERP), Government of Telangana, demonstrates the effectiveness of institutional partnerships in promoting enterprise-led rural livelihoods. Through structured Training of Trainers (ToT) programmes, ni-msme has built the entrepreneurial and managerial capacities of Community Resource Persons (CRPs) drawn from Self-Help Group (SHG) networks. These programmes are designed to equip CRPs with practical tools and methodologies for micro-enterprise development.

Trained CRPs play a critical role in supporting SHGs throughout the enterprise lifecycle, including opportunity identification, feasibility analysis, business planning, implementation, and post-start-up handholding. By integrating entrepreneurship development within the SHG ecosystem, ni-msme has strengthened women-led Agri-enterprises and producer collectives at the village and cluster levels. This approach enhances sustainability, promotes income diversification, and reinforces inclusive rural development by converting livelihood activities into viable micro and small enterprises.

Centre for Digital Branding and Marketing:ni-msme–NABARD for FPOs

With market access and visibility emerging as decisive factors for the sustainability of Agri-enterprises, ni-msme, in collaboration with National Bank for Agriculture and Rural Development (NABARD), has strengthened digital branding and marketing support for Farmer Producer Organizations (FPOs). This initiative addresses one of the most critical gaps faced by producer collectives, the ability to communicate value, quality, and identity in increasingly competitive markets.

Through targeted capacity-building interventions, ni-msme has enabled FPOs to develop competencies in brand creation, product positioning, packaging, storytelling, and use of digital platforms for market outreach. The initiative also focuses on improving understanding of consumer preferences, traceability, and market communication strategies within the MSME framework. By integrating digital branding tools with collective enterprise models, the ni-msme–NABARD collaboration enhances market reach, strengthens price realization, and supports the creation of sustainable brand identities for FPOs, thereby improving their

competitiveness in national and global agri-business markets.

Cluster Development Initiatives

Cluster-based development constitutes a core pillar of ni-msme's Agri-entrepreneurship strategy, particularly in strengthening producer collectives and localized agri-business ecosystems. By promoting agri-business clusters, ni-msme facilitates economies of scale, shared infrastructure, collective branding, and coordinated market engagement. This approach enables producers and enterprises operating within a geographic concentration to move beyond isolated activities toward integrated and professionally managed enterprise systems.

ni-msme's cluster interventions emphasize value-chain integration, enterprise specialization, and collaboration among producers, processors, service providers, and market actors. Capacity building in governance, quality standards, financial management, and market linkage forms an integral part of cluster development efforts. Such clusters help reduce transaction costs, improve productivity, and encourage innovation through knowledge sharing and collective problem-solving. By aligning clusters with MSME frameworks and market systems, ni-msme enhances the competitiveness and sustainability of agri-businesses, making cluster-based models highly relevant in both domestic and international agri-business contexts.

The Way Forward

The future of agri-businesses and producer collectives lies in their ability to adapt, innovate, and integrate with evolving market, technological, and policy environments. As agriculture continues to transition from subsistence-based activities to enterprise-driven systems, sustained institutional support will remain essential for ensuring resilience, competitiveness, and inclusiveness. Strengthening entrepreneurial capacities, deepening value-chain linkages, and enhancing market access will be critical to this transformation.

ni-msme's multi-dimensional engagement across Agri-entrepreneurship, allied sectors, gender inclusion, digital branding, and cluster development positions it as a key catalyst in shaping future-ready Agri-enterprise ecosystems. Going forward, greater emphasis on innovation, digital integration, climate-resilient business models, and global market orientation will further strengthen Agri-based MSMEs and producer collectives. By continuing to bridge agriculture with MSME frameworks and enterprise ecosystems, ni-msme can play a decisive role in advancing sustainable rural livelihoods and competitive agri-businesses in an increasingly interconnected global economy.

Integrated Rural Development Models of Asia and Pacific Region

CIRDAP

Venue: NIRDPR, Hyderabad, India | Date: 19 June 2025

Hyderabad, India: The prestigious launch of the publication "Integrated Rural Development Models of Asia and Pacific Region" was held at the National Institute of Rural Development and Panchayati Raj (NIRDPR), Hyderabad, marking a significant milestone in advancing inclusive and resilient rural development practices across the Asia-Pacific region.

Jointly conceptualized and brought to fruition by the Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP) and KhetiValah—the flagship agri-initiative of the Haladhari Group of Companies—this publication reflects a shared commitment to transform rural livelihoods through innovation, research, collaboration, and knowledge exchange.

The book was developed under the visionary guidance of Dr. P. Chandra Shekara, Director General of CIRDAP, and published by KhetiValah under the leadership of Mr. Lakshman K, Founder & CEO. It has brought together the impactful rural development models, selected across the Asia-Pacific region, which would help in taking impactful policy initiatives for community empowerment, and replication of the successful models in identical situations elsewhere.

A Repository of Regional Success Stories

The publication is a testimony of regional cooperation and shared learning in driving rural transformation. It serves as both a reference and a call to action urging policymakers, practitioners, researchers, and development partners to work together in support of inclusive growth, sustainable livelihoods, and rural resilience.

With a focus on real-world implementation, the book presents integrated rural development success stories and models that highlight the effective approaches to agriculture, livelihoods, governance, capacity building, and rural innovation across diverse country contexts.

Editorial & Research Contributions

The publication was enriched by the valuable editorial guidance from:

Dr. P. Chandra Shekara
Director General
Centre on Integrated Rural Development in Asia and the Pacific (CIRDAP)

Dr. H. Philip
Ex Director, Directorate of Extension Education Tamil Nadu Agricultural University, Coimbatore,Tamil Nadu, INDIA

Dr. N. Sudhakar
Ex Director,
ICAR -Zonal Project Directorate (Zone V) CRIDA Campus, Hyderabad, INDIA.

It covers the curated account of pertinent, diverse and impactful rural development models across Asia-Pacific, received from **CIRDAP: Dr. Usharani Boruah, Ms. Hurain Jannat and Ms. Tahsina Tabassum Sajuti**

Their collective work ensured that the book offers both regional insights and practical framework that canbe adopted by the stakeholders in rural development.

Distinguished presence at the Launch Event

The launch event was graced by eminent delegates and international dignitaries from key development institutions and ministries across the Asia-Pacific region.

Distinguished Delegates

- **Dr. Stanford Blade,** Deputy Director General, ICRISAT
- **Dr. Zelalam B. Taffeesse,** Chief Field Officer, UNICEF
- **Mr. Anjani Singh**, Senior Programme Officer, Bill & Melinda Gates Foundation (BMGF)
- **Mr. Venu Gopal,** State Coordinator, GIZ
- **Dr. P. Kesava Rao,** Associate Professor & Head, CRTCN, NIRDPR
- **Dr. Venkatamallu,** Research Officer, NIRDPR

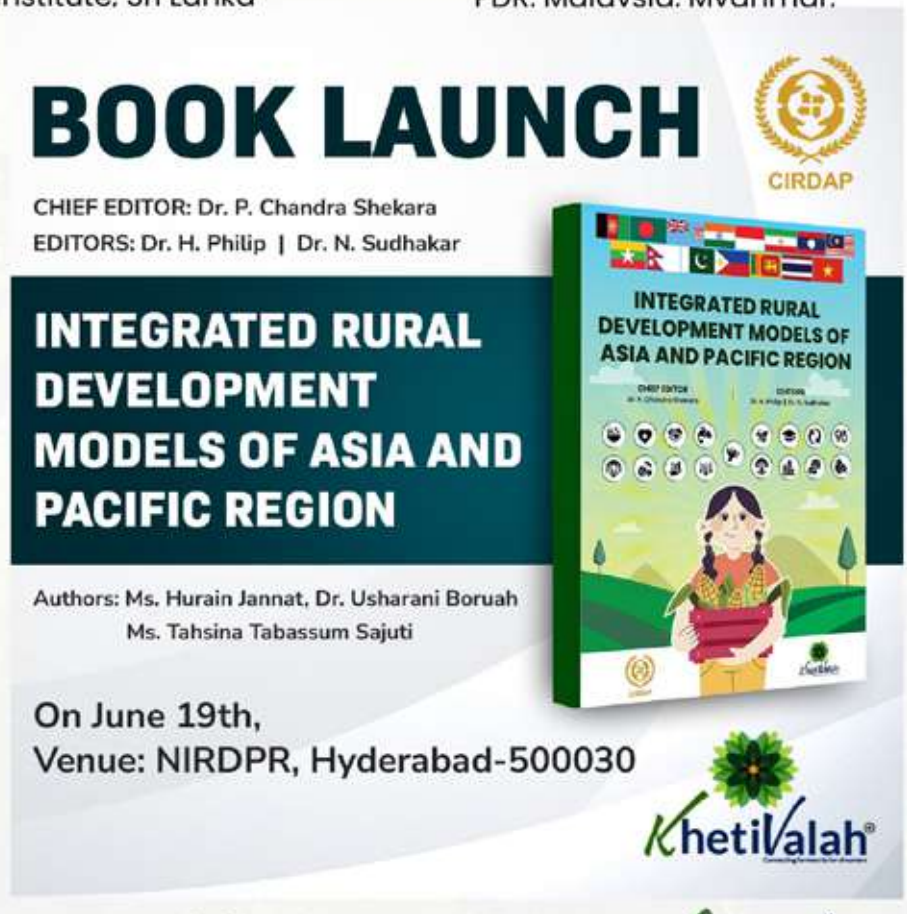
International Guests from Asia-Pacific

- **FAM Zakirul Huq & Shishir Gobinda Saha,** CIRDAP, Bangladesh
- **Ms. Arieta Vialaiwai Rokotuibau,** Ministry of Rural and Maritime Development, Republic of Fiji
- **Mr. Victor Pegi Polnaya,** Ministry of Home Affairs, Republic of Indonesia
- **Mr. Thosak Syluangsoth,** Ministry of Agriculture and Forestry, Lao PDR
- **Mr. Muhammad Razif Bin Ruba Ai,** Ministry of Rural and Regional Development, Malaysia
- **Ms. Aye Kyaw Hlaing,** Ministry of Cooperatives and Rural Development, Myanmar
- **Mr. Kanun Lal Chaudhary,** Local Development Training Academy, Nepal
- **Ms. Lita Meciona Rosales,** Department of Agrarian Reform, Philippines
- **Mrs. Mahawattage Don Susila Lurdu,** Agrarian Research and Training Institute. Sri Lanka
- **Mr. Krit Hansaward,** National FAO Committee & BOFAA, Ministry of Agriculture and Cooperatives, Thailand
- **Ms. Pham Hoang Lan,** Ministry of Agriculture and Environment, Vietnam

Their presence highlighted the importance of cross-border learning and reinforced the shared vision of advancing rural development systems across the region.

About CIRDAP

The Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP) is an intergovernmental and autonomous organization, established in 1979, mandated to promote and strengthen integrated rural development systems across its 15 member countries:
Afghanistan, Bangladesh, Fiji, India, Indonesia, IR Iran, Lao PDR. Malaysia. Myanmar.



Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam.

In a landmark acknowledgment, the United Nations officially recognized July 6, the CIRDAP's Foundation Day - as the World Rural Development Day (WRDD). This global designation is a tribute to CIRDAP's outstanding contribution to improving rural livelihoods and bringing rural development to the center of global development discourse.

CIRDAP continues to disseminate integrated rural development models across its member countries and beyond through multiple platforms such as:

- CIRDAP Exhibition & Museum on Integrated Rural Development in Asia-Pacific (CEMIRD)
- Webinars and knowledge-sharing forums
- International publications like this book

What makes this Book Special?

The launching of this book, "Integrated Rural Development Models of Asia and Pacific Region", is more than a publication milestone—it is a shared commitment to scaling up the solutions that strengthen rural communities, enhance livelihoods, and promote sustainable development across borders.

CIRDAP and KhetiValah reaffirm their dedication to building platforms that connect knowledge with action and drive the rural transformation for a better future.

As an international knowledge repository, this publication serves as a collection of 32 Integrated Rural Development (IRD) success stories, presenting real-world rural transformation cases that can be replicated or adapted anywhere, in the identical situations.

The book is designed to benefit a wide audience including:
policymakers, administrators, academicians, researchers, rural development experts, and development partners, offering a rich learning experience that supports appropriate planning and implementation of rural development initiatives.

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KhetiValah's

KhetiSwags

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Launching web & mobile application Feb 2026

Inviting state wise partners

KhetiSwags
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#Khetiswags #Khetivalah

Agricultural Mechanization in India

Dr. Surendra Singh

Technical Advisor, AMMA-India

Dr. Surendra Singh Ji, the Technical Advisor of Agricultural Machinery Manufacturers Association (AMMA-India), is a key figure in fostering collaboration with AMMA-India and supporting KhetiValah. He holds an extensive educational background, including a B. Tech. in Agricultural Engineering, an M. Engg. in Agricultural Machinery & Management, and a Ph.D. in Agricultural Machinery. His impressive career spans positions at institutions like the Central Institute of Agricultural Engineering (ICAR) and Punjab Agricultural University. Dr. Singh has received various awards, including the ISAE Gold Medal and Dr. K N Nag Gold Medal. He has authored numerous books on agricultural machinery and energy management. Through consultancy work with international organizations, he has been instrumental in promoting sustainable agricultural mechanization. He is Fellow of National Academy of Agricultural Sciences (NAAS), Institutions of Engineers (India) and Indian Society of Agricultural Engineers.

