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Global Agri Magazine
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Volume: 03
Issue: 05
June 2026

A Farmer's IKIGAI

"A reason for being"

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Global Initiative for Regenerative Agriculture & Soil Resilience

FARMER SCIENTIST
RECOGNIZING FARMERS AS KNOWLEDGE LEADERS

ICRISAT
INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

Exclusive Interview

Dr. Himanshu Pathak

Director General
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Founder's Note

Dear Readers,

Advancing Resilient Agriculture through Science, Innovation & Global Collaboration

It is with a great pleasure and honor that we are presenting the June 2026 edition of KhetiValah Global Agri Magazine (e-magazine), bringing together valuable insights, innovations, and knowledge contributions from distinguished experts, researchers, scientists, educators, and practitioners from India and across the world.

This edition highlights the importance of science-driven agriculture, climate resilience, sustainable food systems, nutrition, innovation, and global partnerships in shaping the future of agriculture. Through expert articles and perspectives, our contributors share practical solutions and emerging opportunities for farmers, researchers, policymakers, students, and agri-professionals.

We are honored to feature Dr. Himanshu Pathak, Director General, ICRISAT, in the Cover Story Interview of this edition. His insights on agricultural transformation, climate-resilient farming systems, innovation, and the future of global agriculture offer valuable guidance to our readers. We sincerely thank Dr. Himanshu Pathak for sharing his perspectives and leadership through this meaningful interaction.

This edition also features valuable contributions across our knowledge zones, including KhetiGuru, MilletsCorner, KrishiYashas, Janavanam, TattvaVedika, Agri Innovation & Policy, KrishiGrow, KrushiAharam, and other special features. We sincerely appreciate all contributors whose expertise facilitates agricultural knowledge exchange through KhetiValah Global Agri Magazine.

We are also delighted to announce that beginning with the July 2026 edition, KhetiValah Global Agri Magazine will introduce the KV Global Agri Leadership Series, a special interview feature showcasing distinguished leaders and changemakers from different countries whose work is creating meaningful impact in agriculture and allied sectors. Through this initiative, we aim to share the inspiring leadership stories and global best practices that shape the future of agriculture.

We extend our sincere gratitude to all our authors, interviewees, editorial team members, collaborators, readers, and well-wishers whose continued support strengthens our mission of building a stronger, knowledge-driven, and globally connected agricultural ecosystem.

Join KhetiValah in its mission to build a "Wealthier and Healthier World." 🌍💚

Jai Bharat !

Regards,
Lakshman K
Founder & Chairman of KhetiValah

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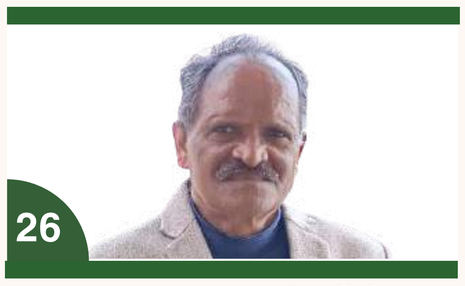
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MilletsCorner

Knowledge Partners

INDIA MILLET INITIATIVE | GIRAS | International Decade of Millets 2024-34

MilletsCorner is a dedicated initiative of **KhetiValah Global Agri Magazine** focused on promoting millet-based knowledge, sustainable farming practices, nutrition awareness, value addition, and market opportunities.

Through this platform, we aim to connect farmers, researchers, institutions, and entrepreneurs to strengthen millet ecosystems and encourage climate-resilient agriculture, healthier food systems, and sustainable livelihoods.

Teff: An Emerging Micro Millet In Northern Karnataka



Dr. Vishwanatha S.

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Agro Meteorology
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Dr. Vishwanatha S., currently an Assistant Professor of Agrometeorology at the College of Agriculture, University of Agricultural Sciences (UAS), Raichur, Karnataka since September 2017. He had successfully completed B.Sc. (Agri.), M.Sc. (Agri.) and Ph.D. with specialization in Agronomy at UAS, Dharwad.

He has been involved in research for over 13 years and is the Principal Investigator (PI) and Co-PI for many World Bank and Govt. of Karnataka funded projects.

He had also received an Young scientist award for his contributions to Agronomy with a substantial publication record- 50 research papers, 10 book chapters and about 10 poster and oral presentations in national and international conferences.



Dr Uday Kumar Nidoni

Professor &
University Head
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Dr. Udaykumar Nidoni is currently working as Professor and University Head of the Department of Processing and Food Engineering, CAE, UAS Raichur and heading the AICRP on PHET as Research Engineer. He is offering the courses to the UG, PG and Ph.D. degree programmes of the university.

He has handled external funded (RKVY, MoFPI, DoCA, DST) projects and developed more than 50 No. of technologies in food processing, millet value addition and involved in developing IoT based sensors in automation of the processing equipments and adoption of Artificial Intelligence in agriculture and allied technologies.

He is serving the farming community, food industries and food business traders by providing skill development training programmes and organizing EDPs.

He is also involved in NABL Accreditated Pesticide Residue and Food Quality Analysis Laboratory at UAS Raichur.



Dr Akshay Kumar Kurdekar

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Dr. Akshay Kumar Kurdekar is an Assistant Professor of Agronomy at the College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India.

He holds a Ph.D. in Agronomy and has qualified the ICAR ASRB–NET examination.

His research focuses on green nanotechnology in agriculture, nutrient management, agronomic biofortification, pulse and millet crops and sustainable crop production systems.

Dr. Kurdekar has received several honors, including the NSS State Award and the Best Ph.D. Thesis Award from Indian Society of Agronomy, IARI New Delhi.

He has published numerous research







*T*eff (Eragrostis tef) is one of the major staple foods of Ethiopia and Eritrea and is now gaining global recognition as an emerging climate-resilient micro millet suitable for dryland agriculture.
It is cultivated mainly for its edible seeds and is considered an important indigenous and traditional crop in these countries and utilized for preparing “injera,” a traditional fermented flatbread that forms the staple diet of millions of people. Teff diversified between 4000 BC and 1000 AD.
It is also known as **“Williams Lovegrass.”**

The word “teff” is derived from the Amharic term “teffa,” meaning “lost,” which refers to the extremely small size of its seeds. Teff belongs to the grass family Poaceae.
Teff is cultivated in countries such as Australia, Cameroon, Canada, China, India, Netherlands, South Africa, United Kingdom, Uganda and the United States. At present, teff is cultivated in about 100 hectares in the districts of Mysuru, Uttara Kannada, Haveri, Gadag and Raichur in the state of Karnataka.
The Central Food Technological Research Institute and Kadamba Foundation, Sirsi are the major organizations promoting teff cultivation in South and North Karnataka respectively.



The word **“teff”** is derived from the **Amharic term “teffa,” meaning “lost,”** which refers to the extremely small size of its seeds.

Unlike many other millets, teff grains are consumed whole without the need for dehusking or polishing because the grain is very small and edible along with its bran and germ.
Owing to its rich nutritional profile and health-promoting properties, teff is increasingly **recognized as a “Super Food,”** comparable to quinoa and chia.

Scientists from the CSIR-Central Food Technological Research Institute (CFTRI) have also highlighted teff as a promising future health grain because of its nutritional superiority and suitability for gluten-free diets.

In recent years, the demand for nutritious and functional foods has increased considerably across the world, leading to renewed interest in underutilized millets like teff.

The grains are increasingly utilized in the preparation of healthy foods, bakery products, gluten-free diets, value-added products and functional food formulations, thereby creating new economic and market opportunities for farmers and food industries.

Considering its nutritional superiority, resilience to climate variability and suitability for dryland ecosystems, teff holds immense potential for strengthening sustainable agriculture, improving nutritional security and diversifying millet-based cropping systems in North Karnataka.

Therefore, promoting research, cultivation practices and awareness regarding teff can play a vital role in future food security and sustainable agricultural development.



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Teff **cultivation** in Karnataka

Package of practice

Climate and Season:
Teff is a climate-resilient micro millet suitable for cultivation under both irrigated and rainfed conditions in Karnataka. The crop can be grown throughout the year under different agro-climatic conditions, particularly during the monsoon (June–July) and post-monsoon (October–November) seasons. However, sowing from September to the second fortnight of December is considered ideal for obtaining better growth and yield.
Teff is highly tolerant to drought and relatively resistant to major pests and diseases, making it suitable for dryland farming systems of North Karnataka. Teff can be successfully cultivated in paddy fallow systems after the harvest of rice, particularly under residual soil moisture conditions.
In paddy fallows, teff can be sown immediately after rice harvest using minimum tillage or zero-tillage practices to conserve residual moisture.



Cultivation practices and crop growth
Seeds Mixed With Sand

Sowing & Transplanting

Line Sowing:
Seeds should be mixed with sand in a 1:1 or 2 ratio to ensure uniform distribution and easy sowing.
The seeds should be sown in rows spaced 30 cm apart with 10 cm spacing between plants within the row. Shallow sowing is recommended because of the tiny seed size.

Transplanting: For transplanting, seeds should be sown in a nursery after mixing with sand in equal proportion (1:1) and lightly covered with soil. Seedlings aged about 21–24 days should be carefully transplanted into the main field at recommended spacing.
Broadcasting:
In the broadcasting method, seeds mixed with sand should be spread uniformly over the field followed by light blade harrowing operation for proper seed-soil contact.