Agricultural Mechanization in India

Indian agriculture has travelled many folds after independence to date in terms of increase in net sown area, cropping intensity, crop yields, and mechanization levels. The net sown area increased from 136.34 million ha in year 1961-62 to 141.93 Mha in year 1981-82. Presently net sown area is confining to around 140 Mha for crop production. Cropping intensity increased from 115% in year 1961-62 to 156% in year 2023-24. Food grain production increased from 50.82 million tonnes in 1950-51 to 332.30 million tonnes in year 2023-24 with increase in yield by 4.82 times. Oil seeds are grown in 26.84 Mha along with commercial crops such as sugarcane in 4.89 Mha, cotton in 16.87 Mha and Jute & Mista in 0.69 Mha area. Horticulture crops are grown in 28.12 Mha with total production of 351.92 million tonnes during the year 2023-24. Amongst horticulture crops, maximum area under cultivation is 40.39% for vegetable crops with 60.5% share in total horticultural production followed by 24.92% for fruits having 30.78% share in production, 15.79% in plantation crops with 4.56% share in production, 15.29% in spices with 3.12% share in production, 9.67% in flowers with 0.81% share in production and 2.63% in aromatic and medicinal plants with 0.18% share in horticulture production.

Food grains, pulses, oilseeds, vegetables, commercial crops etc are having almost all field operations like, seedbed preparation, seeding/ planting/ transplanting, fertilizer broadcasting, spraying, interculture, harvesting/ digging/ plucking and threshing. One of the essential inputs for increasing cropping intensity and crop yield is completion of unit operations for cultivating these crops in timeliness manner, effective placement of seeds/nursery, desired depth, with reduced human involvement and increased efficiency. This can be achieved by mechanization only. The farm mechanization uses machineries and technologies in agricultural practices, a transformative force in modern farming. Power is needed for carrying out the farm operations. The source of power in agriculture is human beings, draught animals, mechanical (tractors, power tillers, combine harvesters and diesel engine) and electric motors. Farm mechanization helps in increasing the productivity up to 12-34%, saving in seeds by 20%, saving in fertilizer by 15-20%, enhancing cropping intensity by 5-22%, increasing gross income of the farmers by 30-50%.

Assessment of farm power sources in the Country

Mechanization also imparts capacity to the farmers for carrying out different farm operations, with ease and freedom from drudgery, making the farming agreeable vocation for educated youth as well. It helps the farmers to achieve timeliness and precisely meter and apply costly input for better efficacy and efficiency.

Availability of farm power source in the country is assessed based on the data of Tractor and Mechanization Association (TMA), Power Tiller Manufacturers Association (PTMA), Agricultural Machinery Manufacturers Association (AMMA-India), All India Combine Manufacturers Association (AICMA), Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare GoI, and available literatures (Singh et al., 2014, Singh, 2015., Singh & Singh, 2021). The population of farm workers and draught animals were as per the Census and NITI Ayog data.

Availability of farm power in the country

Animate power: Combo power of human beings and animal utilised for carrying out farm operations are termed as animate power. Dynamics of agricultural workforce and draught animals during 1961 to 2025 is shown in Fig 1. Share of animate source of power in total Farm Power Availability started declining from 91.2% in year 1961-62 to 4.45% in year 2024-25. This is due to introduction of mechanical source of power particularly tractors, power tillers, electric motors, diesel engines and combine harvesters.

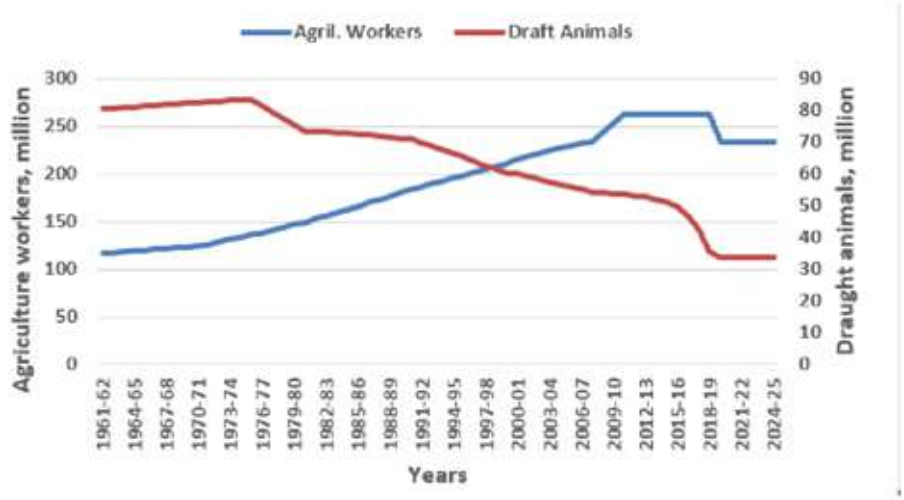


Fig. 1. Dynamics of agriculture workforce and draught animal during different years in the country

Mechanical Power

The sources of mechanical power include tractors, power tiller, combine harvesters, electric motors and diesel engines. The population of these source of mechanical power from 1961-62 to 2024-25 is presented in Fig. 2. The share of mechanical source of power to total farm power availability (FPA) in the country is in increasing trend from 6.4% in 1961-62 to 75.6% in year 2024-25.

Domestic sale of tractors in Year 1961-62 was 3,877 which rose to 9,39,713 in year 2024-25. The population of tractors in the country has increased to 10.94 million in year 2024-25 from 0.037 million in 1961-62 (Fig. 2). Power availability for Indian agriculture from tractor has increased from 0.97 million kW in year 1961-62 to 285.53 million kW in year 2024-25 at CAGR of 9.45%. Share of tractor power to total FPA has increased to 51.84% in year 2024-25 from 2.42% in year 1961-62

The sale of power tiller in the country started from 22 in 1961-62 and reached to 40,000-50,000 per year from 2010-11 onwards. The CAGR of sale of power tiller since 1961-62 to 2024-25 is at the rate of 12.65%. The population of power tiller in the country has increased from 0.013 million in 1964-65 to 0.77 million in 2024-25 (Fig. 2). Power available from power tiller is 4.32 million kW and its power share to total FPA is presently 0.79%.

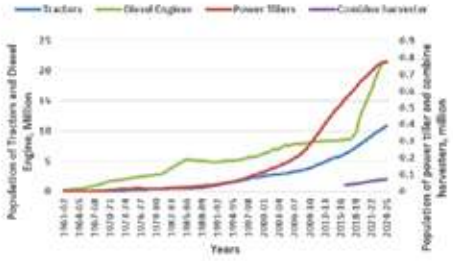
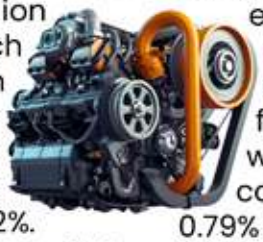


Fig. 2. Population of mechanical source of power during different years in the country

The population of diesel engine was 0.23 million in year 1961-62 which rose to 21.573 million in year 2024-25 (Fig. 2). The CAGR of diesel engine during these years is 7.12%. Currently, power availabe from diesel engines in agriculture is 120.81 million kW and its share in total FPA is 21.93%.



The population of combine harvesters in India is assessed to 0.0755 million in 2024-25 (Fig. 2) at CAGR of 8.3%. The power availability from combine harvesters is currently (2024-25) 5.56 million kW which is 1.01% share in total farm power availability

The power available from electric source in Indian agriculture was 0.96 million kW in year 1961-62. During 2024-25, the power from electric source has gone to 110.09 million kW. Share of electric power in total farm power has increased to 20% in year 2024-25 from 2.41% in 1961-62.

Farm power availability in India

Farm power availability per net sown area was 0.3 kW/ha in 1961-62 which is currently (2024-25) 3.93 kW/ha at CAGR of 4.20%. Tractor availability on net sown area decreased to 12.8 ha in 2024-25 from 3659.4 in year 1961-62.

The share of these sources of farm power is presented in Fig. 3. It is clear that highest share of tractors in total farm power availability is 52% followed by 22% from diesel engine, 20% from electric motors, 2.33% from draught animal, 2.12% from agricultural workers, 1.01% from combine harvesters and 0.79% from power tiller.

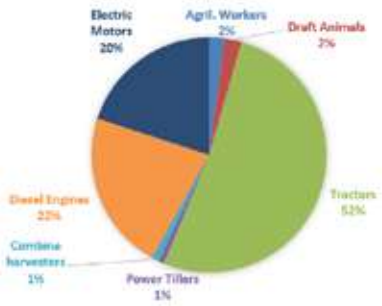


Fig. 3. Current share of different source of farm power in total Farm Power Availability

Relationship between farm power availability and food grain productivity is presented from 1961-62 to 2024-25 in Fig. 4. It is clearly visible a linear relationship between farm power availability and food grain productivity. The contribution of farm power availability can be visualised towards enhancement of food grain production in terms of timeliness of operation, saving of seeds, fertilizers, pesticides etc., precision of placement and availability of machineries in addition to the quality seeds and related agronomical practices.

Fig. 4. Relation between farm power availability and food grain productivity

Farm mechanization

Attachments have been developed by the research organizations, state agricultural universities and manufacturers with the tractor for making versatility power unit as important power source for various farm operations. Singh (2024) reported the availability of 250 medium to large scale units, 2500 small scale industries, 15000 tiny industries and 1 million village level artisans in the country.

Agri Facts

- Drip irrigation can increase fertilizer efficiency through fertigation by placing nutrients near active roots.

These industries are Rs. 1,50,000 Crores annual industry at CAGR growth 5-8%. Some important farm machine/implements introduced in Indian agriculture for reducing drudgery with reduced time are crop threshers in 1957, combine harvesters in 1970, zero till drill in 1991, inclined plate planters in 1992, laser guided land levellers in 2005, direct seeded rice drill in 2010 and modified happy seeders in 2017. In addition to these, rotavators, cultivators, harrows, ploughs, etc are also being used by the farmers. The wheat, rice, maize are the highly mechanized crops with overall mechanization levels of 69, 53 and 46%, respectively and followed by pulses (41%), oil seeds (39%), cotton (36%), sugarcane (35%) and sorghum and millets (33%).

The overall farm mechanization level in the country is about 55% as reported by (Singh, 2024), as against 95% in USA and Western Europe, 80% Russia, 75% in Brazil and Argentina, 38% in China, and 20% in Africa.

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Lakshman K, Founder & CEO of KhetiValah, in an exclusiv interview with Dr. P. Chandra Shekara, Director General, CIRDAP.

Dr. P. Chandra Shekara
Director General
Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP)

Dr. P. Chandra Shekara has more than three decades of experience towards integrated rural development, especially in the areas namely Agricultural Extension Management, Agri-Entrepreneurship Development, Agricultural Marketing Management and Public Private-Partnership. Dr. Shekara headed three premier National Institutions in India which work for the Ministry of Agriculture and Farmers Welfare, Government of India: Director General of CCS National Institute of Agricultural Marketing (CCS NIAM), Director General (In-charge) of National Institute of Plant Health Management (NIPHM) and Director General of National Institute of Agricultural Extension Management (MANAGE). 'He published 81 Research papers including 25 books'.

Your Journey & Vision

Sir, you have an exceptional career in rural development, right from your impactful work at MANAGE to now leading CIRDAP. Can you please reflect on the key milestones in your incredible journey and how they've influenced your vision for integrated rural development in Asia-Pacific?

Born into a farmer's family in a village, my passion for Agriculture was by choice, not chance, leading me to earn my Bachelor's, Master's, and Doctorate in Agricultural Extension from the University of Agricultural Sciences, Bangalore. In 1990, I joined the Indian Coffee Board, focusing on capacity building for Kerala coffee growers and published 100 Years of Coffee Research, a comprehensive document with 1500 technologies, making innovations accessible to farmers. My doctorate addressed extension and research gaps in India's coffee industry. In 1999, I joined MANAGE, a premier institute under the Ministry of Agriculture, where I focused on gaps in extension systems, conducted a national seminar on private extension, published two books,an pioneered public - private partnerships, like with Danuka Group in Hoshangabad, Madhya Pradesh. Spearheaded the Agri-Clinic and Agribusiness Centre scheme, training 85,000 unemployed agricultural graduates, with 40,000 establishing enterprises, creating jobs for 2.4 lakh rural youth and curbing migration. From 2013 to 2018, led the USAID-funded Feed the Future India Triangular Training Program, training 1440 officials from 20 African and Asian countries in modern agricultural technologies. In 2018, as Director General of CCS NIAM, Jaipur, established 10 academic departments, promoted startups under Rastriya Krishi Vikas Yojana, and transformed Farm Business School into commodity-specific agribusiness schools. In 2020, as Director General of MANAGE, Hyderabad, expanded capacity building programs from 125 to 550, reaching 1.5 lakh stakeholders, trained 60,000 rural youth in skills, and certified 70,000 Krishi Sakhis in natural farming. Supported 2000 agri-startups, launched innovative programs like Jai Jawan Jai Kisan for ex-servicemen, MANAGE FPO Academy, Agri Film Festival, awards for agricultural extension thesis,a National Network of Agricultural Journalists, CSR forums, Krishi Gyan Deep lecture series, and SEWA for retired professionals. As a son of a farmer, keeping farmers central to my work has been fulfilling. At CIRDAP, my vision is to leverage this experience to

drive integrated rural development across 15 Asia-Pacific countries, fostering sustainable growth and poverty alleviation through regional cooperation.

CIRDAP's Strategic Direction

What unique role does CIRDAP play in fostering regional cooperation among its member countries, and how do you envision strengthening this role in the current global context?

CIRDAP, established in 1979 by the FAO as anautonomous intergovernmental organization, has expanded from six to 15 member countries: Afghanistan, Bangladesh, Fiji Islands, India, Indonesia, Iran, Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka,Thailand, and Vietnam. As a multi-level, multi-sector platform, CIRDAP facilitates the exchange of good practices among countries, institutions, and professionals through training, research, policy advocacy, consultancy, documentation, dissemination, and pilot projects to innovate and strengthen integrated rural development models. Agriculture, the lifeline for most developing countries, and rural development are critical for the Asia-Pacific region , where over half the world's population resides, with 70% living in rural areas. CIRDAP coordinates efforts to enhance sustainable rural progress, addressing challenges like climate change and poverty. In the current global context, CIRDAP is strengthening its role by fostering learning with in the region and sharing Asia-Pacific's experiences, expertise, success stories,and lessons with the global community while adopting best practices from around the world to improve rural living standards.

Integrated Rural Development in Action

Integrated rural development is the central pillar of CIRDAP's mission. Can you please elaborate on how this model is implemented in member countries and its impact on sustainable rural development?

Integrated rural development the cornerstone of CIRDAP's mission, addresses the multidisciplinary and multi-sectoral needs of rural communities across agriculture, infrastructure, health, education, climate change, disaster management, and more, requiring coordinated efforts to uplift living standards. CIRDAP implements this through over 255 research and pilot projects, sharing lessons with its 15 member countries to promote sustainable livelihoods. The Asia Pacific Journal of Rural Development publishes research from institutions and professionals, while the annual Rural Development Report addresses region-specific priorities, both circulated widely to stakeholders. Regular webinars sensitize professionals, and tailored training programs equip practitioners with skills to tackle local challenges. Through research, policy advocacy, pilot projects, documentation, and dissemination, CIRDAP leverages social media, its monthly Voice of CIRDAP bulletin, and other platforms to reach large audiences, establishing itself as a vital knowledge exchange hub for integrated rural development across Asia and the Pacific.

Major Rural Challenges Today

What do you consider the most pressing current challenges for rural communities in Asia-Pacific, and how CIRDAP is tailoring its programs to address the new emerging needs?

key challenges include food security due to low agricultural productivity from limited access to advanced technologies, and issues with public distribution systems like quality and transparency. Nutrition security is another concern, as families may not grow or consume nutritionally adequate food, requiring education on nutrition-sensitive agriculture. Income security is critical, with agriculture engaging families

only part-time, necessitating diverse income-generating activities like rural tourism or cooperatives to curb youth migration. Climate change demands adoption of climate-smart practices for sustainable livelihoods. Digital illiteracy hinders access to modern technologies and services, calling for widespread literacy campaigns and skill development to create job opportunities. These are the major hurdles impacting rural communities today.

Leveraging Technology for Rural Growth

Technology can deliver cost-effective, real-time services to rural communities in Asia and Pacific, narrowing the urban-rural gap, discouraging youth migration to cities, and even attracting urban residents to rural areas. The main barrier is digital illiteracy, which prevents access to these benefits. National campaigns to promote digital literacy are essential, alongside connecting village institutions, local governments, educated youth, and groups like cooperatives or farmers' organizations with startups and digital service providers. This integration can drive prosperity and happiness in rural communities by fostering job creation and access to modern facilities

Women Empowerment & Inclusive Growth

What do you consider the most pressing current challenges for rural communities in Asia-Pacific, and how CIRDAP is tailoring its programs to address the new emerging needs?

Women make up over half the population in Asia-Pacific countries, yet social discrimination and lack of education limit their ability to contribute to societal, familial, and personal development. Education is critical for gender empowerment, requiring societal will, sensitization, and accessible education facilities in rural areas, which governments must prioritize. Organizing women into groups like self-help groups, food security groups, farm women producers' organizations, or agricultural cooperatives provides social strength, fosters leadership, and develops skills for income generation and constructive engagement. These groups also serve as platforms to promote issues like nutrition sensitivity, which women can lead at home and in communities. CIRDAP through initiatives, supports this by conducting four key research projects: in Nepal, sensitizing political representatives on gender-responsive budgeting; in India, creating livelihood opportunities for transgender communities, who face significant rural discrimination; in Sri Lanka, involving women and youthin village development thro-
ugh skill-building, knowledge dissemination, and market access; and in Iran, promoting women's intensive involvement in the silk value chain. Additionally, CIRDAP organizes webinars and social media campaigns to emphasize gender progress and inclusive development opportunities, driving women's empowerment and inclusive growth across the region.

Agri Facts

- Heat stress in poultry reduces feed intake, lowers egg size, and increases mortality risk ventilation is profit protection.
- Modern broiler strains can reach market weight in 5–7 weeks, but performance drops sharply if brooding is weak.
- In poultry, water quality and water intake are often more important than farmers realize—poor water can crash performance.
- Uniform chick weight at placement is one of the strongest predictors of uniform final body weight in broilers.

Environmental and Economic Sustainability

How can CIRDAP strike a balance between environmental sustainability and economic viability in its rural development initiatives, especially in climate-sensitive regions?

Income security is crucial for rural communities in Asia and Pacific, and fostering income-generating activities through skill development and self-employment in green businesses supports economic growth while providing value-added services. CIRDAP promotes climate-smart agriculture andgreen business opportunities, such as beekeeping, agroforestry, through supportive policy frameworks. kitchen-gardening, natural and organic farming, and agroecological approaches, ensuring environmental sustainability. Direct marketing, enabled by technology, links producers to consumers, eliminating middlemen to maintain profitability for green businesses. The growing urban demand for green services offers opportunities for rural providers, supported by capacity building, digital literacy, and digital marketing, with rural youth and government backing playing key roles. CIRDAP initiatives, including rural tourism, MSME programs focusing on green businesses, and cooperative programs promoting green startups, aim to balance economic and environmental sustainability. Additionally, CIRDAP emphasizes climateresilient development policies across Asia and Pacific to ensure long-term ecological and economic balance

Impactful Collaborations & Partnerships

Strategic partnerships play a crucial role in rural development. Can you share some examples of collaboration—national or international—that has significantly contributed to CIRDAP's impact on rural development?

CIRDAP collaborates closely with its 15 member countries in Asia and Pacific, with rural development ministries serving as link ministries, their ministers on the governing board, and secretaries on the executive committee, while national institutes of rural development form the technical committee to drive policy, mentoring, and execution of rural development practices. CIRDAP has MOUs with over 50 partner institutions across the region, working in diverse areas like agriculture, nutrition, physical disability, climate change, rural governance, and employment, facilitatingmutual collaboration in program execution. Additionally, CIRDAP leverages a vast net-work of rural development experts from governments, universities, NGOs, and freelancers, who contribute to webinars, conferences, publications, and action research projects as CIRDAP experts. CIRDAP's ability to operate region-wide from one location stems from these impactful partnerships. Notably, Kethivallah, a key partner, collaborates closely with CIRDAP, publishing Book on integrated rural development models in Asia and Pacific, which is highly valued by stakeholders, and CIRDAP is grateful for Ketiwala's role in this effort.

Agri Facts

- Global egg production is dominated by China, USA, and India among top producers.
- Egg shell quality is strongly linked with calcium availability + vitamin D3 + lighting program.
- In layers, poor gut health shows up quickly as wet droppings, thin shells, and uneven egg size.

Future Priorities and Roadmap

As you look ahead, what are the CIRDAP's top priorities over the next five years, especially in the context of climate change, food security, and migration of rural youth?

CIRDAP aims to ensure food, nutrition, and income security for rural communities in Asia and Pacific while maintaining a sustainable balance between economic and environmental concerns in development processes. A key priority is fostering closer integration of technology with rural areas to provide urban-like facilities, reducing youth migration to cities and attracting urban visitors. This will be achieved through skill development and technological interfaces to create employment and self-employment opportunities via entrepreneurship, empowering individuals to contribute to their families and society. CIRDAP plans to reach the last mile by implementing policies, programs, and collaborations with member countries, partner institutions, and stakeholders to address these core rural needs effectively.

KhetiValah's Mission & Your Perspective

KhetiValah has been actively focusing on critical themes like soil fertility management, regenerative agriculture, value chain development and urban participation in sustainable agricultural practices to build a wealthier India and a healthier planet. You have been a great supporter of these initiatives. How do you view KhetiValah's mission and its alignment with CIRDAP's goals can help to improve the rural economies? What future support, guidance and suggestions would you offer to take this movement forward, especially in the context of integrated rural-urban agri linkages?

CIRDAP commends KhetiValah' impactful efforts to enhancerural prosperity, particularly for farmers, and expresses gratitude for KhetiValah' publication of the book on Integrated Rural Development Models in Asia and Pacific, which has gained significant popularity in the region. CIRDAP envisions a collaborative platform with KhetiValah' to promote soil fertility protection, regenerative agriculture, and strengthened value chain development, ensuring that environmentally sustainable agricultural and green products from rural communities meet growing urban demand, making these practices financially viable and sustainable. By creating urban-like facilities in rural areas, CIRDAP and KhetiValah' aim to curb rural youth migration through profitable agricultural enterprises, fostering richer agriculture, happier farmers, and ultimately a wealthier nation and healthier planet.

With Respect and Gratitude

It has been a great honour to interact with Dr. P. Chandra Shekara, Director General of the Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP). We are sincerely grateful for the opportunity to conduct this interview and for the continued privilege of working and engaging with you, Sir.

At KhetiValah, our mission is to encourage the adoption of improved and regenerative agricultural practices that align with the United Nations Sustainable Development Goals (UN SDGs) and create meaningful impact at the grassroots level. Insightful guidance and encouragement from visionary intellectuals and policymakers such as you serve as a powerful source of motivation, strengthening our resolve and energizing our journey forward.

We thank you wholeheartedly for your valuable time, wisdom, and inspiring leadership. Your vision continues to guide and motivate us as we work towards inclusive, resilient, and sustainable rural development.

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A Gender-Responsive Approach to Climate Change Resilience in Agriculture

Loubna AMHAIR
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Climate change has evolved into a major development challenge, deeply affecting food systems, agriculture, rural livelihoods, and social stability worldwide. Its impacts are not gender-neutral; rural women in agriculture face greater vulnerability due to persistent inequalities in access to land, finance, technology, education, and decision-making. However, women are also key drivers of climate resilience. Their knowledge and leadership in farming practices, resource management, and community systems play a critical role in adaptation and sustainability. This article highlights the urgent need for gender-responsive climate action in agriculture, emphasizing that empowering women, strengthening inclusive policies, and ensuring equitable access to climate finance and technologies are essential for building resilient, climate-smart, and socially just food systems

Climate Change and Agriculture

Climate change is increasingly recognized as a systemic risk to global development. Rising temperatures, changing rainfall patterns, prolonged droughts, floods, and extreme weather events are disrupting agricultural production, threatening food security, and undermining rural livelihoods—especially in developing regions. According to recent assessments by the Intergovernmental Panel on Climate Change (IPCC), climate impacts are intensifying faster than anticipated, with agriculture among the most vulnerable sectors.

Agriculture remains the backbone of livelihoods for billions of people worldwide, particularly in Africa, Asia, and the Middle East and North Africa (MENA) region. In these regions, rain-fed agriculture dominates, making farmers highly exposed to climate variability. Yet vulnerability is not distributed evenly. Social, economic, and gender inequalities shape who is most exposed to climate risks and who has the least capacity to adapt.

Gender is a critical, yet often underestimated, dimension of climate vulnerability. Women represent a substantial share of the global agricultural workforce—estimated at around 43 percent worldwide and up to 60 percent in parts of Sub-Saharan Africa. Despite their contribution, women consistently face systemic barriers that limit their productivity and resilience. Climate change acts as a threat multiplier, exacerbating pre-existing inequalities related to poverty, land tenure, labor division, and access to resources.