Irrigation

Varieties / Hybrids	Zone and condition	Duration (days)	Sowing period
Local (Brown type teff)	All zones of the state except coastal and hilly regions; Irrigated and Rainfed	70-80	Can be grown throughout year ; Ideal sowing time is from the first fortnight of September to the second fortnight of December
Seed rate per acre:			
1. Transplanting	100–120 g		
2. Line sowing	320–360 g		
3.Broadcasting	480–720 g		
Organic manures per acre			
Manure or compost	1 – 2Tonnes		
Chemical fertilizers per acre			
1. Nitrogen	8 kg		
2. Phosphorus	3.2 kg		
3. Potash	3.2 kg		

Weed management and intercultivation: To reduce weed competition during the early stages of crop growth. Hand weeding should be done 30 days after sowing for the line sown crop. In transplanted fields, hand weeding should be done 20 days after transplanting. After 45 days of sowing, intercultivation with wheel hoeing should be carried out to control weeds and keep the field weed-free to improve soil aeration and to conserve soil moisture.
Plant Protection Measures: Major pests and diseases are generally less common in teff cultivation. However, proper field sanitation, timely weeding, and balanced nutrient management help in preventing pest and disease incidence.
Water stagnation should be avoided to maintain healthy crop growth.
Harvesting and yield: The crop matures within 70–80 days depending on the variety and growing conditions. Harvesting should be done when the plants turn yellowish and grains become hard. Timely harvesting is important to minimize grain shattering losses.



Teff crop at maturity stage



Line sowing



Teff seedlings in nursery bed

Yield	Grain Yield (q/acre)	Straw yield (q/acre)
Transplanting	2.0-2.8	3.2 -4.00
Line Sowing	1.2 – 1.6	2.0 – 3,2



crop grown under paddy fallow field



Threshing of crop after harvest



Cleaned Teff grains

Teff based food products prepared at UAS Raichur

















Celebration of Field Day of Teff Crop





Field Day Celebration

Nutritional Composition :

Teff grain is highly nutritious and contains,Protein (11.15%), crude fat (3.03%), Carbohydrates (72.28%), crude fiber (5.22%), Moisture (9.68%) and Total Ash (3.86 %). It also contains important minerals such as, Calcium (1806.30 mg/Kg), Iron (327.27 mg/Kg), Copper (18.45 mg/Kg), Magnesium (2401.31 mg/Kg), Manganese (63.29 mg/Kg), Potassium (5324.44 mg/Kg), Sodium (108.62 mg/Kg) and Zinc (26.23 mg/Kg).

Wheat contains a protein called gluten and continuous consumption may lead to a disease called ‘Celiac’ disease in Western countries. Since teff is gluten-free, it can be used as an alternative to wheat to help avoid digestive disorders.

Teff grain is consumed in several forms and plays an important role in human nutrition. It is commonly used for preparing porridge and traditional fermented foods and beverages.

Teff flour can be utilized independently or blended with other cereal flours in bakery products such as bread, biscuits, pancakes, and other value-added foods.

The grain is highly nutritious because it is consumed whole without dehusking or polishing, thereby retaining the bran, germ, fiber and essential micronutrients.

Constraints in Teff Cultivation in North Karnataka

Despite its adaptability and nutritional superiority, teff cultivation in North Karnataka faces several constraints that limit its wider adoption and productivity under dryland farming conditions.

- Extremely small seed size leading to difficulty in sowing and uneven crop establishment
- Susceptibility to lodging due to weak and slender stems
- Poor awareness regarding scientific cultivation practices
- Low research attention and limited agronomic recommendations
- Labor-intensive harvesting and post-harvest operations
- High grain loss during threshing and cleaning due to tiny seed size
- Lack of organized markets and value-chain development
- Limited awareness regarding nutritional and economic benefits of teff

Conclusion -

Teff is emerging as a promising micro millet for North Karnataka due to its drought tolerance, low input requirement and exceptional nutritional value. The crop is well suited for dryland farming conditions and offers opportunities for both food security and farmer income enhancement.

With increasing awareness about healthy and gluten-free foods, teff has strong potential in domestic and export markets. Promotion of cultivation practices, seed availability and consumer awareness can help teff become an important climate-resilient millet crop in the region.



Voices on Teff



R.S. Patil, Organic Farmer, Gadag:
“I procured teff seeds from CFTRI and successfully cultivated the crop on three acres in Karnataka. Teff grows without much fuss, requires very little attention, and performs well under dry conditions.
It is also useful as livestock fodder and even as thatching material. Organically grown teff has excellent export potential.”



Dr N.S. Sudhakar, Retired Professor :
“Teff, now recognized globally as a superfood, is a staple crop in Ethiopia and Eritrea. Injera prepared from teff provides livelihood to nearly 6.5 million farmers in Ethiopia, and two-thirds of the daily protein intake of Ethiopians comes from teff. The crop is highly nutritious, drought resistant, and suitable for dryland agriculture.”

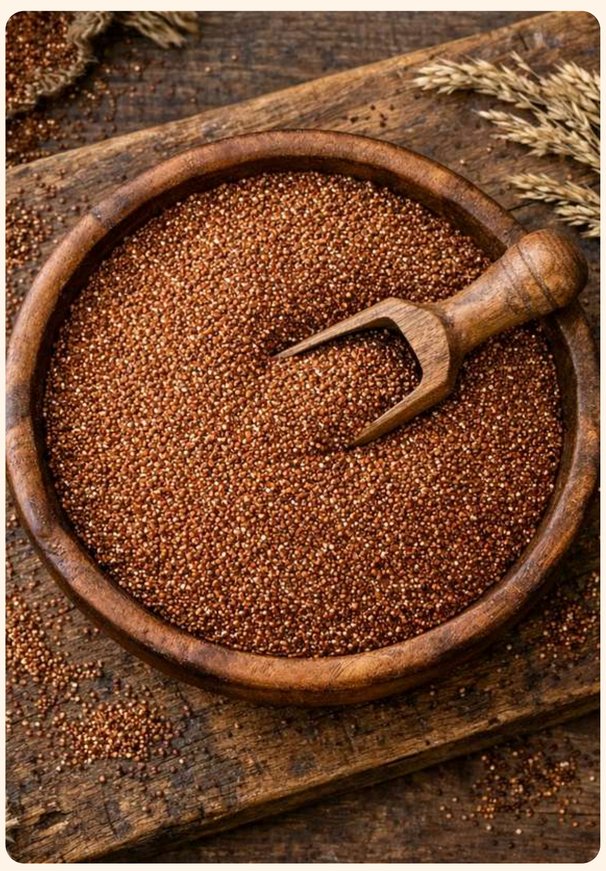


Professor Rajasekharan, CFTRI, Mysuru:
“There is very little awareness about teff in India. If proper awareness is created, more farmers would be interested in cultivating this nutritious and climate-resilient crop. Teff has great potential for dryland farming systems.”



Dr Deepa Prakash, Nutritionist:
“Teff helps control lifestyle diseases such as diabetes and obesity because it is gluten-free and rich in resistant starch. Merely 100 g of teff can significantly contribute to daily iron requirements. I personally consume teff porridge regularly because it provides sustained energy throughout the day.”









Kadamba Foundation, Sirsi

"Teff is rich in complex carbohydrates, dietary fiber, iron, calcium, and healthy unsaturated fats. It possesses a lower glycaemic index compared to wheat and is highly beneficial for diabetic and gluten-intolerant individuals. Fermented teff foods also improve iron bioavailability and digestive health."





Haile Gebrselassie and Kenenisa Bekele – Ethiopian Athletes

"They believe that teff products are one of the major reasons behind the energy and fitness of Ethiopian athletes. Teff-based foods help maintain higher oxygen levels in the blood, which may contribute to improved endurance and better sports performance.

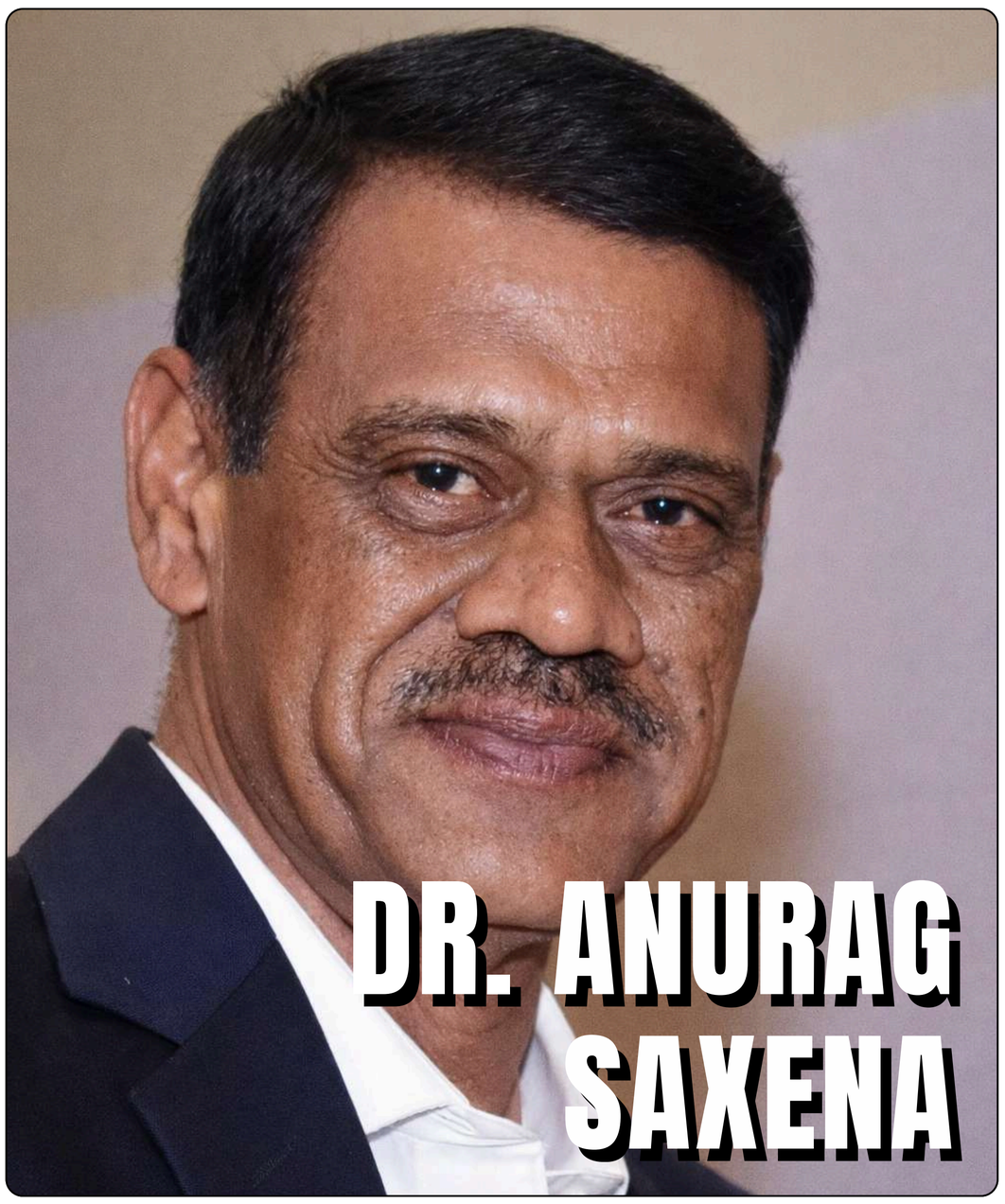
Products prepared from teff, including injera, are commonly consumed by athletes before and after training.



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Beyond Green Revolution

Building **Resilient Agriculture** for Tomorrow

By

Dr.Anurag Saxena
ICAR-National Dairy Research Institute, Karnal

National Dairy Research Institute

ABOUT THE AUTHOR

Dr. Anurag Saxena is a distinguished agricultural scientist with over 35 years of experience in agricultural research, natural resource management, climate-resilient farming, and the application of Artificial Intelligence in agriculture. He currently serves as Principal Scientist and In-charge of the Forage Research & Management Centre at ICAR–National Dairy Research Institute (NDRI), Karnal.

A Ph.D. in Agronomy from G.B. Pant University of Agriculture and Technology, Pantnagar, Dr. Saxena has contributed extensively to sustainable agriculture in both the hot arid regions of Rajasthan and the cold arid ecosystems of Ladakh. His research focuses on water management, climate adaptation, cropping systems, protected cultivation, and agricultural sustainability.

Having led several national and international projects, he has authored over 100 scientific publications and received numerous prestigious awards for advancing climate-smart agriculture and farmer-centric innovation.

> The global population is projected to approach **10 billion by mid-century,** while climate change is altering rainfall patterns, increasing temperatures and intensifying droughts and floods.
>
> Agriculture lies at the center of **this crisis**









The **Synergy ;** Which We Have

Human civilization has evolved alongside its ability to manage land and water. From early river valley systems to modern intensive agriculture, food production has shaped societies and economies. Today, however, this relationship faces unprecedented strain. The global population is projected to approach 10 billion by mid-century, while climate change is altering rainfall patterns, increasing temperatures and intensifying droughts and floods.

Agriculture lies at the center of this crisis. In countries like India, the challenge is, especially Big for supporting over 16% of the global population with only about 4% of freshwater resources. This imbalance highlights the urgent need to rethink how food is produced, how water is managed and how natural systems are sustained.

Green Revolution ; **Success** with **Consequences**

Green Revolution transformed Indian agriculture, increasing food grain production from about 50 million tonnes at independence to over 300 million tonnes.

High-yielding varieties, chemical fertilizers, pesticides and irrigation expansion played key roles in achieving food self-sufficiency.

However, this success came with long-term costs. Intensive chemical use degraded soil health, while excessive groundwater extraction lowered water tables.

The dominance of rice and wheat reduced crop diversity, making farming systems less resilient. Socio-economic impacts were also significant.

Rising input costs increased financial pressure on small farmers, often leading to debt and vulnerability. What began as a technological success gradually revealed ecological and economic limitations.

Soil - The **Living** Foundation

Soil is a dynamic living system, rich in microorganisms that support nutrient cycling and plant growth. Modern agricultural practices viz., continuous monocropping and heavy chemical use, have reduced soil organic matter and microbial diversity. As soil health declines, its ability to retain water and nutrients weakens, lowering productivity.

This creates a cycle where declining fertility leads to increased chemical inputs, further degrading soil. Restoring soil health requires treating it as a living ecosystem rather than an inert medium.

Nutrition **Paradox ;** More **Food** , Less **Nourishment**

Despite increased food production, nutritional quality has declined. Traditional crops such as millets have been replaced by refined cereals like rice and wheat.

While calorie availability has improved, micronutrient intake has decreased. Millets are rich in calcium, iron and fibre, whereas polished rice lacks essential nutrients.

This shift has led to **“hidden hunger,”** where people consume enough calories but suffer from micronutrient deficiencies such as iron, zinc and vitamin A.

Addressing food security must therefore include nutritional diversity, not just production.

Water **Footprint** & Food **Choices**

Every food product has a water footprint, amount of water required for its production. Animal-based products, especially beef, consume significantly more water than plant-based foods. Similarly, rice is more water-intensive than millets and pulses.

Adopting less water-intensive crops and diets can reduce pressure on water resources while maintaining nutrition. Thus, consumer choices play an important role in promoting sustainable agriculture.

Pollution - Agriculture’s **Silent Burden**

Modern agriculture contributes significantly to environmental pollution. Fertilizer runoff leads to nutrient accumulation in water bodies, causing algal blooms and oxygen depletion. Pesticides contaminate soil and groundwater while industrial pollutants introduce heavy metals into agricultural systems.

These contaminants enter the food chain, posing risks such as neurological disorders, hormonal disruption and cancer. Farm workers are directly exposed, while consumers face long-term health risks through contaminated food. Addressing agricultural pollution is therefore essential for both environmental and public health.

Bio-Farming - Working **with Nature**

Bio-farming (organic or eco-friendly agriculture) offers a sustainable alternative by aligning farming practices with natural processes.

It emphasizes soil health, biodiversity and reduced chemical use. Practices such as composting, crop rotation, green manuring and biological pest control improve soil fertility, enhance water retention and reduce environmental impacts.

By increasing microbial activity and nutrient cycling, bio-farming strengthens resilience to climate variability. It also relies on locally available resources, making it cost-effective and suitable for small farmers. Overall, bio-farming promotes sustainability, adaptability and long-term productivity.









Benefits Beyond Productivity

Bio-farming delivers multiple benefits across environmental, economic and social dimensions.

It reduces pollution, improves soil structure, enhances biodiversity and promotes efficient resource use. Economically, it lowers input costs and offers opportunities for premium pricing of organic produce. From a health perspective, it improves food safety and nutritional quality.

Socially, it supports rural livelihoods, reduces migration and encourages self-reliant farming systems.

Challenges in Transition

Despite its benefits, transitioning to bio-farming presents challenges. Initial yields may decline as soils recover and farmers adapt new practices.

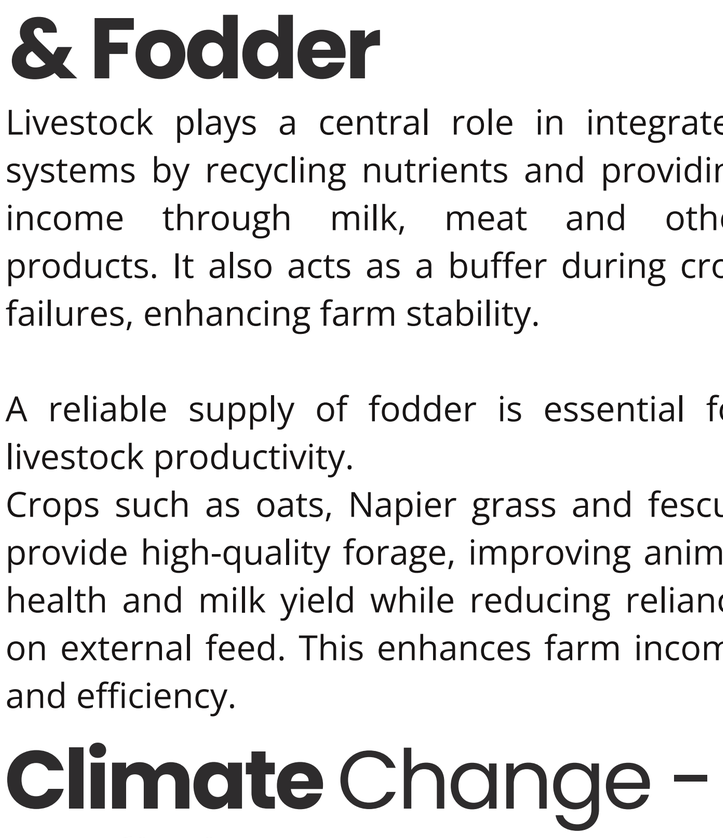
Soil restoration can take several years, delaying productivity gains. Knowledge gaps and limited access to training hinder adoption.

Certification processes are often complex and costly and market access for organic produce remains uncertain. These constraints are particularly significant for small farmers with limited resources.

Integrated Farming: A Holistic Approach

Integrated farming combines crops, livestock and agroforestry into a unified system, where outputs from one component serve as inputs for another.

This approach enhances resource efficiency, reduces waste and improves resilience.



Role of Livestock & Fodder

Livestock plays a central role in integrated systems by recycling nutrients and providing income through milk, meat and other products. It also acts as a buffer during crop failures, enhancing farm stability.

A reliable supply of fodder is essential for livestock productivity.

Crops such as oats, Napier grass and fescue provide high-quality forage, improving animal health and milk yield while reducing reliance on external feed. This enhances farm income and efficiency.

Climate Change – Defining Challenge

Climate change is already affecting agriculture through rising temperatures, erratic rainfall and increased frequency of extreme events. Heat stress reduces crop productivity, while unpredictable rainfall disrupts sowing and water availability.

Water scarcity is expected to intensify, particularly in already stressed regions.

Declining groundwater and increased competition for water resources will further challenge agricultural sustainability.

Building Climate-Resilient Agriculture

Adapting to climate change requires resilient and resource-efficient practices. Drought-tolerant crops can maintain yields under stress conditions. Efficient irrigation methods such as drip and sprinkler systems improve water-use efficiency.