Recognizing climate change as both an environmental and social challenge is essential. A gender-responsive approach to climate resilience in agriculture provides a powerful entry point for designing solutions that are effective, equitable, and sustainable

Climate Change and the Gender Gap in Agriculture

Climate change affects women and men differently due to socially constructed roles, responsibilities, and power relations. In many rural contexts, women are primarily responsible for food production for household consumption, small livestock management, water

collection, fuelwood gathering, food processing, and caregiving. These roles place women at the frontline of climate impacts.

One of the most persistent drivers of gendered vulnerability is unequal access to productive resources. Globally,women own less than 15 percent of agricultural land, despite producing a large share of the world's food. Limited land tenure security restricts women's ability to invest in climate-resilient practices such as soil conservation, agroforestry, or irrigation. Similarly, women have less access to credit, insurance, agricultural inputs, extension services, digital technologies, and climate information systems.

Education and literacy gaps further compound vulnerability. In many regions, women have lower levels of formal education and limited access to training opportunities, reducing their ability to adopt climate-smart technologies or engage with emerging digital agricultural services. When combined with restricted participation in decision-making at household,community, and national levels, these factors severely constrain women's adaptive capacity.

Climate-related shocks also tend to increase gender-based violence and insecurity, particularly in fragile and conflict-affected contexts. Displacement, competition over scarce resources, and economic stress can heighten risks for women, making gender-responsive climate policies not only a development priority but also a human rights imperative.

Women as Agents of Climate Adaptation and Resilience

Despite facing disproportionate risks, women play a central role in building climate resilience within agricultural systems. Across cultures and regions, women have developed sophisticated knowledge related to crop diversity, seed conservation, soil fertility, water management, and food preservation. This indigenous and local knowledge—often transmitted across generations—constitutes a critical asset for climate adaptation.

Women farmers are more likely to adopt diversified cropping systems, intercropping, and agroecological practices that enhance resilience to climate shocks. In livestock systems, women are key actors in small ruminant and poultry production, which are often more resilient to climate variability and provide vital sources of nutrition and income.

At the community level, women frequently play leadership roles in informal networks, cooperatives, and self-help groups that facilitate knowledge sharing, collective action, and mutual support during times of crisis. Evidence shows that when women are empowered and included in local governance structures, communities are better able to anticipate, absorb, and recover from climate-related shocks.

However, women's potential as climate actors remains largely underutilized. Structural barriers—including discriminatory laws, social norms, and limited access to finance and technology—continue to prevent women from fully contributing to climate solutions. Unlocking this potential requires deliberate, targeted, and sustained investments in women's empowerment.

Gender-Responsive Climate Action: From Policy to Practice

Gender-responsive climate action goes beyond acknowledging women's vulnerability. It requires integrating gender considerations into the design, implementation, monitoring, and financing of climate policies and agricultural programs. This includes :

- Ensuring women's equal access to land rights, productive resources, and climate-resilient technologies;
- Strengthening gender-responsive agricultural extension and climate information services;
- Supporting women-led enterprises and value chains in climate-smart agriculture;
- Promoting women's participation and leadership in climate governance at all levels.

In recent years, progress has been made at the global policy level. Gender considerations are increasingly reflected in Nationally Determined Contributions (NDCs), National Adaptation Plans (NAPs), and climate strategies. However, significant gaps remain between policy commitments and implementation on the ground.

Climate finance is a critical lever for change. Yet women and women-led organizations continue to face barriers in accessing climate funds. Gender-responsive climate finance mechanisms—designed to reach women farmers, cooperatives, and entrepreneurs—are essential to ensure that investments do not reinforce existing inequalities.

Regional Perspectives: Lessons from Africa and Morocco

In Africa, several countries have made strides in integrating gender into climate and agricultural policies. Gender mainstreaming strategies in countries such as Uganda and Tanzania have helped align sectoral policies with women's needs and priorities, particularly in agriculture and natural resource management.

Across Africa, climate change poses a direct threat to agriculture-based livelihoods, food security, and rural economies. The continent is warming faster than the global average, with increasing frequency of droughts, floods, and erratic rainfall patterns. Women, who make up a significant share of Africa's agricultural labor force, are particularly exposed, yet they are also at the forefront of adaptation and resilience efforts.

In Ethiopia – Women and Climate-Smart Agriculture

In Ethiopia, where rain-fed agriculture dominates and climate variability is a major constraint, gender-responsive climate-smart agriculture (CSA) initiatives have demonstrated measurable impact. Programs supported by government institutions and international partners have targeted women farmers through improved access to drought-resistant seeds, small-scale irrigation technologies, and tailored extension services. Women-led farmer groups adopting CSA practices—such as crop diversification, conservation agriculture, and water

Agri Facts

- Ammonia toxicity becomes more dangerous when pH and temperature rise—summer is the risk season.

harvesting—have reported improved yields, enhanced household food security, and greater resilience to climate shocks. Crucially, when women gained access to climate information services and participated in local decision-making, adoption rates and long-term sustainability increased significantly.

In Kenya – Women-Led Water and Natural Resource Management

In arid and semi-arid lands of Kenya, women's associations have played a pivotal role in community-based water management. Faced with recurrent droughts, women have organized around the construction and management of water pans, rainwater harvesting systems, and solar-powered boreholes. These initiatives not only reduced the time women spent collecting water but also strengthened agricultural productivity and livestock survival rates. By integrating women into local water governance structures, communities improved transparency, conflict prevention, and adaptive capacity.

In the Sahel Region – Women, Agroecology and Resilience

In the Sahel, where desertification and land degradation are acute, women farmers have been central to agroecological restoration efforts. Initiatives promoting farmer-managed natural regeneration (FMNR), composting, and the use of indigenous crops have enhanced soil fertility and biodiversity. Women's knowledge of local ecosystems and seed varieties has proven critical in restoring degraded land while ensuring household nutrition. These approaches underscore the value of aligning climate adaptation with traditional knowledge and gender inclusion.

Across these African experiences, a clear lesson emerges: when women are supported through secure land rights, access to finance, climate information, and leadership opportunities, agricultural resilience is significantly strengthened. Gender-responsive adaptation is therefore not only socially just but also economically and environmentally effective.

Morocco: Integrating Gender into Climate and Agricultural Transformation

Morocco offers an instructive example from the MENA region. As a country highly dependent on agriculture and vulnerable to climate change, Morocco has undertaken major reforms to integrate gender equality into development planning. Initiatives targeting oasis ecosystems,

rural women's cooperatives, and climate-resilient value chains illustrate how gender-responsive approaches can strengthen local adaptation while improving livelihoods.

National strategies aligned with sustainable development and gender equality objectives have helped create an enabling environment for women's economic empowerment, particularly in rural areas. These efforts demonstrate that gender equality is not only a social goal but also a strategic investment in climate resilience and economic sustainability.

Morocco is among the countries most exposed to climate change in the MENA region, with increasing water scarcity, recurrent droughts, and heightened pressure on agricultural systems. Given the strategic importance of agriculture for employment and food security, the country has adopted a proactive

approach to climate adaptation, increasingly recognizing the role of women as key actors of resilience.

Oasis Ecosystems and Women's Cooperatives

Oasis regions in southern Morocco represent some of the most climate-vulnerable ecosystems, facing water stress, soil salinization, and biodiversity loss. Gender-responsive development programs implemented in these areas have focused on strengthening women's economic empowerment through cooperatives specializing in date processing, aromatic and medicinal plants, and traditional products. By combining income-generating activities with environmental conservation and climate awareness, these initiatives have enhanced women's adaptive capacity

while preserving fragile ecosystems. Women's involvement in water-saving techniques and sustainable land management has proven essential to maintaining oasis resilience.

Argan Value Chain and Climate Adaptation

The argan tree, endemic to . Morocco, plays a vital role in combating desertification and supporting rural livelihoods. Women's argan cooperatives have become an internationally recognized example of gender-responsive, climate-resilient value chains. By organizing women producers, improving access to markets, and promoting sustainable harvesting practices, these cooperatives have contributed to ecosystem protection while generating stable income for rural women. Climate adaptation measures, such as sustainable forest management and diversification of income sources, have strengthened both environmental and social resilience

Climate-Smart Agriculture under National Strategies

Morocco's agricultural strategies have increasingly integrated climate adaptation and gender considerations, particularly in vulnerable rural areas. Programs supporting drip irrigation, drought-resistant crops, and agricultural advisory services have shown stronger results when women farmers are explicitly targeted. Tailored training and capacity-building initiatives have enabled women to adopt climate-smart practices, enhance productivity, and participate more actively in local agricultural governance.

Beyond sectoral programs, Morocco has undertaken institutional reforms to promote gender equality, recognizing it as a lever for inclusive and sustainable development. National planning frameworks increasingly emphasize gender mainstreaming across climate, agriculture, and rural development policies, reinforcing the link between women's empowerment and national climate resilience.

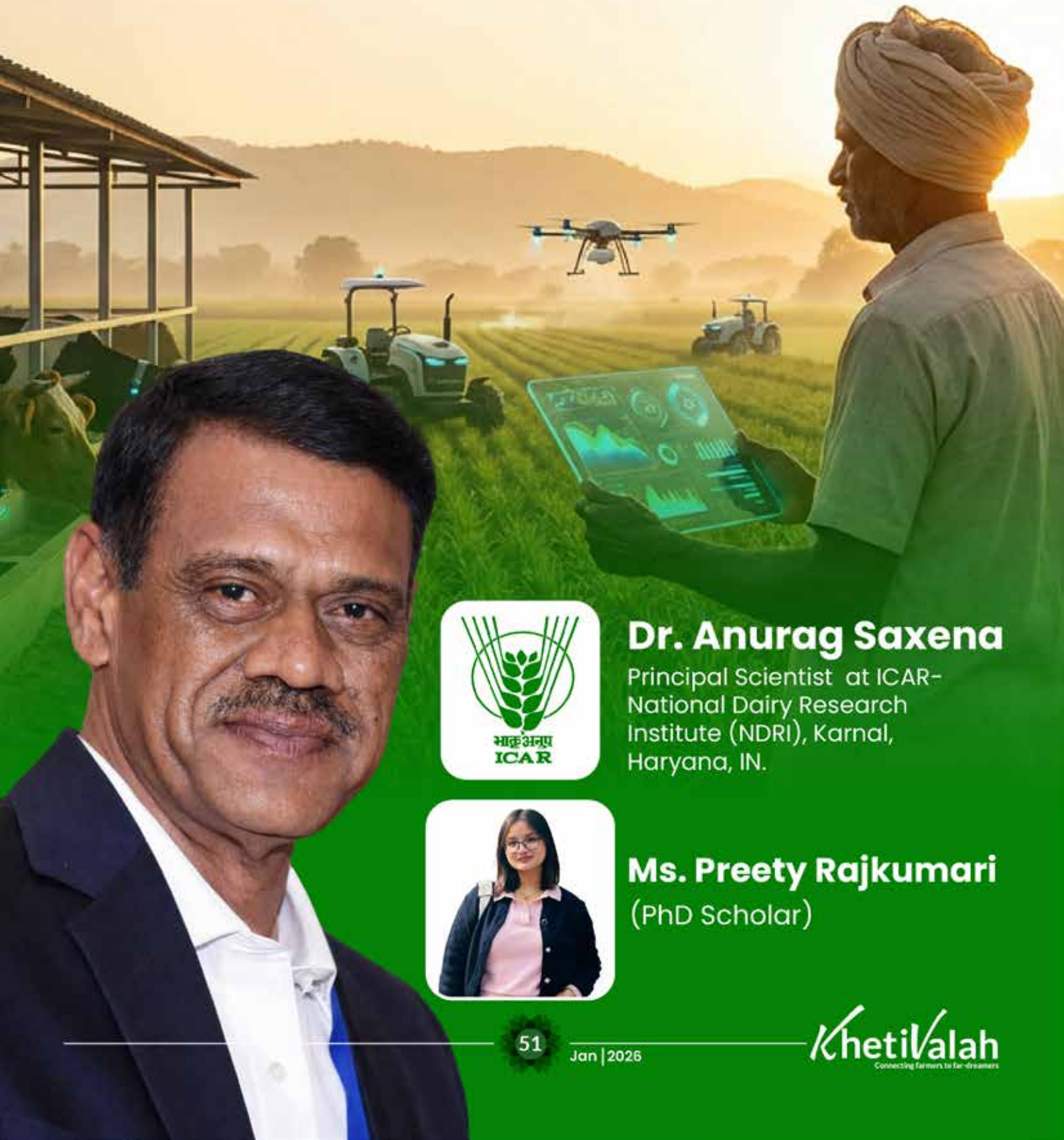
Conclusion: Investing in Women for a Climate-Resilient Future

Climate change demands collective, inclusive, and transformative action. Addressing its impacts on agriculture and food systems requires more than technical solutions—it requires tackling the underlying social and gender inequalities that shape vulnerability and resilience.

Women are at the heart of agricultural systems and rural economies. Empowering them is one of the most effective strategies to enhance climate resilience, improve food security, and promote sustainable development. Gender-responsive climate action is not a marginal issue; it is a cornerstone of effective climate policy.