Soil moisture conservation through mulching, conservation tillage and organic matter enhances water retention and reduces evaporation. Healthy soils act as natural reservoirs, enabling crops to withstand climatic variability.

Rethinking Agriculture for the Future

Ensuring food and water security requires a holistic approach that integrates sustainable practices, efficient resource management and technological innovation. Improving water management through efficient irrigation, rainwater harvesting and safe wastewater reuse is essential.

Sustainable practices such as crop rotation, composting and integrated pest management can restore soil health and reduce chemical dependence. Reviving traditional knowledge, including the use of resilient crops like millets and indigenous varieties, can enhance adaptability.

At the same time, modern innovations viz., climate-resilient crop varieties, precision farming and digital advisory systems can improve efficiency and decision-making.

Conclusion –

Agriculture stands at a critical crossroads.

While the Green Revolution ensured food security, its long-term ecological and socio-economic costs highlight the need for transformation.

Future agriculture must move beyond productivity-focused approaches toward systems that are sustainable, resilient and nutritionally secure.

By integrating ecological principles, efficient resource use and technological innovation, it is possible to build an agricultural system that not only feeds the growing population but also protects the environment and supports farmer livelihoods.



Farmer'sBookShelf

Books by Farmers, Experts, and Agri Institutions

KhetiValah Farmer's BookShelf is a knowledge-sharing initiative dedicated to showcasing books, publications, reports, and learning resources related to agriculture, rural development, climate resilience, soil health, AgriTech, AI in agriculture, and sustainable development. Through a dedicated section in the KhetiValah Global Agri Magazine (e-magazine), we regularly feature noteworthy books and publications from KhetiValah and partner organizations, helping connect valuable knowledge with farmers, researchers, students, and development professionals.

Flavours of Influence

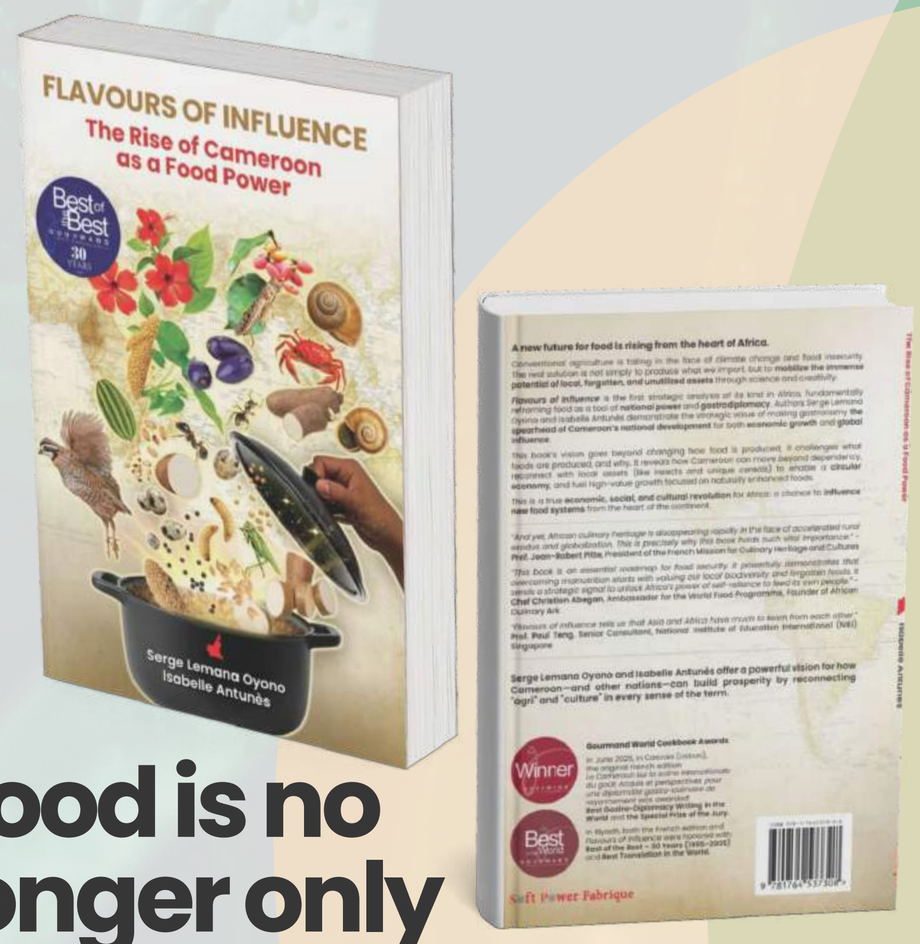
The Rise of Cameroon as a Food Power

As climate disruption, geopolitical tensions, and technological acceleration reshape global food systems, the question is no longer simply how to produce more — but how food systems are designed, and for whose benefit.

Using Cameroon as a lens, Flavours of Influence explores what becomes possible when biodiversity, culinary knowledge, science, and economic strategy are reconnected. This is Cameroon's chance — and perhaps the chance of many countries more broadly — not just to feed the world, but to feed its imagination. Today, cuisine is often treated as a simple outcome of food systems — shaped by what industrial agriculture, global supply chains, and standardised production make available.

But what if we inverted the formula ? When cuisine leads, production follows. When cuisine leads, we stop producing commodities and start cultivating distinction, resilience, and value. Policies begin designing agriculture around ingredients rather than commodities, around flavour, nutrition, biodiversity, and cultural distinction rather than volume alone.

Flavours of Influence introduces a call to reconnect "agri" and "culture" — restoring the relationship between what territories produce, what people value, and how economies build lasting resilience and influence. In this era of alternative proteins and future foods, the future may belong not only to those who scale standardised production, but to those able to reconnect ingredients, culture, biodiversity, science, and economic imagination in ways that create distinctive and lasting value.



Food is no longer only about production

> "And yet, African culinary heritage is disappearing rapidly in the face of accelerated rural exodus and globalization. This is precisely why this book holds such vital importance."
> **— Prof. Jean-Robert Pitte · President, French Mission for Culinary Heritage and Cultures**

> "This book is an essential roadmap for food security. It powerfully demonstrates that overcoming malnutrition starts with valuing our local biodiversity and forgotten foods."
> **— Chef Christian Abégan · Ambassador, World Food Programme · Founder, African Culinary Ark**

> "Flavours of Influence tells us that Asia and Africa have much to learn from each other."
> **— Prof. Paul Teng · Senior Consultant, NIEI Singapore**

ABOUT AUTHORS

Co-authored by Cameroonian diplomat Serge Lemana Oyono and cultural geographer and development economist Isabelle Antunès, Flavours of Influence contributes to emerging global conversations around food systems, soft power, biodiversity, and the future of value creation in emerging food economies.





AWARDS & AVAILABILITY

Awarded multiple distinctions at the Gourmand World Cookbook Awards 2025, including **"Best of the Best 30 years (1996-2025)" & "Best Gastrodiplomacy Writing in the World."**

- Paperback edition: Available through major online bookstores including Amazon, Barnes & Noble, Waterstones, and other international retailers.
- Digital edition: Available directly through Soft Power Fabrique at softpowerfabrique.com.

— Serge Lemana Oyono & Isabelle Antunès

KrishiYashas
Building Industry-Ready Agri Professionals

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GIRAS
Global Initiative for Regenerative Agriculture & Soil Resilience

KhetiValah's KrishiYashas, a special feature of **KhetiValah Global Agri Magazine** (e-magazine), focuses on career guidance, professional growth, and placement opportunities across agriculture and allied sectors. Every month, this initiative highlights emerging career pathways, industry expectations, and opportunities within the global agri ecosystem to help aspiring professionals build successful careers.

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Career Opportunities in Sustainable Agriculture



PROF. SAPNA A. NARULA

Is Director of the Chaudhary Charan Singh National Institute of Agricultural Marketing (CCS NIAM), Jaipur, and a distinguished academician, researcher, and sustainability expert with over 25 years of experience in teaching, research, consultancy, and institution building. Her areas of expertise include sustainability management, agricultural marketing, food value chains, climate change, ESG, CSR, and sustainable business strategies.

Prior to joining CCS NIAM, she served in several leadership positions, including Founder Dean of the School of Management Studies at Nalanda University and Head of Business and Sustainability at TERI. Her research focuses on sustainability, climate-resilient agricultural systems, rural livelihoods, and responsible business practices. She has published extensively in leading international journals, guided doctoral scholars, and contributed to major national and international development initiatives.

Prof. Narula is the recipient of several prestigious recognitions, including the India Responsible Leadership Award 2023, and continues to contribute actively to advancing sustainable development and agricultural transformation.



SHRI RANJITH P.C

Is a faculty member, researcher, and agricultural development professional at the Chaudhary Charan Singh National Institute of Agricultural Marketing (CCS NIAM), Jaipur.
With over seven years of experience, he has worked across agricultural marketing, agribusiness management, climate-resilient agriculture, agricultural policy, project monitoring and evaluation, and ecosystem services.
Prior to joining CCS NIAM, he was associated with ICAR institutions and BISA-CIMMYT, contributing to research, extension, and development initiatives.

He has led numerous training and capacity-building programs, consultancy assignments, and stakeholder engagement activities. His interests include climate adaptation, Farmer Producer Organizations (FPOs), agricultural value chains, and sustainable agribusiness development.
He has also authored research papers, training manuals, and articles in leading national publications.



Ambitions & Policies



India is a frontrunner when it comes to climate change policy and action. As the nation aspires to become a USD 5 trillion economy while simultaneously committing to being Net Zero by 2070, green mobility, industrial decarbonisation and sustainable agriculture have been identified as major priorities for our net zero goal.

As the climate change threatens multiple sectors, it is time we make our agriculture and food systems climate resilient which would not only ensure the food and nutritional security of our population but also environmental resilience.

Agricultural policies in India such as Farmer Producer Organisations, digital agriculture and PM Fasal Bima Yojana, PM Krishi Sinchayi Yojana, National Mission on Natural Farming and Soil Health Cards have delivered substantial benefits to our farmers especially small and marginal farmers. Government of India is giving a huge push to sustainable agriculture through various policies such as organic certification, natural farming, precision farming, regenerative agriculture in order to make our farming competitive and climate resilient.

It is at this juncture that there is an urgent demand for professionally trained managers who can integrate sustainability with business, agriculture, rural development and technology.

Why **Sustainability** in Agriculture **Matters** Today

India, being one of the largest agrarian economies, faces unique opportunities and challenges:

- Nearly 45% of India's workforce is dependent on agriculture.
- Agriculture contributes significantly to greenhouse gas emissions and water consumption
- Climate variability is affecting productivity and farmer incomes.
- Increasing urbanization and industrialization demand sustainable resource management.
- Consumers and investors are increasingly preferring environmentally responsible businesses.

The global sustainable agriculture market, valued at nearly USD 15 billion in 2020, is projected to reach approximately USD 29 billion by 2027, growing at a CAGR of over 10%.

Similarly, the global ESG investment market has crossed trillions of dollars, creating enormous opportunities for sustainability professionals. India's commitments under international climate agreements, including the Panchamrit pledge announced during COP26, further strengthen the need for skilled sustainability managers.

The changing business landscape & push for careers in **sustainable Agriculture domain**

Just as information technology and biotechnology transformed employment opportunities in the 1990s and 2000s, sustainability and climate-related sectors are expected to become major employment generators in the coming decades. Industry experts predict that sustainability skills will soon become essential across managerial roles.

Organizations are increasingly seeking professionals who understand both business management and environmental responsibility. The number of universities offering sustainability-focused programmes has increased substantially over the past five years, reflecting the growing demand for trained professionals.

The present demand for sustainability management professionals is growing rapidly due to several factors:

- Increasing Awareness: Industries, governments, and consumers are becoming more conscious about environmental sustainability, climate change, and responsible food production systems.
- Government Initiatives: India is promoting sustainable development through programmes related to, Natural farming, Organic agriculture, Renewable energy, Carbon neutrality, Water conservation, Sustainable supply chains, Circular economy and Climate-resilient agriculture.



Mandatory carbon market regime in India provides more opportunities for sustainability professionals. These initiatives require trained professionals capable of implementation and management.

- Corporate Sustainability Commitments: Large corporations are now integrating ESG (Environmental, Social, and Governance) frameworks into business operations. Sustainability reporting, carbon accounting, green procurement, and responsible sourcing have become major operational priorities.
- Rise of Agri-Tech and Green Technologies: Technologies such as Precision agriculture, Artificial Intelligence (AI), Internet of Things (IoT), Remote sensing, Carbon tracking systems, Climate analytics, are transforming agriculture and sustainability management.
- International and Development Sector Opportunities: Organizations such as United Nations, Food and Agriculture Organization, World Bank, IFAD, International NGOs, IRRI, ICRISAT, CIMMYT, WRI and others are investing heavily in sustainable rural and agricultural development projects.
- Corporate Social Responsibility: India is

one of the few countries to make CSR mandatory for selected companies. A lot of groundwork is happening through CSR initiatives in these countries.

There is a huge demand for CSR professionals who can work in agriculture, water management, rural development, skill development and health management space.









Future Demand: A Career Sector with Immense **Growth Potential**

The future demand for professionals in Sustainability Management is expected to grow significantly due to multiple global and national developments. With the world population projected to reach nearly 9.7 billion by 2050 , ensuring food security while conserving natural resources will require innovative, climate-resilient, and sustainable management practices. Climate change is already impacting agriculture, water resources, supply chains, and rural livelihoods, creating a strong need for professionals who can design and implement adaptation and mitigation strategies. At the same time, countries across the globe including India are moving towards Net Zero and green economy goals, which will generate large-scale opportunities for sustainability managers, ESG analysts, carbon auditors, renewable energy consultants, and climate policy experts. Global investors are also increasingly prioritizing environmentally responsible and sustainable businesses, making ESG-linked investments a key criterion for financing and business growth. Furthermore, the organic farming and sustainable agriculture sectors are expected to grow at a CAGR of 8–10% over the next decade, creating additional employment and entrepreneurial opportunities. These emerging trends clearly indicate a strong and long-term demand for professionals trained in Sustainability Management.

The sustainable agriculture domain offers huge opportunities for our young workforce. As we are moving towards Hi-tech and sustainable agriculture, agribusiness corporates now require skilled professionals who can work alongside farmers to promote sustainable technologies and can also train them about the right use of technologies. The sustainability departments are already well established in these companies and professionals are needed to write sustainability reports, collect environmental footprint data within the organisation from suppliers.

These managers are trained in GHG management, water management and waste management.

As the businesses are transitioning to circular business models, sustainability professionals are better equipped to make business decisions which will minimise environmental footprint, reduce waste and adopt circularity in supply chains. Decarbonisation efforts in agribusiness and other industries opens new vistas for sustainability managers.

As the consumers are demanding sustainable products and services, companies are working towards making their supply chains green by encouraging green procurement, farmers empowerment, certification and implementation of sustainability standards. This is where workforce trained in sustainability may pitch in. Sustainable packaging especially in food sectors open new vistas for these managers.

In addition to agribusiness sector, sectors such as oil & gas, textile and cement and other sectors are doing a lot of work on afforestation, biodiversity, water management and sustainable agriculture and managers trained in these areas are very well equipped to handle these jobs.

Besides the top management consultancies who have separate sustainability divisions, hundreds of mid-level consultancies have emerged in this domain who could provide opportunities to these graduates. In the next section, we provide details of such opportunities. The current policy environment and available funding opportunities .

Career Opportunities After PGDM in **Sustainability Management**

One of the strongest aspects of PGDM SM is its wide range of career opportunities across multiple sectors.

Employment Sectors

Graduates can work in:

Corporate Sector

- ESG divisions
- Sustainability consulting
- CSR management
- Green supply chain management
- Renewable energy firms
- Sustainable sourcing and procurement

Agribusiness Companies

- Sustainable agriculture projects
- Agri-value chains
- Carbon farming initiatives
- Agri-tech platforms

Government and Policy Institutions

- Rural development agencies
- Agriculture departments
- Climate missions
- Sustainability projects

International Organizations and NGOs

- Climate adaptation programmes
- Sustainable livelihoods projects
- Food security initiatives
- Environmental management programmes

Start-ups and Entrepreneurship

Students can establish ventures related to:

- Organic farming
- Waste management
- Climate services
- Agri-tech
- Carbon credit aggregation
- Sustainable food systems
-

Emerging Job Roles

The programme opens pathways to several high-growth roles:

- Sustainability Manager/ Officer
- ESG Analyst
- Climate Risk Consultant
- Carbon Managers/ Carbon Auditors
- Sustainable Supply Chain Manager
- Agribusiness Manager
- CSR Manager
- Circular Economy Consultant
- Renewable Energy Project Executive
- Sustainable Finance Analyst
- Agri-Tech Manager
- Rural Development Consultant
- Environmental Compliance Officer
- Impact Assessment Specialist

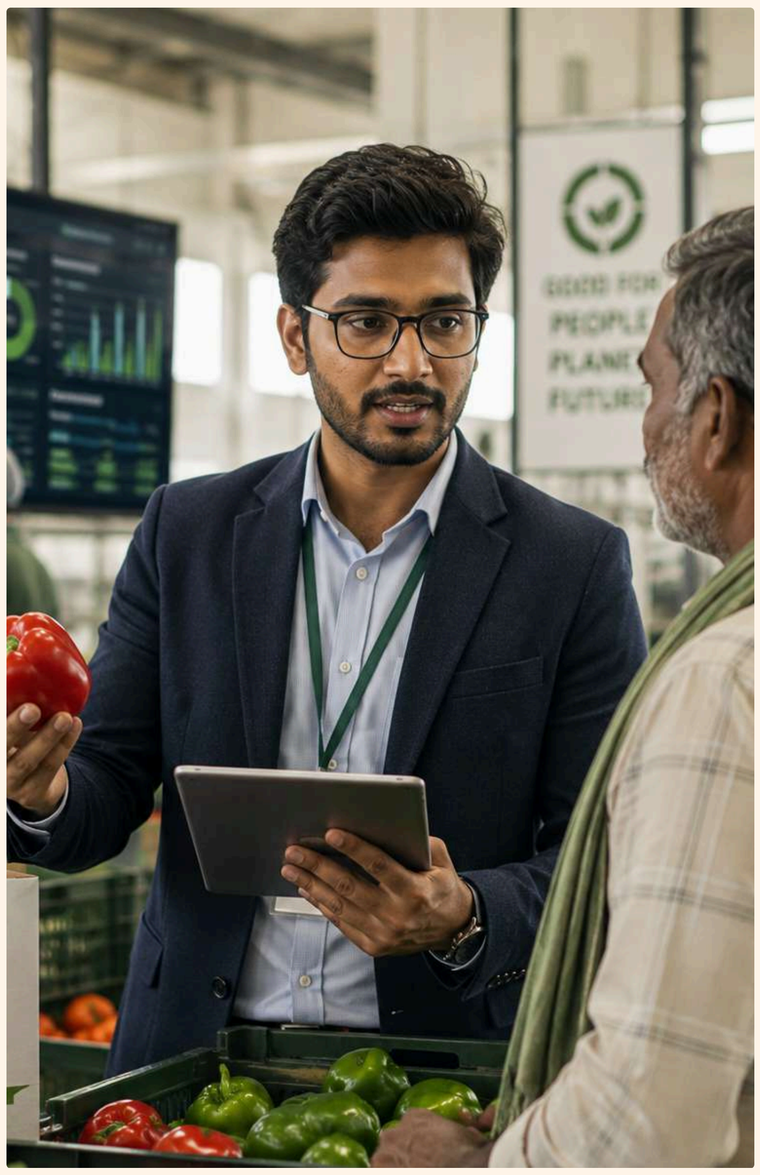




Future Demand: A Career Sector with Immense **Growth Potential**

In this evolving landscape, the Post Graduate Diploma in **Management in Sustainability Management (PGDM SM) offered by CCS National Institute of Agricultural Marketing, an autonomous institute under the Ministry of Agriculture & Farmers Welfare, Government of India** is emerging as one of India's pioneering programmes aimed at developing future-ready sustainability leaders.