Governments, international organizations, the private sector, and civil society must work together to ensure that women are recognized, supported, and empowered as key actors in climate adaptation and mitigation. By doing so, we can build agricultural systems that are not only climate-resilient, but also more equitable, inclusive, and sustainable for future generations.

Artificial Intelligence and Smart Machines: Transforming Precision Agriculture and Animal Husbandry



Dr. Anurag Saxena
Principal Scientist at ICAR-National Dairy Research Institute (NDRI), Karnal, Haryana, IN.

Ms. Preety Rajkumari
(PhD Scholar)

Feeding the world in the twenty-first century is one of humanity's most complex and pressing challenges. By 2050, the global population is projected to approach 10 billion, increasing food demand by nearly 70 percent. At the same time, agriculture faces shrinking cultivable land, severe water scarcity, declining soil health, labor shortages, and increasingly unpredictable weather patterns driven by climate change. These constraints make expansion through traditional methods neither feasible nor sustainable.

For decades, agriculture has relied on uniform management practices—applying the same quantity of water, fertilizer, or chemicals across entire fields and monitoring livestock largely through visual observation. While effective during times of abundant resources, such approaches are inefficient in today's risk-prone, resource-constrained world. Modern agriculture demands a shift from intuition-driven decisions to knowledge-based, precision-driven management.

This is where Artificial Intelligence (AI) becomes transformative. Operating quietly in the background, AI is reshaping how crops are grown and animals are managed. From satellites orbiting the Earth to sensors embedded in soil and smart collars worn by livestock, AI is transforming agriculture into a data-rich, precise, and adaptive system. Importantly, AI does not replace farmers; it strengthens their ability to observe, decide, and respond with confidence.

From Muscle to Mind: The Evolution of Farming

Agriculture has evolved from dependence on human and animal muscle to mechanized systems powered by tractors, harvesters, and irrigation pumps. These advances formed the backbone of modern agriculture and enabled food security across many regions. However, mechanization also encouraged uniformity, treating fields as single units and animals as herds rather than individuals.

In reality, agriculture is inherently variable. Soil fertility can change within a few meters, moisture levels fluctuate daily, pest pressure varies spatially, and each animal differs in health, productivity, and stress tolerance.

Agri Facts

- Alternate Wetting and Drying (AWD) in rice can reduce methane emissions and save water.
- Aquaculture now supplies more than half of global seafood consumption, overtaking wild capture in many regions.
- In fish ponds, dissolved oxygen crashes at night are a major cause of sudden mortality.

Today's agriculture is undergoing another transformation from muscle-driven systems to mind-driven systems. Farms are increasingly equipped with sensors, cameras, GPS-enabled machines, cloud platforms, and decision-support software that continuously collect data, learn from patterns, and assist farmers in making precise, timely decisions. This shift underpins precision agriculture and precision livestock farming.

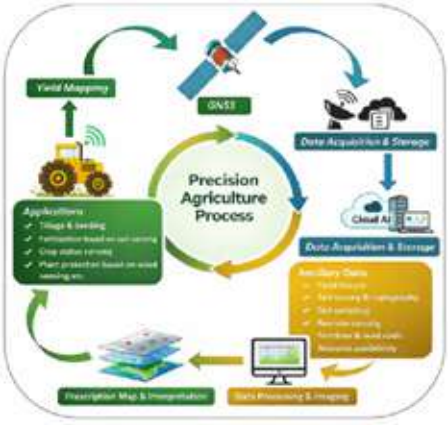
What Is Precision Agriculture?

Precision agriculture is the management of spatial and temporal variability in agricultural production. Instead of assuming uniform conditions, it recognizes that variability is the norm and seeks to manage it intelligently.

The central principle is simple yet powerful: apply the right input, at the right rate, at the right time, and in the right place.

This approach relies on a suite of technologies, including:

- Global Positioning System (GPS)–guided tractors and implements
- Satellite and drone-based remote sensing
- Soil moisture and nutrient sensors
- Yield monitors and crop growth models
- Automated and variable-rate application equipment



These tools allow farmers to "see" their fields in unprecedented detail. However, they also generate enormous volumes of data far more than can be interpreted manually. Artificial Intelligence plays a critical role by converting raw data into actionable insights, making precision agriculture practical and scalable.

Understanding Artificial Intelligence in Simple Terms

Artificial Intelligence refers to computer systems that perceive their environment, learn from experience, and make decisions to achieve specific goals. Unlike traditional software that follows fixed rules, AI systems improve as they process more data.

Key AI approaches used in agriculture include:

- Machine Learning (ML): Algorithms that identify patterns and relationships in large datasets. For example, ML models can predict crop yield based on weather, soil properties, and management practices.

- Deep Learning: A subset of ML inspired by the human brain, particularly effective in image and pattern recognition. It is widely used for detecting crop diseases, nutrient deficiencies, weeds, and animal behavior from images and videos.

- Expert Systems: Decision-support tools that mimic the reasoning of human specialists, offering recommendations on irrigation scheduling, fertilizer application, pest control, or animal health management.

Crucially, AI in agriculture is designed to complement—not replace—farmers. It enhances human expertise by providing timely, data-driven insights, enabling better decisions under uncertainty.

Smart Fields: AI in Crop Production

Yield Prediction and Risk Management

One of AI's most valuable contributions to crop production lies in prediction. By integrating historical yield data, soil characteristics, weather records, satellite imagery, and management inputs, AI models can forecast crop yield, biomass accumulation, and phenological stages such as flowering and maturity.

Such forecasts help farmers:

- Select appropriate crops and varieties
- Optimize sowing and harvesting schedules
- Plan storage and logistics
- Anticipate market supply and price trends

By reducing uncertainty, AI-based predictions improve both agronomic and economic resilience.

Watching Crops from the Sky

Remote sensing has revolutionized how crops are monitored. Satellites and drones equipped with multispectral and thermal sensors capture information on crop color, canopy structure, temperature, and reflectance. These subtle signals often reveal stress long before visible symptoms appear.

AI-driven image analysis converts this data into detailed crop health maps, highlighting areas affected by:

- Water stress
- Nutrient deficiency
- Pest infestation
- Disease outbreaks

Farmers receive early warnings through mobile apps or dashboards, allowing targeted interventions and preventing yield losses.

Intelligent Weed and Pest Management

Weeds and pests are among the most significant yield-limiting factors in agriculture. Traditional blanket spraying is costly, environmentally damaging, and often unnecessary.

AI-powered sprayers equipped with computer vision systems can distinguish crops from weeds in real time. Herbicides or pesticides are applied only where required, resulting in:

- Reduced chemical usage
- Lower production costs
- Less environmental pollution
- Slower development of resistance

This approach represents a major step toward sustainable crop protection.

Disease Diagnosis Through Images

Smartphone-based AI applications are transforming plant disease diagnosis. A farmer can photograph a diseased leaf, and AI algorithms compare the image against vast databases to identify the disease and suggest management options.

This rapid, evidence-based diagnosis:

- Reduces dependence on guesswork
- Enables timely control measures
- Minimizes unnecessary chemical application

Such tools are particularly valuable for smallholders with limited access to extension services.

Intelligent Irrigation: Saving Water Drop by Drop

Water scarcity is a defining challenge of modern agriculture. AI-driven irrigation systems integrate data from soil moisture sensors, weather forecasts, and crop growth models to determine precisely when and how much water is required. Automated delivery through drip or sprinkler systems improves water-use efficiency, reduces energy consumption, and enhances yield stability especially in arid and climate-vulnerable regions.

Beyond Crops: AI in Animal Husbandry

Precision agriculture now extends into precision livestock farming, where individual animals become the focus.

Continuous Monitoring of Animal Health and Behavior

Wearable sensors and smart collars continuously record animal movement, feeding behavior, rumination, posture, and body temperature. AI algorithms analyze these data streams to detect deviations from normal behavior often the earliest indicators of illness or stress.

Farmers receive automated alerts when animals show signs of:

- Mastitis
- Lameness
- Heat stress
- Postpartum disorders

Early detection enables timely treatment, reducing losses and improving animal welfare

Predictive Disease Management

Machine learning models use milk yield, milk conductivity, activity patterns, and physiological indicators to predict disease onset before clinical symptoms appear. This predictive approach shifts animal health management from reactive treatment to preventive care, lowering veterinary costs and improving productivity.

Automated Milking and Reproductive Management

Robotic milking systems represent one of the most successful applications of AI in dairying. Cows voluntarily enter milking units where AI monitors milk yield, quality, and udder health in real time. These systems reduce labor dependency while improving consistency and hygiene.

Similarly, AI-based estrus detection systems analyze movement and behavioral data to accurately identify heat periods, significantly improving breeding efficiency and reproductive performance.

Big Data, IoT, and the Connected Farm

Modern farms are becoming integral parts of the Internet of Things (IoT) networks of interconnected sensors, machines, and platforms that continuously exchange data. Weather stations, soil probes, drones, livestock sensors, and farm machinery collectively generate vast volumes of agricultural data.

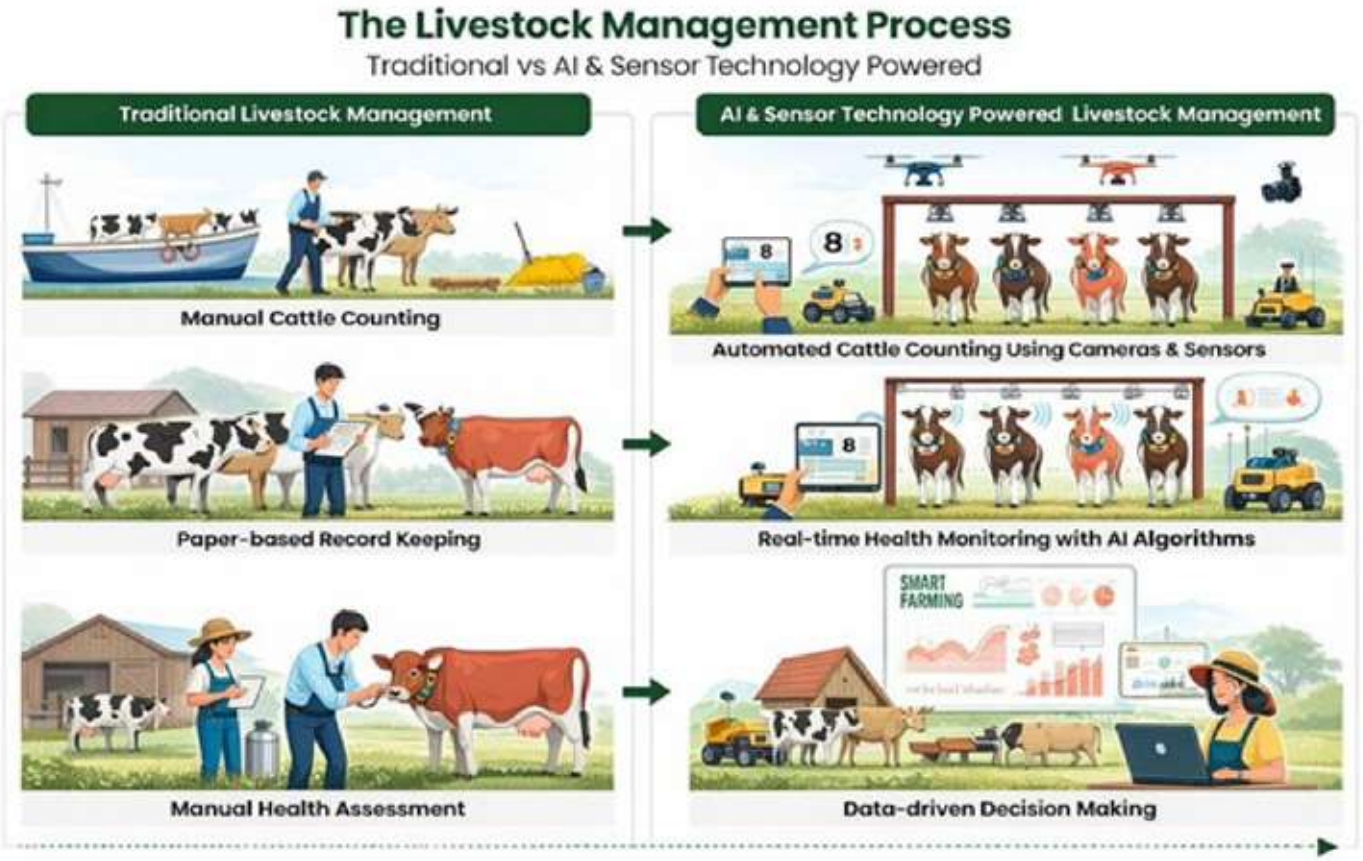
AI transforms this "big data" into usable knowledge by:

- Filtering noise
- Detecting trends and anomalies
- Supporting real-time decision-making

Agri Facts

- Mulching reduces evaporation, suppresses weeds, and improves soil temperature stability.
- Protected cultivation enables off-season production and premium pricing but demands strict humidity control.
- In polyhouses, high humidity increases risk of fungal diseases like botrytis and powdery mildew.
- Calcium disorders like blossom-end rot in tomato often result from irregular watering and poor transpiration.