The programme is designed to equip students with managerial, analytical, technological, and policy-oriented skills required to address complex sustainability challenges in agriculture, agribusiness, rural development, climate adaptation, ESG compliance, carbon management, circular economy, sustainable supply chains, and green entrepreneurship.



Key Features of the Programme & Pedagogy

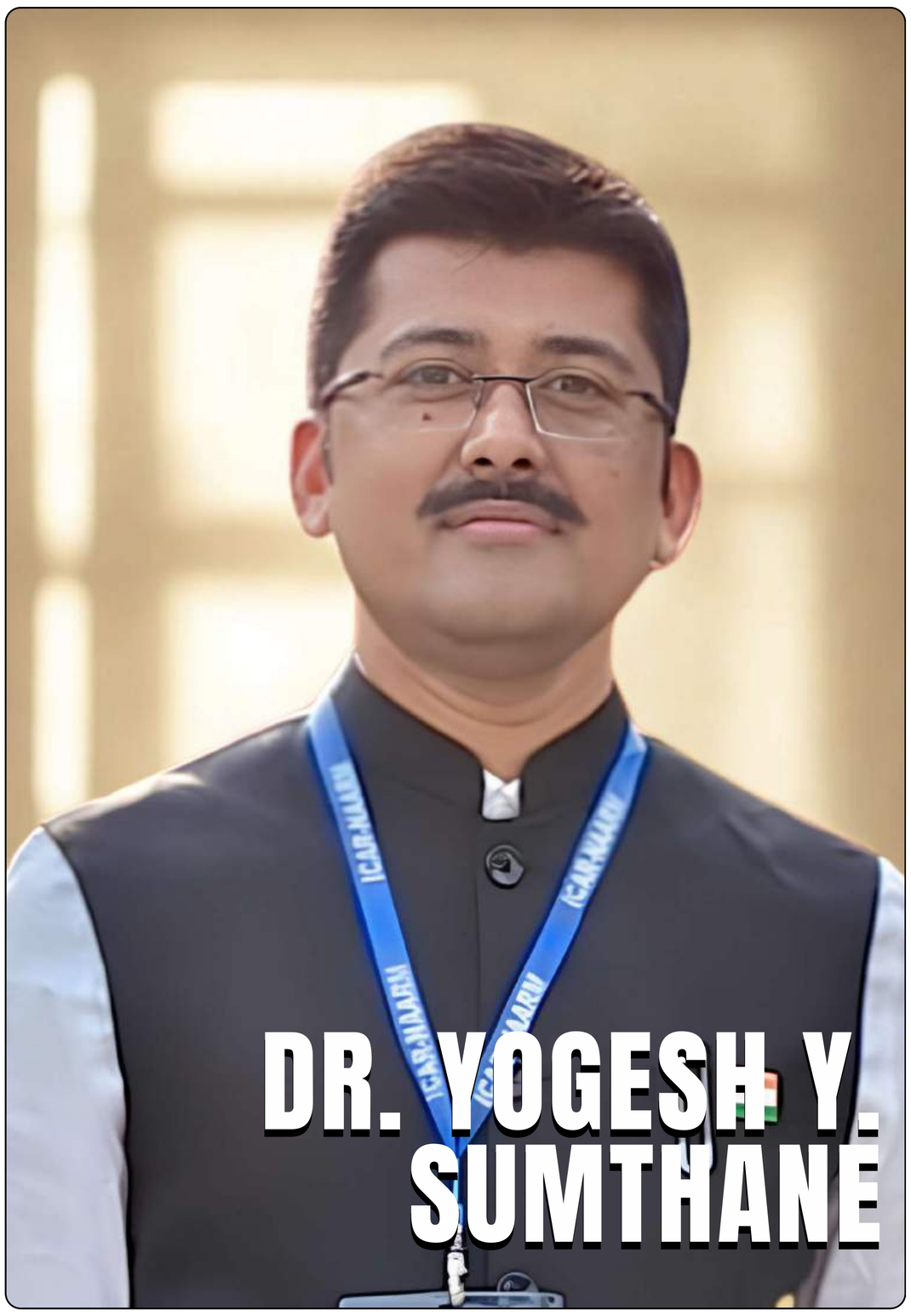
- **Interdisciplinary Learning:** The programme combines management education with sustainability science, environmental economics, climate policy, and agribusiness.
- **Industry-Relevant Curriculum:** Students gain exposure to ESG reporting, Carbon markets, Sustainable finance, Circular economy, Sustainable supply chain management, Renewable energy systems, Agri-tech innovations and Climate-smart agriculture, carbon markets
- **Practical Exposure:** The programme emphasizes, Field visits, Industry interaction, Live projects, Internships, Case studies, Rural immersion, Industry mentoring
- Focus on Emerging Technologies: Students are trained in areas such as AI in agriculture, Precision farming, GIS and remote sensing, Data-driven sustainability analytics, Digital agriculture
- **Industry and Institutional Linkages:** Collaborations with industries, government departments, agribusiness firms, FPOs, Global NGOs, and development agencies provide strong practical orientation.

Conclusion -

As the employment sector faces huge transformation, both data analytics and sustainability have been identified as critical skills of the century. The smart career choices made today will offer better leadership roles and returns tomorrow. In the above section, we have explored various job roles and there are avenues for entrepreneurship in sectors such as sustainable agriculture, renewable energy, climate-tech, waste management, and circular economy enterprises, while providing international relevance and alignment with future global economic trends.

As industries, governments, and development organizations increasingly prioritize sustainability and responsible business practices, graduates of sustainable agricultural management programme are expected to play critical roles in driving sustainable growth and innovation.

The programme is particularly suitable for students from diverse academic backgrounds including agriculture, engineering, science, commerce, environmental studies, rural management, management, and social sciences, thereby creating a multidisciplinary learning environment that prepares future sustainability leaders for a wide range of sectors and career pathways.



Non-Wood Forest Products
For
Forests People

By

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ABOUT THE AUTHOR

Dr. Yogesh Y. Sumthane is a distinguished forestry scientist specializing in Wood Science and Technology, with expertise spanning research, education, innovation, and forest-based industries.
He holds a Ph.D. in Forestry and an MBA in Business Administration. Over his career, he has authored 7 books, 21 research papers, multiple book chapters, and more than 150 articles in journals and newspapers.

His contributions have earned several prestigious honors, including the Young Scientist Award, Best CEO Award, Prof. M.S. Swaminathan Award, and Best Scientist Award in Forestry (2025).

Dr. Sumthane holds multiple copyrights, patents, and a trademark, and has led projects supporting tribal livelihoods and sustainable forest products.
He regularly speaks at international conferences and serves as a member of leading forestry and agroforestry organizations.

> It is time to realize the importance of forest as a resource of Non-Timber Forest Products (NTFP's), as an environmental necessity, as an aesthetic need, a source of recreation and a home of important heritage of wildlife.



As Things Are -

All over the world over 1.6 billion people including many indigenous communities depend on forests for food and fuel, it's second to home. Forest provides us with oxygen, shelter, jobs, water, nourishment and fuel. In the ancient times forests were treated as a sacred resource in India.

However, in past couple of hundred years, due to faulty policies, they have been looked merely as a source of commercial timber and the entire forestry department has been geared only for that end use. It is time to realize the importance of forest as a resource of Non-Timber Forest Products (NTFP's), as an environmental necessity, as an aesthetic need, a source of recreation and a home of important heritage of wildlife.

All these useful contributions of forests, other than just timber, are being realized now.

The significance of the NTFPs is being increasingly realized through better understanding of their value to the economy as well as to the environment. The emerging trend of market preference for natural products and the increasing emphasis on the efficient and sustainable use of natural resources have further helped gain this appreciation. Greater understanding of the role of NTFPs in the overall socio-economic well-being of the communities living around forests is better understood today.

Worldwide, forests have been under constant threat of degradation through uncontrolled and highly diversified land use for increasing societal needs; agricultural expansion; and environmentally non- sustainable management , including lack of adequate forest-fire control, poaching, unsustainable commercial logging, over grazing, unregulated browsing, airborne pollution and economic incentives offered by other sectors of economy, detrimental to the forests.

The major impacts of forest degradation are reflected in soil-erosion, loss of biological diversity, damage to wildlife habitats, and degradation of watershed areas and overall deterioration of the quality of life. The use of Non-Timber Forest Produce (NTFP) is as old as human existence. In sustenance and rural economics, the role and contribution of NTFPs are crucial because of their richness of biodiversity, as source of food, fodder, fibre, fertilizes, herbal products, construction material, cosmetics and cultural products. They support village level craft activity. NTFPs provide raw materials to support processing enterprises. They include internationally traded commodities used in food products and beverages, confectionery, flavourings, perfumes, medicines, paints, polishes and more. Some 80 per cent of the population of the developing world depend on NTFPs for their primary health and special nutritional needs. Several million tribal people all over the world depend on these forest products to meet their sustenance consumption and income needs. In many countries NTFPs form an important component of forest products exports.

The materials obtained and collected from forests are innumerable, and can be classified as: food (edible product); fodder and grasses; bamboo; cane; medicinal products (plants, leaves, flowers, fruits, barks and root with curative properties); spices, resins, gums, commercial leaves, natural dyes and tannins, starches, oils and fats, essential oils, insecticides, fibres & flosses & insect products like Lac, honey, silk, etc.

Records in **India**

In India, there are 3,000 plants having medicinal value, 200 plants bearing essential oils or commercial oil seeds, 100 species yielding dyes of commercial importance and 120 species providing gums and resins. The following production of NTFPs have been recorded: 1,01,200 tonnes of food products, 1,32,250 tonnes of Myrobalan, 70,97,000 tonnes of Sal seeds, 6,97,600 tonnes of Mahua, 1,15,000 tonnes of Neem seeds, 1,600 tonnes of Palmarosa oil, 150 tonnes of Eucalyptus oil, 160 tonnes of Sandal oil ,
950 tonnes of Lemon grass oils, 1,80,500 tonnes of gums, 17,000 tonnes of resin, 3,60,000 tonnes of Bidi leaves, 47,16,000 tonnes of bamboos, 5,750 tonnes of fibres and 13,000 tonnes of Lac (Tiwari, 2010).

Besides direct products and benefits, there are lot of indirect benefits of forests also which include environmental protection and amenity (social values).

Research Questions

- What is the socio-economic status of tribal communities in Bundelkhand ?
- How do NWFPs contribute to household income ?
- What are the major challenges in NWFP utilization?
- What strategies can improve livelihood security ?

Study Area

The present study was conducted in the Bundelkhand region of Uttar Pradesh, focusing on four districts: Banda, Chitrakoot, Lalitpur, and Sonbhadra.

This region is characterized by semi-arid climatic conditions, marked by low and erratic rainfall, high temperatures, and frequent droughts (Gupta et al., 2014).

Banda district is predominantly rural, with agriculture and forest-based activities forming the primary sources of livelihood.

However, low rainfall and poor soil fertility limit agricultural productivity, increasing dependency on forest resources.

Chitrakoot district is known for its forest cover and tribal population. The region has significant potential for NWFP collection, including medicinal plants and forest produce such as mahua and tendu leaves.

Lalitpur district exhibits a mixed landscape of forest and agricultural land. The presence of tribal communities and limited economic opportunities make NWFPs an important source of income.

Sonbhadra district has relatively dense forest cover compared to other districts in Bundelkhand. It is home to several tribal communities, including Gond and Kol, who rely heavily on forest resources for their livelihoods.

The socio-economic conditions in these districts are characterized by low literacy rates, limited access to healthcare and education, and high levels of poverty **(Singh *et al.*, 2019).** These factors contribute to the dependence on NWFPs as a primary source of income and subsistence.

Methodology

The study adopts a descriptive and analytical research design to assess the socio-economic status of tribal and rural communities in the Bundelkhand region (Creswell, 2014).
Both primary and secondary data sources were utilized to ensure a comprehensive analysis.

Primary data were collected through field surveys using structured questionnaires, personal interviews, and direct observations. The questionnaire was designed to capture information related to demographic characteristics, income sources, occupation, education, and dependency on NWFPs.
A sample representing approximately 10% of the village population was selected using random sampling techniques (Kothari, 2004). Care was taken to include both male and female respondents to capture gender-based differences in livelihood activities.

Secondary data were collected from various sources, including government reports, research papers, and publications from organizations such as FAO, World Bank, and UNDP.
The collected data were analyzed using descriptive statistical tools such as percentage analysis, tabulation, and graphical representation. Comparative analysis was also conducted to identify variations across districts and demographic groups.
Ethical considerations were maintained throughout the study by ensuring informed consent from respondents and maintaining confidentiality of the data collected.

Data analysis & **interpretation**

The data collected from the field survey were analyzed using descriptive statistical methods such as percentage analysis, tabulation, and graphical representation to understand the socio-economic conditions of the respondents (Kothari, 2004).
The analysis focuses on demographic characteristics, occupation patterns, income sources, and dependency on NWFPs.

Parameter	Category	Percentage (%)
Gender	Female	60%
	Male	40%
Age Group	25-50 years (Active)	Majority
	Below 25 years	Lower
Education	Primary/ No Formal	Significant

Table 1: Demographic characteristics of respondents

- **Gender Distribution**

The gender-wise distribution of respondents reveals that approximately 60% of the respondents are female, while 40% are male. This indicates that women play a dominant role in forest-based livelihood activities, particularly in the collection and processing of NWFPs (Singh & Kumar, 2021).
Women are actively involved in gathering products such as tendu leaves, mahua flowers, and medicinal plants, which are later sold in local markets.



Bamboo Value addition product's for the local markets

Their contribution to household income is significant, although often undervalued in economic assessments (Endamana et al., 2016).

- **Age Group Distribution**

The majority of respondents fall within the age group of 25–50 years, representing the economically active population. Younger individuals (below 25 years) show less interest in forest-based activities due to migration and the search for alternative employment opportunities (UNDP, 2021).

Older individuals (above 50 years) are involved in traditional knowledge-based activities such as medicinal plant collection, highlighting the importance of indigenous knowledge systems in NWFP utilization (Lepcha et al., 2018).

- **Educational Status**

The educational status of respondents indicates a low literacy rate, with a significant proportion of individuals having only primary-level education or no formal education at all. This lack of education limits their ability to access better employment opportunities and adopt modern techniques for value addition (World Bank, 2019).

- **Occupation Pattern**

The occupation pattern of respondents shows that:

- 45% depend on forest-based activities
- 30% are engaged in agriculture
- 20% depend on wage labor
- 5% are involved in other activities

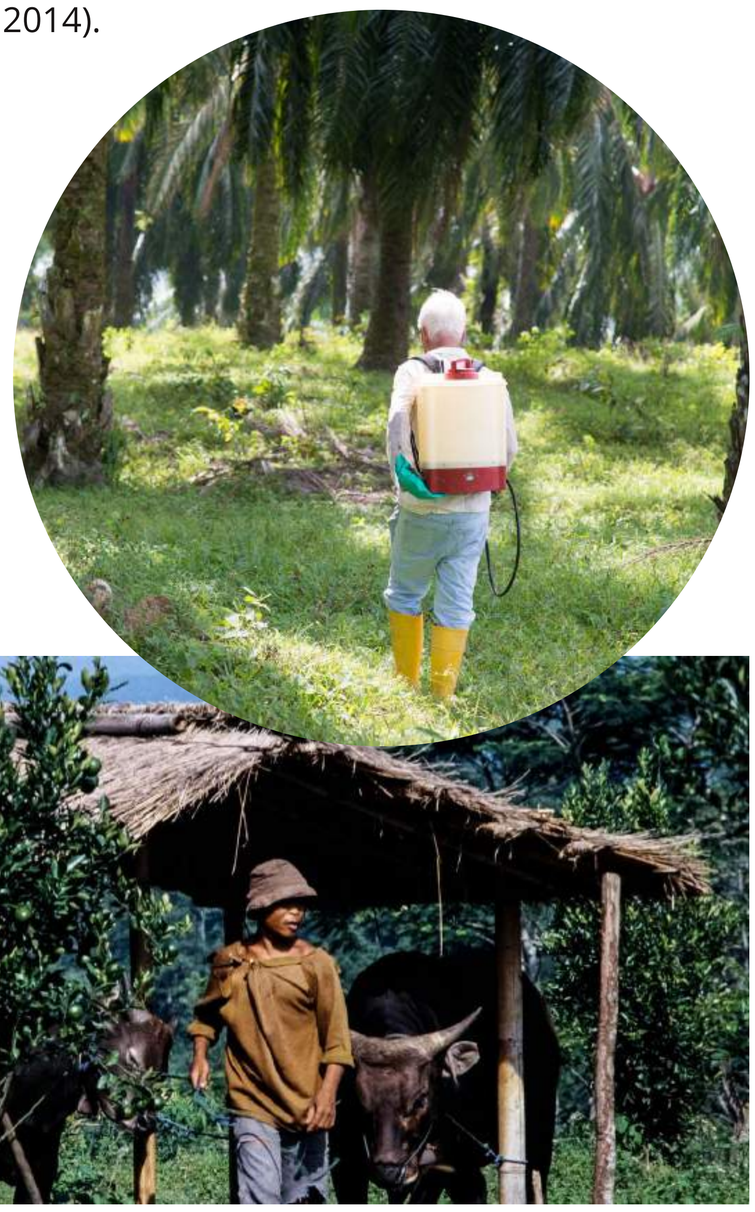
Occupation	Percentage (%)
Forest-based activities (NWFPs)	45 %
Agriculture	30%
Wage Labor	20%
Others	5%

Table 2: Primary Occupation of respondents

This indicates a high level of dependency on NWFPs due to limited livelihood options in the region (Pandey et al., 2016).

- **Income Sources**

The analysis of income sources reveals that NWFPs contribute significantly to household income, particularly during non-agricultural seasons.
Products such as tendu leaves, mahua flowers, honey, and medicinal plants are major sources of income (Lepcha et al., 2020).
Agricultural income is often uncertain due to erratic rainfall, making NWFPs a reliable alternative source of livelihood (Gupta et al., 2014).



District	Level of Dependency	Key Factors
Sonbhadra	Highest	Dense forest cover; Gond and Kol tribes
Chitrakoot	High	Diverse forest products (Mahua, Tendu)
Lalitpur	Moderate	Mixed forest and agricultural land
Banda	Mixed	Low rainfall; high forest dependency

Table 3: District- wise NWFP dependency levels

This variation is influenced by factors such as forest availability, population density, and economic conditions (Singh et al., 2019).

NWFP Name	Primary Use	Collection Role
Tendu Leaves	Commercial (income)	Predominantly women
Mahua Flowers/ Seeds	Food & income	High household value
Honey	Consumption & sale	Traditional knowledge
Medicinal Plants	Traditional medicine	Older generation knowledge

Table 4: Major NWFPs and their Utility

These products are used for both consumption and commercial purposes, contributing to food security and income generation (FAO, 2020).

Result & Discussion

The results of the study clearly indicate that NWFPs play a crucial role in sustaining the livelihoods of tribal and rural communities in Bundelkhand. The high level of dependency on forest resources highlights the limited availability of alternative income sources in the region (Pandey et al., 2016).

One of the key findings is the significant role of women in NWFP collection and marketing. Women not only contribute to household income but also play a vital role in ensuring food security and managing household resources (Endamana et al., 2016).

However, the study also reveals several challenges that limit the economic potential of NWFPs.

These include lack of market access, inadequate infrastructure, and exploitation by middlemen.

As a result, collectors often receive low prices for their products, reducing their income and livelihood security (FAO, 2020).