User-friendly mobile apps and dashboards present complex analytics in intuitive visual formats, making advanced technology accessible even to non-specialists.



Automated Milking and Reproductive Management

Despite its promise, AI-driven agriculture faces several challenges. Digital literacy varies widely, high-quality data may be unevenly available, and technology costs can be prohibitive for small and marginal farmers. Infrastructure limitations, such as internet connectivity and power supply, also pose barriers in many rural areas.

At the same time, agriculture operates under inherent uncertainty weather extremes, pest outbreaks, and volatile markets demand constant adaptation. These challenges, however, also highlight why AI is essential. Intelligent systems capable of learning and adapting will be crucial for building climate-resilient and sustainable food systems.

Why AI in Agriculture Matters

Artificial Intelligence is no longer a futuristic luxury; it is rapidly becoming a necessity. By enabling higher productivity with fewer resources, AI reduces environmental impact, improves farmer incomes, enhances animal welfare, and strengthens food security.

Most importantly, AI empowers farmers with knowledge transforming raw data into timely decisions and uncertainty into opportunity. The farm of the future will not be run by machines alone, nor by humans alone, but through a thoughtful partnership between the two—helping redefine how food is produced, efficiently, responsibly, and intelligently, for a world that must feed more people with fewer resources than ever before.

Agri Facts

- Pollination can become a limiting factor in protected crops unless managed with bees or manual support.

Building Healthy Soils for Higher and Sustainable Crop Productivity

Dr A. Subba Rao

Dr. A Subba Rao
Ex. Director, ICAR-IISS, Bhopal

Contributions are well recognized in the field potassium and phosphorus chemistry and fertlity, integrated plant nutrient recommendations, soil test based nutrient management for achieving targeted yields of crops. Developed and field tested farmers' resource based integrated nutrient supply systems in some agroeco-regions. As Director, IISS, Bhopal initiated several national and international collaborative research projects, NAIP Projects, central and state government funded projects in the areas of soil health, climate change,nanotechnology, biofortification, biodiversity. Several projects completed have provided valuable information in the areas of soil test based nutrientrecommendations, soil health, soil contamination, quality of different manures/composts, composting techniques, phytoremediation, nanotechnology, carbon sequestration and crop adoption to climate change.Published over 120 research papers in reputed national and international journals in the field of specialization of "Soil chemistry, soil fertility, soil testing, integrated nutrient management, climate change and carbon sequestration".

A healthy soil is a dynamic living system that is capable of providing multiple benefits to agro-ecosystems such as sustaining plant and animal production and health, enhancing or maintaining air - and water quality, controlling nutrients availability in soil, accumulating soil carbon, supporting biodiversity and reducing soil erosion. Soil health is foundation of sustainable agriculture, directly influencing crop productivity, environmental quality and resilience of farming system.

The key soil functions include

1.Food and other biomass production
2.Environmental interaction
3.Biological habitat and gene pool
4.Source of raw materials
5.Physical and cultural heritage and
6.platform for man-made things,

Soil health indicators can be grouped into chemical, physical and biological measurements that assess how the soil is functioning. The common soil health indicators include soil organic carbon, pH and nutrient levels, electrical conductivity and cation exchange capacity (Chemical), texture, soil structure, penetration resistance, bulk density and water infiltration (Physical) and the presence of earth worms and microbial biomass, enzyme activity and soil respiration (Biological).

There are six soil characteristics/parameters which favorably influence soil health that intern help to sustain plant and animal life on the planet earth. They are soil structure, soil organic matter, soil pH, crop nutrient supply from soil, biodiversity/biological activity and soil erosion.

Soil structure

Soil structure is the arrangement of individual soil particles (sand, silt and clay) into larger aggregates. The arrangement of soil particles and pore space between them determine the ease of movement of air and water and plant roots spread in the soil. Soil structure determines water retention, air circulation, root growth and drainage. In well structured soil deep and dense root systems develop. Adequate aeration allows the roots to breathe and microorganisms to thrive in the soil.

Addition of organic materials like compost, manure, leaf letter and crop residues increase the soils ability to bind the soil particles, thus promote aggregation. Zero tillage or minimum tillage maintains or improves the soil structure, reduces soil erosion and improves soil health. Cover crops help to improve the organic matter status of soil, reduce erosion, reduce compaction, improve water retention and infiltration rate.

2. Soil organic matter

Soil organic matter is the life blood of soil. It is a mixture of living organisms, dead plant, animal remains and microbial residues which form both active, easily decomposable and stable, long lasting humus (the term organo-mineral complexes, is now being used in place of humus). It plays crucial role in soil health, influencing soil physical, chemical and biological properties by improving soil structure, retaining water, cycling and making available plant nutrients and supporting microbial life. Soil with high organic matter content is typically darker in colour,

emits earthy smell and possesses good water conducting properties. Application of manure/compost at recommended rates, mulching, green manuring and cover crops etc help in maintaining or improving soil organic matter status.

3.pH Regulation in Soil

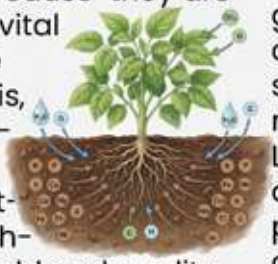
Soil pH governs the availability of different plant nutrients by changing their ionic form and also by influencing their solubility with the most nutrients are optimally available in the pH range of 6.0 to 7.5.Highly acidic or alkaline soils leads to nutrient deficiencies or toxicities, as some nutrients may become insoluble or fixed and some others may be excessively soluble. So it is essential to maintain optimal soil pH to ensure the availability of adequate amounts of different nutrients for normal plant growth and development.

In acid soils the common nutrient deficiencies are P, Ca, Mg, B, Mo and toxicities of Al and Mn may manifest in some acid soils. In sodic soils the common nutrient deficiencies include P, Fe, Mn , Zn and Cu which becomes less available as soil pH increase.

The common amendments like lime for acid soils, gypsum and sulphur for sodic soils are being used to adjust the soil pH in the range 6.0 to 7.5.Application of farmyard manure also moderates soil PH. Alternative materials and methods are also available for amelioration of acid and sodic soils.

4. Crop Nutrient demand and supply from soil

Plants need 17 essential nutrients for their normal growth and development. Plant nutrients are critical for crop production because they are essential for vital processes like photosynthesis, enzyme function and cell division, directly impacting their growth, yield and quality.



Plants require macro (N,P,K, Ca,Mg,S) in greater amounts and micronutrient (Fe ,Mn, Cu,Zn,B,Cl) in smaller amounts to meet the plant nutritional requirements. Plants exhibit deficiency symptoms when nutrients in short supply. Plant nutrient requirements change throughout the plant's life cycle, with high demand for macronutrient N, P and K during rapid growth stages, and phosphorus during both early stages and also at tillering and panicle initiation. Micronutrients, though required in small amounts, they are required for various physiological processes including enzyme function and chlorophyll production. Imbalanced nutrients use leads to reduced plant growth, soil acidification, changes in soil biota and altered soil chemistry

Based on soil testing prescribed amounts of both macro and micronutrients nutrients are supplied through fertilizers, manures/compost and biofertilizers . The more the input of organic sources, the less will be the dependence on fertilizer nutrients. Crop rotations, residue recycling, green manuring and cover crops apart from enhancing soil health, also play role in nutrient supply to crop plants. Leguminous cover crops fix atmospheric nitrogen and provide nitrogen to the next crop and prevent nutrient leaching.

Agri Facts

- The global poultry market size was estimated around US$ 300+ billion in 2024 and is expected to keep growing strongly with rising protein demand.
- Brazil is among the world's largest chicken exporters, supplying major markets in Asia and the Middle East.

5. Biological activity in soil- the life beneath the soil surface

Soil teems with billions of diverse microorganisms including bacteria, fungi and other microorganisms and invertebrate, playing crucial roles in regulating and sustaining soil heath. Biodiversity maintenance is essential for crop productivity sustenance through enhanced nutrient supply, nutrient cycling, improved soil structure and crop resilience against the pests and diseases. Loss of biodiversity can disrupt the delicate balance of the soil food web, reducing the ability of microbes to carry out important processes like organic matter decomposition, nutrient fixation and release.

Practices which promote soil biodiversity are crop rotations, reduced tillage, and regular application of organic manures, composts, green manuring and crop residues. Minimum tillage avoids soil disturbance and favors the buildup of soil organic matter in soils which serves as both food and energy source for the soil biota.

Less use or no use of herbicides and soil insecticides help in the buildup of the population of diverse soil microbes and help them to carry out their functions optimally.

Soil erosion

Soil erosion is the loss of the top soil from the land's surface because of the action of water, wind and ice. This process is accelerated by the human activities including deforestation, intensive agricultural practices like tilling, over grazing and improper land use and construction activities (construction of roads and buildings etc). The consequences of erosion are loss of fertile soil, loss of organic matter and plant nutrients, reduced agricultural productivity, sedimentation in rivers and streams, clogging the water ways and environmental degradation. When top soil is lost, the soil becomes less fertile and will not be able to support plant growth, which can lead to decline in ecosystems and decreased agricultural productivity. Soil health deteriorates when essential plant nutrients and organic matter contents are reduced or lowered in soil.

The best practices to control soil erosion include soil conservation practices like conservation tillage, use of cover crops and creating physical and vegetation barriers. Cover crops and crop residues prevent soil erosion by protecting the soil surface from the wind and rain, improving the structure of the soil and conserving moisture.

Agri Facts

- Poultry is one of the fastest feed-to-meat conversion industries, which is why broiler farming expands quickly in many countries.
- In commercial layer farming, White Leghorn lines are widely preferred for high egg numbers and efficiency.
- A well-managed commercial layer can produce around 280–320 eggs/year depending on strain, feed quality, and environment.
- Feed cost commonly forms 60–75% of total poultry production cost, making feed management the #1 profit lever.

Actionable points to build soil health

Assessment and Monitoring

1. Test soils at some periodicity for pH, organic matter, nutrient levels and biological activities. Apart from conventional soil tests, soil health sensors now available that measure key soil properties like moisture, temperature, pH, nutrients (NPK) and electrical conductivity to provide real-time data for precise application of input like water and nutrients and crop health, often via IOT, for analysis and decision making. Digital soil fertility maps can also be used for the application of nutrients from different sources.

Balanced plant nutrients application taking care of both macro and micronutrient for overall plant health and performance is desired. While managing nutrient supply, right source, rate, time and method need to be followed for diverse soils and crops.

2. Amending soils for correcting soil reaction and improving soil structure

- Apply requisite amounts of lime to acid soils and gypsum/sulphur to alkali/sodic soils to bring the soil pH in the 6.0-7.5 range. Addition of farmyard manure and composts also help in moderation of soil pH and amelioration of the problem soils.
- Apply compost and organic manures in adequate amounts to build the soil organic matter status
- Utilize organic amendments and green manure etc. replenishes the soil nutrients.
- Improving soil structure
- Regular additions of manures, composts, residue recycling, cover crops etc. to build good soil structure.
- Alleviate compaction using sub soiling or growing deep rooting crops
- Maintain living roots –round the year (using cover crops) to increase aggregation and porosity

3.Encouraging beneficial organisms/ biodiversity conservation

- Inoculate soils with beneficial microorganisms-bacteria, fungi and mycorrzal inoculants
- Monitor and reduce heavy metal input to soil to support a diversified, resilient microbial ecosystem

4. Restoring vegetative cover

- Plant cover crops, restore marginal land and minimize bare fallow.

KV Dialogue
Website Launch

The Official Website of KV Dialogue Global Series is Now Live!

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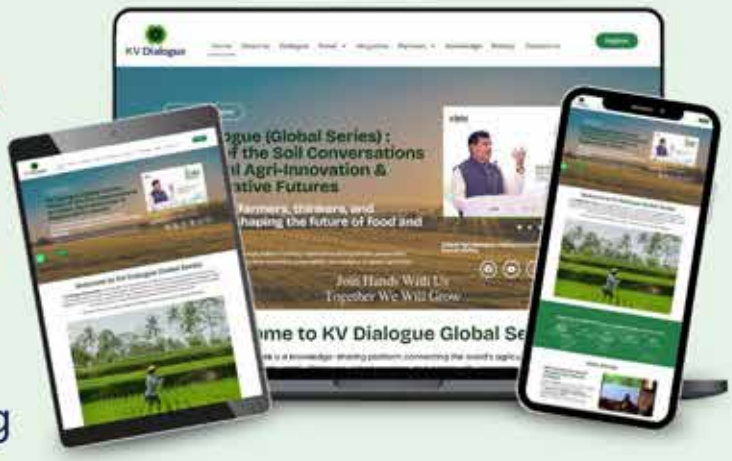

KhetiValah Dialogues will be presented in various regional and international languages:

Language	Name of the Dialogue	Day
English	KV Dialogue (Global Series)	Friday
Telugu	ఖేతీవలः చర్చ – KhetiValah Charcha (Telugu)	Thursday
Tamil	கவே உரையாடல் – KV Uraiyadal (Tamil)	Wednesday
Hindi (National)	खेती संवाद – KhetiSamvad (Hindi)	Monday
Uttar Pradesh	खेती संवाद – KhetiSamvadUP (Hindi)	Wednesday
Madhya Pradesh	खेती संवाद – KhetiSamvadMP (Hindi)	Friday
Marath	शेती संवाद – ShetiSamvad (Marathi)	Tuesday
Assamese	খতেি সংলাপ – KhetiSanglap (Assamese)	Tuesday
Gujarati	ખેતીનો સંવાદ – KhetinoSamvad (Gujarati)	Wednesday
Bengali	খতি সংলাপ – KhetiSanlapa (Bengali)	Saturday
Rajasthani	खेता री बातां – Kheta Ri Bataan (Rajasthani)	Thursday
Kannada	ಖೇತೀವಾಲ ಸಂವಾದ – KhetiValahSamvada (Kannada)	Thursday
Odia	ଚାଷୀ ସଂଳାପ – ChasiSanglapa (Odia)	Tuesday
Meghalaya	KhetiKobor (Meghalaya)	Monday
Other countries		
Philippines	KV Diyalogo (Filipino)	Every Wednesday
Sri Lanka	කථිකා කිරීම – KarthikaKireema (Sinhala)	Every Wednesday
Other Verticals		
UrbanKrishi	Urban Gardening & Farming	Every Friday
TattvaVedika	Artificial Intelligence Dialogues	Thursday
NaariShakthi Samvad	Women Empowerment Dialogues	Saturday

Makhana- A Fast Emerging Superfood of India

Dr. Vidyanath Jha is a distinguished botanist, academic administrator, and science educator with more than four decades of teaching, research, and leadership experience. He retired as Professor of Botany and Principal of constituent colleges under L.N. Mithila University, Darbhanga. A former CSIR Research Fellow and recipient of several national research projects and visiting fellowships (UGC, INSA, CSIR), Dr. Jha is nationally known for his pioneering work on Makhana (Euryale ferox) and its role in the economic development of Bihar. He has published over 150 research papers, 200 popular science articles, and three books, and has served on the editorial boards of reputed scientific journals. Recipient of numerous national and international honors, including the Prof. P. Sensarma Medal, World Environment and Leadership Award, D.Litt. (Honoris Causa), and Lifetime Achievement Award, Dr. Jha continues to contribute actively to science, environment, education, and regional development through writing, lectures, and public outreach.

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Makhana (Euryale ferox Salisb.) is a rooted floating macrophyte growing in stagnant fresh water pools of north and north eastern India. A number of fossil reports from the European countries reveal its wider distribution in the past. However, no extant E. ferox is to be seen in that continent today.

Till about four decades back Makhana was held as an obscure crop outside the area of its cultivation. It was after a consistent public demand that a National Research Centre (NRC) for Makhana was set up at Darbhanga under the ICAR (Indian Council of Agricultural Research) setup. The first ever variety of the crop under the name of SWARNA VAIDEHI was released by the NRC (Kumar et al. 2015, 2016). Proper estimation of genetic divergence in the plant could lead to the development of other improved varieties.

Another variety called SABOUR MAKHANA was released by the Bihar Agricultural University; Sabouron the basis of work done under its setup at the Purnea based BPS Agricultural College. Certified seeds of Makhana are made available by these two institutes sxto the farmers in about a dozen districts of Bihar earmarked for Govt. subsidy of 75% on its cultivation.

Farmers from different states have received training at the two main centres of Makhana research at Darbhanga and Purnea. E. freox plants could be raised through tissue culture and made available to the needy farmers for its enhanced production (Kumaretal.2020).-

Commercial production of Makhana plants needs to be undertaken.

Infestation of the human pandemic called COVID 19 got in tensified on account of weak immune system. It was during this period that the immune stimulant properties of Makhana were publicized and there was a steep rise in its demand. Raising the production of the crop as well as its productivity has emerged as a major challenge before the growers.

Agri Facts

- In dairy, the biggest invisible loss is often subclinical mastitis, which reduces yield without obvious symptoms.

Makhana Cropping System

Makhana based cropping system incorporates its integrated aquaculture with fishes and the rotational cropping with other arable and water crops. Fishes like Singhi, Mangur, Kabai, Saura etc. have Makhana ponds as their ideal habitat. The rich detritus sustains the growth of these air breathing/detritivores fishes. Farmers, however, now leave sufficient open spaces in the middle and peripheral portions of these ponds to facilitate the dissolution of atmospheric oxygen. Thereby the culture fishes like Rohu, Katla, Mrigal etc. are also made to survive in Makhana ponds. Thus, Makhana based water bodies are serving idea reservoir to facilitate the country wide fight against the protein based malnutrition

Stages of Crop Growth Cycle

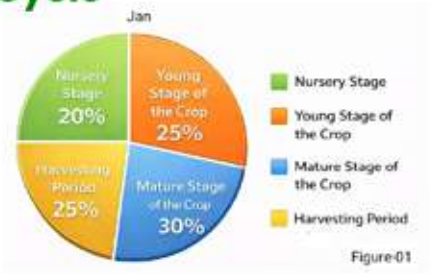

Figure-01

Makhana is basically a 7 to 8 months crop that starts from January. During April to July- August it is in its grand growth stage with flowering and fruiting. Harvest is performed during August-September.The pond is utilized for growing fishes like Rohu, catla, Mrigal during this vacant period. Alternatively this period (September-December) is utilized for cultivation of water chestnut (Trapanatansvar. bispinosa). Under the Khet me Khetisy stem the crop is transplanted during April. Under such a dispensation Rabicrops likewheat /potato /Torietcare grown during January-March,with some overlappings in April as well.

Harvest of the crop is made by the fishermen by making dives into the pond water. They virtually sweep the floor and bring the raw seeds as horeby using bamboo appliances called Auka and Gaanj (Jha et al 2003). The pond remains vacant for 3-4 months during September-December and are utilized for growing the culture fishes that are harvested before the influx of submerged weeds and Makhana plantlets. The detritivores/airbreathing fishes like Singhi, Mangur, Kabai, Saura etc. remain stuck to the bottom and it is difficult to harvest them unless the pond water is fully emptied. The detritus is quite rich in nutrients and sustains these fishes well. Angle fishing is the best way to take them out by the anglers. Nothing except seed is taken out of the pond. The plants are damaged about a fortnight before the actual harvest to facilitate them to decay and disintegrate.

The culture shows ponds in village Raje of Mangachhi CD Block of Darbhanga district that now has a sprawling growth of lotus (Nelumbo nucifera). It was till the year 2022 that this pond was used for Makhana cultivation. In view of steep fall in the price of Makhana during 2022 Makhana farmers chose not to cultivate it this year (i.e., 2023) and instead opted for only fish cultivation. However, lotus seeds which are known for their long dormancy found an opportunity to germinate and spring up. N.nucifera is a perennial plant and sprouts up when any such occasion arises. E.ferox is also enumerated as a perennial plant but in order to facilitate the harvest of its seeds lyingat the pond bottom that the spiny plants have to be

destroyed. As such at the best it is an annual crop only.

Fig.03 shows a water pocket adjacent to the famous Rajokhari tank in the village Keoti (CD Block Keoti Ranway) in Darbhanga district during November 2022. The farmer of this water body also chose not to harvest the

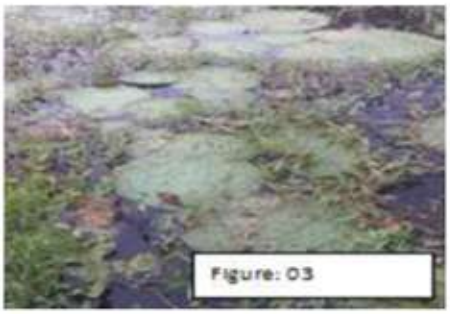
Figure: 03

Fig.03 shows a water pocket adjacent to the famous Rajokhari tank in the village Keoti (CD Block Keoti Ranway) in Darbhanga district during November 2022. The farmer of this water body also chose not to harvest the seeds and allowed the plants to remain as such. This was because the harvest would have incurred more expenditure over the wages to be given to the harvesters.

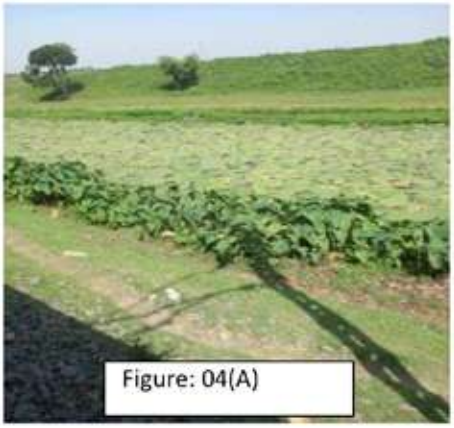
Figure: 04(A)

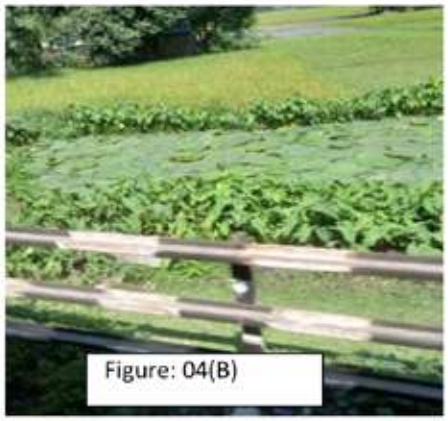
Figure: 04(B)

Fig.04 (A & B) shows Makhana being grown in a waterlogged patch east of the eastern Kosi embankment in Supaul district inbetween Saraigarh and GarhBaruari railway stations. Colocasia sp. and Garmadhan are also seen being grown side by side. Colocasia sp. growing extensively in the area is utilized as a cuisine in the region and is a good source of mineral supplements.

In view of the growing demand of Makhana at national and global levels, farmers have geared up to raise the area under its cultivation. However, keeping in view the market uncertainties these farmers are now raising the demand for minimum price guarantee for this crop as well six districts of north Bihar (Darbhanga, Madhubani, Saharsa, Supaul, Katihar and Araria) have been earmarked for promotion of Makhana under ODOP (One District One Product scheme).

There is a practice of sending the gift of Makhana to the groom by the parents of a newlywed woman. Ayurvedic system of Indian medicine holds Makhana to have spermatogenic action. It helps arrest the process of spermatorrhoea. Recent trial shave substantiated this fact.

Simple garlands made of Makhana pops are now offered to the baratis (those accompanying the groom during wedding).

Exquisite Makhana garlands are offered to the distinguished guests and deities. Efforts are being made to popularize Makhana garlands as the barmala during wedding. Mithila region has a much diversified way of utilizing.

Makhana. Several culinary items prepared from it include dessert (powdered Makhana cooked in milk), snacks (fried and salted pops), paag (roasted in a solution of jaggery/sugar), rayata (salted, paste form), barfi etc. Several types of laddoos are also prepared. Panjiri offered to Lord Krishna at Mathura and other places in the country includes Makhana pops as an essential component. Outside Mithila, Makhana dessert has intact pops in swollen form. Recent years have also witnessed a new connotation to the meaning of Dal-makh(a) ni. Earlier it was meant for pulse cooked in butter and consumed by the affluent Punjabis. But now pulses are cooked with Makhana pops as well.

That way the overlapping of pronunciation applies to Makhana in reality.

Patent has been granted to CIPHET, ICAR in 2013 on Mechanized System for Popping and Decortications of Makhana Seeds (Gorgon Nut). Euryale ferox. It has been developed by the scientists S. N. Jha and R. K.Vishwakarma. It has been granted GI tag under the name of Mithila Makhana. It was a disgrace that the national status to NRC, Darbhanga was later withdrawn. The NRC status has been restored to it in the year 2023. S.N.Jha and B.B.Verma (ICAR) obtained an Indian patent on Instant Makhana Kheer Mix. Constituents of the mix include ground popped Makhana, whole milk powder or dairy whitener, sugar and optional ingredients to enhance taste, flavor, color and stability.

Makhana and Climate Resilience

Last few years have witnessed Makhana turning into a climate resilient crop, more so in the Madhubani and Darbhanga districts of north Bihar. In these two districts Makhana has been traditionally cultivated in ponds having 4-5 feet deepwater. But recent years have witnessed a decline in the annual precipitation. As such the farmers have taken are course to cultivating the crop in about 1.5-2 feet water only. This new development in Makhana cultivation has been christened as Khet me Kheti (i.e., Makhana cultivation in arable plots) (Kumar & Jha. 2022).

In the eastern districts of theerst while Purnea division this method of Makhana cultivation in arable plots has been practiced since a long time. This is because the are alies in Kosibas in where water table is high and there is a tradition of extracting ground water through bamboo borings at a cheaper rate. There is a trend of cultivating Makhana, Garma dhan (summer paddy) and Makai (maize) in the adjacent plots. This is a common practice observed in between Kursela and Kishanganj alongside the railway line between Barauni and Guwahati.

A Rampant Confusion Over Makhana Being a Product of Lotus

Makhana is largely confused to be a product of lotus (Nelumbonucifera). The latter has a wider global distribution while the former is confined to the northern India, Korea, Japan and China. As both the aquaphytes belong to the same water lily family Nymphaeaceae, Makhana pops are generally considered to be the product of lotus, which is a misnomer. Google/Internet is full of this misnomer that needs to be corrected. More so; its cultivation is localized in about a dozen districts of Mithila zone in northern Bihar and the border areas of Nepal and Bangladesh.

In India also, its wild populations are found in the north western temperate lakes of Kashmir to the north eastern lakes and water bodies of Assam, West Bengal, Odisha, Tripura and Manipur. Local in habitants in Manipur harvest its fruits with the help of angle rods while plying on boats in the water bodies. The intact fruits thus collected are mostly sold in the Ema market of Imphal. It is generally the cuisines prepared from the raw parts of the plant and its fruits that are consumed. There is a need to incorporate the utility practices in Mithila area to Manipur lakes and vice versa. The young plantlets during February-April have to be simply discarded to facilitate sufficient open spaces for full expansion of only the desired number of plants. These young plant lets need to be harnessed for the diverse groups of secondary metabolites that could be utilized for nutraceutical purposes.

Agri Facts

- Milk fat drop is frequently linked to low effective fiber and rumen acidosis, not only genetics.
- A cow's milk yield is closely tied to dry matter intake (DMI)—intake is the real engine of production
- A cow's milk yield is closely tied to dry matter intake (DMI)—intake is the real engine of production

Migration of Fishing Community for Makahana Harvest and Popping Purposes

It is generally the fishermen from Darbhanga and Madhubani districts who migrate to the districts of Kosi and Purnea divisions and other adjoining are as of West Bengal and Assam to perform the job of harvest and post-harvest pop making processes. Earlier only the male members of fishing community used to migrate. But growing economic compulsions now leave them no option but to move along with their f amilies and children. Often they have to fend with the unhygienic situation at the processing sites. They are traditionally skilled to perform these arduous tasks. The socio-economics of this internal migration of fishing communities for 4-6 months at a stretch needs to be studied. Technological interventions have been made in the field of Makhana processing. The popping machine developed by the Central Institute of Post Harvest Engineering and Technology, Ludhiana has now achieved perfection. The machine needstobe madeavailableto the poor Makhana growers at cheaper rates. This would help minimize the role of middle men in this business. There is a need to make the harvest process less arduous. A number of entrepreneurs have joined the industry of developing processed Makhana eatables with various flavours and tastes.The affluent businessmen now purchase raw seeds from the growers in Mithila area and get the guris (raw seeds) processed at CIPHET, Ludhiana.

Makhana has attracted a global attention on account of a number of nutritional and medicinal properties that have come to light in recent years. It has been found to have a low glycemic index (Liaquat et al. 2022). It is gluten free diet effective in heart ailments and several other diseases.

A recent paper by Mahesh Kumar et al, (2023) has thrown light on nutrient composition, in vitrostarch digestibility, individual polyphenols and antioxidant properties of raw and popped Makhana. A study made by Biswas Et Al (2020) refers to the enzyme mediated resistant starch production from this plant. Devi et al (2020) studied the effect of popping on physicochemical, technological, anti oxidant and microstructural properties of Makhana. Leaves of E. ferox are also a rich source of anthocyanins and need to be exploited for this property as well (Wu et al. 2020). Seed coat of E. ferox that is simply used as fuel during pop making has been found to be hepatoprotective (Jian et.al. 2019). As such there is a need to explore it in detail for its drug potentials. Recent decades have witnessed a growing realization at global level in favour of Makhana emerging as a superfood. This is because of a number of researches substantiating its nutritional and medicinal significance (Jha et al, 1991a, b. 2018, He et al 2019, Kapoor et al 2022, Jiang et al 2023 etc). It is with a view to popularize Makhana at a global level that items made of Makhana were displayed during the recent G20 summit at Delhi (Fig.05

Govt of India has setup a Makhana Board and is hoped that now Makhana production would get a boost by bringing more and more areas in different states under its cultivation.

Agri Facts

- Calf colostrum timing matters: feeding early improves immunity and survival dramatically.
- In beef and dairy, heat stress reduces fertility before it visibly reduces milk—reproduction is the first hit.
- Mycotoxins in feed can reduce growth and immunity even when animals look "normal."

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Vertical Farming in Horticulture:
A Sustainable Solution for Urban Food Security and Climate-Resilient Agriculture

Dr. Cipriano M Ticman Jr

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Dr. Cipriano M. Ticman Jr. is an Assistant Professor I and Institute Director at Isabela State University – Cauayan Campus, Philippines. His work is centered on the agricultural sector, with a strong emphasis on practical improvements in production systems. He prioritizes efficiency, sound resource management, and sustainable, evidence-based approaches over outdated practices and guesswork.

Dr. Ticman is actively engaged with farmers and other agricultural stakeholders, promoting modern technologies and informed decision-making through training, extension, and knowledge transfer. He recognizes the significant influence of environmental conditions, market dynamics, and policy frameworks on agricultural performance.

His work supports the efficient and sustainable use of agricultural resources in response to current production and development challenges.

Opening Insight

In many parts of the world, the question is no longer whether food can be produced, but where and how it can be grown sustainably amid shrinking land, changing climates, and expanding cities. The increasing distance between farms and consumers has renewed interest in production systems that are efficient, resilient, and closer to urban populations. Vertical farming has emerged within the context not as a replacement for traditional agriculture, but as a complementary approach that rethinks how horticultural crops can be grown in the modern world.

Introduction

Horticulture plays a vital role in human nutrition, public health and livelihoods across different regions of the world. From fresh vegetables in urban markets to fruits and herbs supporting local economies, horticultural crops contribute significantly to food security and income generation in both developed and developing countries. However global trends such as rapid urbanization, climate variability, declining arable land, and increasing pressure on water resources are challenging conventional horticultural production systems.

These constraints are no longer limited to one region or country. Cities across Asia, Europe, Africa, and the Americas face similar concerns: growing populations, longer food supply chains, postharvest losses, and reduced access to fresh produce. In this global context, vertical farming has emerged as a practical and adaptable approach to horticultural production. By cultivating crops in vertically arranged systems under controlled environmental conditions, vertical farming offers a location-independent solution that can be tailored to diverse climatic, economic, and social settings. This article explores vertical farming in horticulture from a global perspective, highlighting its technologies, crop suitability, benefits, challenges, and future potential in building sustainable and climate- resilient food systems.

Understanding Vertical Farming

Vertical farming refers to the cultivation of plants in vertically stacked layers, often within enclosed structureswhere environmental conditions are carefully regulated. Unlike conventional farming, which depends heavily on natural soil and climate, vertical farming relies on controlled environment agriculture (CEA) to manage temperature, humidity, light, carbon dioxide levels, and nutrient supply.

These systems can be established in a wide range of spaces such as warehouses, rooftops, greenhouses, shipping containers, and unused urban buildings. By bringing food production closer to consumers, vertical farming helps shorten supply chains and ensures the availability of fresh, high quality horticultural produce throughout the year.

Agri Facts

- Pre-harvest calcium sprays can improve fruit firmness and shelf life in several fruits.

Key Principles Behind Vertical Farming

The effectiveness of vertical farming in horticulture is based on a few simple but powerful principles:

- Making efficient use of vertical space to increase production per unit area
- Maintaining a controlled growing environment for uniform crop growth
- Using soilless cultivation systems for precise nutrient and water management
- Minimizing pest and disease pressure, thereby reducing chemical inputs
- Locating production units near markets to reduce transportation losses.

Together, these principles allow growers to achieve consistent yields and quality while using fewer natural resources.

Technologies That Enable Vertical Farming

Soilless Growing Systems

Soilless cultivation is central to vertical farming. The most commonly used systems include hydroponics, aeroponics, and aquaponics. In hydroponics, plant roots are immersed in or periodically exposed to nutrient-rich water solutions. Aeroponics involves suspending plant roots in air and misting them with nutrients, while aquaponics integrates plant production with fish culture.

These systems provide plants with balanced nutrition, promote faster growth, and significantly reduce water use compared to traditional soil-based farming.

Lighting Solutions

Since sunlight is often limited in indoor environments, artificial lighting plays a crucial role in vertical farming. Light emitting diode (LED) technology is widely used because it is energy efficient and allows precise control over light intensity and spectrum. Specific wavelengths, particularly in the red and blue range, are known to support photosynthesis, leaf development, and flowering in horticultural crops.

Environmental Control and Automation

Modern vertical farms are equipped with sensors and automated systems that continuously monitor and adjust growing conditions. Temperature, humidity, nutrient concentration, and carbon dioxide levels are managed in real time to match crop requirements. The use of digital tools, data analytics, and artificial intelligence is gradually improving production efficiency while reducing labor dependency.

Horticultural Crops Best Suited for Vertical Farming

Not all crops are equally suitable for vertical farming. The system is most effective for high value crops with relatively short growth cycles and compact growth habits. Common examples include leafy vegetables such as lettuce, spinach, kale, and arugula; culinary herbs like basil, mint, coriander, and parsley; and nutrient dense microgreens.

With advanced infrastructure and careful management, fruiting crops such as strawberries, cherry tomatoes, and peppers can be grown successfully. In addition, ornamental and medicinal plants that require stable growing conditions benefit greatly from vertical farming systems.

Environmental Advantages

One of the strongest arguments in favor of vertical farming is its positive environmental impact. Water use efficiency is significantly higher, as most systems recycle water within a closed loop, reducing losses due to evaporation and runoff. In many cases, water savings up to 80-90 percent have been reported compared to conventional horticulture.

Vertical farming also reduces pressure on land resources by producing more food in smaller footprint. Controlled environments help limit pest and disease outbreaks, which in turn reduces or eliminates the need for chemical pest

cides. Furthermore, locating-farms close to consumers lowers transportation requirements and associated greenhouse gas emissions, contributing to a smaller carbon footprint.

Socio- Economic Significance

From a global standpoint, vertical farming offers important socio- economic opportunities across different regions and income settings. In high-income countries, it supports local food production, reduces dependence on imports, and meets consumer demand for fresh, safe, and sustainably produced food. In developing and emerging economies, vertical farming can complement traditional agriculture by providing employment, supporting urban and peri-urban livelihoods, and improving access to nutritious food.

The technology also encourages youth participation in agriculture by combining farming innovation, automation, and entrepreneurship. Localized production of horticultural crops shortens supply chains, improves food availability, and enhances resilience against disruptions cause by climate extremes,

pandemics, or trade constraints. Year-round cultivation further helps stabilize supply and prices, benefiting both producers and consumers.

Challenges and Constraints

Despite its potential, vertical farming is not without limitations. Initial investment costs for infrastructure, lighting, climate control, and automation can be high. Energy consumption, especially for artificial lighting, remains a major concern, particularly in regions with high electricity costs.

Future Outlook

Looking ahead, the global outlook for vertical farming in horticulture is promising, although its pathways of adoption may differ across regions. Technological advances in energy-efficient lighting, automation, and digital crop management are expected to reduce operational costs and improve system performance. At the same time, research on crop varieties suited for indoor and controlled environments will play a key role in expanding crop diversity.

Policy support, investment in renewable energy, and knowledge-sharing across countries will be essential for scaling up vertical farming sustainably. In regions facing land scarcity or harsh climatic conditions, vertical farming may serve as a strategic food security measure, while in others it may function as a high- value niche system. Globally, vertical farming is

Agri Facts

- Mineral imbalance (especially Ca:P ratio) can affect bone health and reproductive performance.
- Dairy profitability improves when farmers track cost per litre, not only total litres.
- Crop diversification reduces market risk and improves resilience during climate shocks.

best viewed as a complementary approach that strengthens the resilience and sustainability of agri-food systems rather than replacing conventional agriculture

Conclusion

Vertical farming represents a thoughtful evolution in horticultural production at a time when food systems worldwide are under increasing pressure. By combining controlled environment agriculture, soilless cultivation, and modern technologies, it offers a practical response to challenges related to land scarcity, climate uncertainty, and the growing demand for fresh, safe, and nutritious food.

While vertical farming is not universal solution , its strength lies in its adaptability. When integrated with conventional horticulture, renewable energy sources, and sound policy support, it can enhance food system resilience across diverse geographic and socio-economic contexts. As cities continue to expand and climate- related risks intensify, vertical farming is well positioned to contribute meaningfully to sustainable horticulture and global food security.

Closing Insight

The future of horticulture will likely be shaped by a balance between tradition and innovation. Vertical farming reflects this balance by drawing on scientific advances while responding to real-world constraints faced by growers and consumers alike. As part of an integrated food system, it invites collaboration among farmers, researchers, policymakers, and entrepreneurs to collectively reimagine how fresh food is produced for a rapidly changing world.

Agri Facts

- Controlled atmosphere storage slows ripening by managing oxygen and carbon dioxide levels.
- Farm data recording improves decisions on feed, fertilizer, and disease control—"records create profits."

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