The findings are consistent with previous studies, which emphasize the need for policy interventions to improve market linkages, promote value addition, and provide institutional support to forest-dependent communities (World Bank, 2019).

Another important observation is the impact of low literacy levels on livelihood opportunities. Limited education restricts access to better employment and reduces



Ziziphus fruits for local market to get smart income

awareness about government schemes and programs (UNDP, 2021).

The study also highlights the importance of sustainable forest management practices. Overexploitation of forest resources can lead to depletion of NWFPs, affecting both the environment and the livelihoods of dependent communities (FAO, 2020).

Challenges Faced by communities

The study identifies several socio-economic and institutional challenges faced by tribal and rural communities in Bundelkhand. These challenges significantly affect their livelihood security and limit the benefits derived from NWFPs.

- **Low Literacy and Education**

A majority of respondents have low levels of education, which restricts their ability to access better employment opportunities and government schemes (UNDP, 2021).

- **Lack of Market Access**

Forest-dependent communities often face difficulties in accessing markets due to poor infrastructure and transportation facilities. This leads to dependence on local traders and middlemen (FAO, 2020).

- **Exploitation by Middlemen**

Middlemen play a dominant role in the marketing of NWFPs, often offering low prices to collectors, thereby reducing their income (World Bank, 2019).

- **Lack of Value Addition**

Most NWFPs are sold in raw form without any processing or value addition, resulting in lower income for collectors (Pandey et al., 2016).

- **Unsustainable Harvesting Practices**

Overexploitation of forest resources due to increasing dependency can lead to depletion of NWFPs, affecting long-term sustainability (FAO, 2020).

- **Climate Change & Environmental Stress**

Frequent droughts and erratic rainfall patterns in Bundelkhand negatively impact both agriculture and forest resources (Gupta et al., 2014).





Mahua flower collection for livelihood sustainability

Policy implications

The findings of the study suggest several policy measures to improve the socio-economic conditions of tribal and rural communities:

- **Strengthening Value Chains**

Developing efficient value chains for NWFPs can enhance income generation and reduce exploitation by intermediaries (World Bank, 2019).

- **Market Development**

Establishing local markets and improving transportation infrastructure can help collectors access better prices for their products (FAO, 2020).

- **Skill Development and Training**

Providing training in processing, packaging, and marketing can promote value addition and increase income (UNDP, 2021).

- **Women Empowerment**

Recognizing and supporting the role of women in NWFP activities can improve household income and socio-economic conditions (Singh & Kumar, 2021).

- **Sustainable Forest Management**

Promoting community-based forest management practices can ensure the sustainable use of NWFPs and conservation of forest resources (FAO, 2020)

- **Government Support and Schemes**

Awareness and implementation of government schemes related to forest rights, livelihood development, and rural employment should be strengthened (Singh et al., 2019).



Current and potential production and employment in collection of NTFPs in Uttar Pradesh (India)

S.NO.	Description	Collection period
1.	**Fibres and Flosses :**	
	(i) Fibre	March-May
	(ii) Kapok floss	May-June
	(iii) Grasses	October-March
2.	**Bamboo and cane :**	
	(i) Bamboo	All year round
	(ii) Canes	All year round
3.	**Essential oils :**	
	(i) Lemon grass	May-June
	(ii) Palmarosa	October-November
	(iii) Eucalyptus	All year round
	(iv) Cinnamon	All year round
	(v) Sandal	All year round
	(vi) Deodar	All year round
	(vii) Pine	All year round
4.	**Non-edible oil seeds :**	
	(i) Mahua	April-June(northern), Oct-Nov(southern)
	(ii) Neem	May-June
	(iii) Karanj	June-October (Different parts of the country)
	(iv) Kusum	June-July
	(v) Sal	April-June
	(vi) Kokum	May-June
	(vii) Nahor	May-June
	(viii) Undi	April-June and September-November
5.	**Tans and dyes :**	
	(i) Babul bark	All year round
	(ii) Avaram bark	All year round
	(iii) Wattle bark	All year round
	(iv) Myrobalans	January-March
6.	**Gums and Resins :**	
	(i) Karaya gum	April-June
	(ii) Ghatti and babul	April-June
	(iii) Resins	March-June
7.	**Lac and tasar silk :**	
	(i) Lac and lac products	October-January and April-July
	(ii) Tasar silk	August-December
	(iii) Tendu leaves	April-June
8.	**Drugs, spices and insecticides :**	
	(i) Sarpagandha	Not available
	(ii) Kuth	October
	(iii) Cinchona	Not available
	iv) Edible products	Not available

Survey Data based on Questionnaire of NTFPs (Non-Wood Forest Products) collection and Utilization from Banda, Chitrkoot, and Lalitpur, Sonebhadra

S.No	Survey in District	Male	Female	Total	Age group	NTFPs using %
1	Banda District	15	25	40	35-48	25-30%
2.	Chitrakoot District	30	70	100	30-50	55-60%
3.	Lalitpur District	35	65	100	35-50	60-65%
4.	Sonebhadra District	60	45	105	30-45	70-80%





CONCLUSION –

The present study highlights the significant role of Non-Wood Forest Products (NWFPs) in sustaining the livelihoods of tribal and rural communities in the Bundelkhand region. The findings indicate that a large proportion of households depend on forest resources for income generation, food security, and subsistence needs (Pandey et al., 2016).

Despite their importance, NWFPs remain underutilized due to various socio-economic and institutional constraints such as lack of market access, low literacy levels, and exploitation by middlemen (FAO, 2020).
Women play a crucial role in the collection and processing of NWFPs, contributing significantly to household income and livelihood security (Singh & Kumar, 2021). However, their contributions are often undervalued and require greater recognition and support.

The study emphasizes the need for integrated policy interventions aimed at improving market access, promoting value addition, and ensuring sustainable forest management. Strengthening institutional support and enhancing awareness among communities can significantly improve their socio-economic conditions (World Bank, 2019).

In conclusion, NWFPs have immense potential to contribute to rural development and poverty alleviation in semi-arid regions like Bundelkhand.
Harnessing this potential requires a coordinated effort involving government agencies, non-governmental organizations, and local communities (UNDP, 2021).

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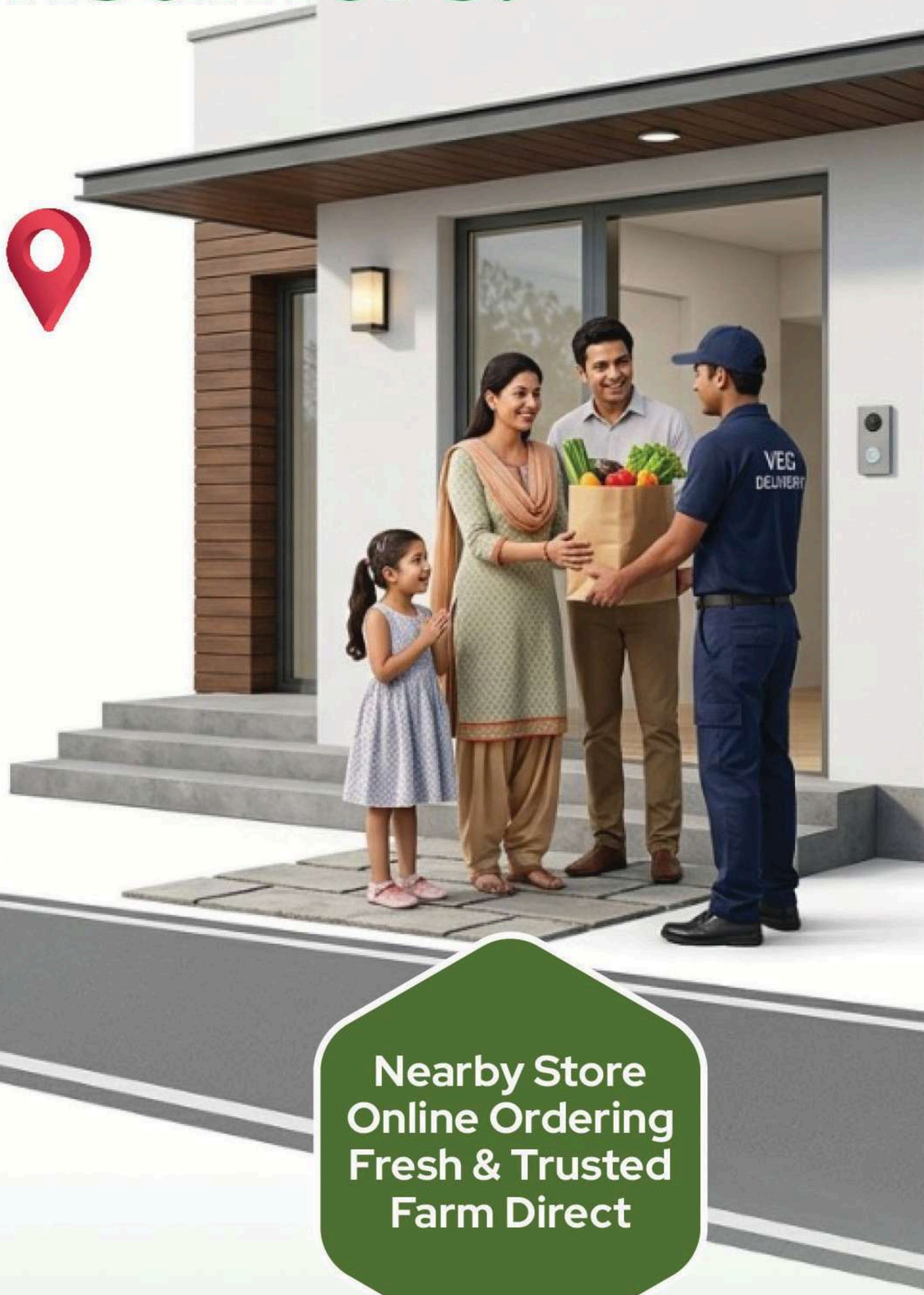
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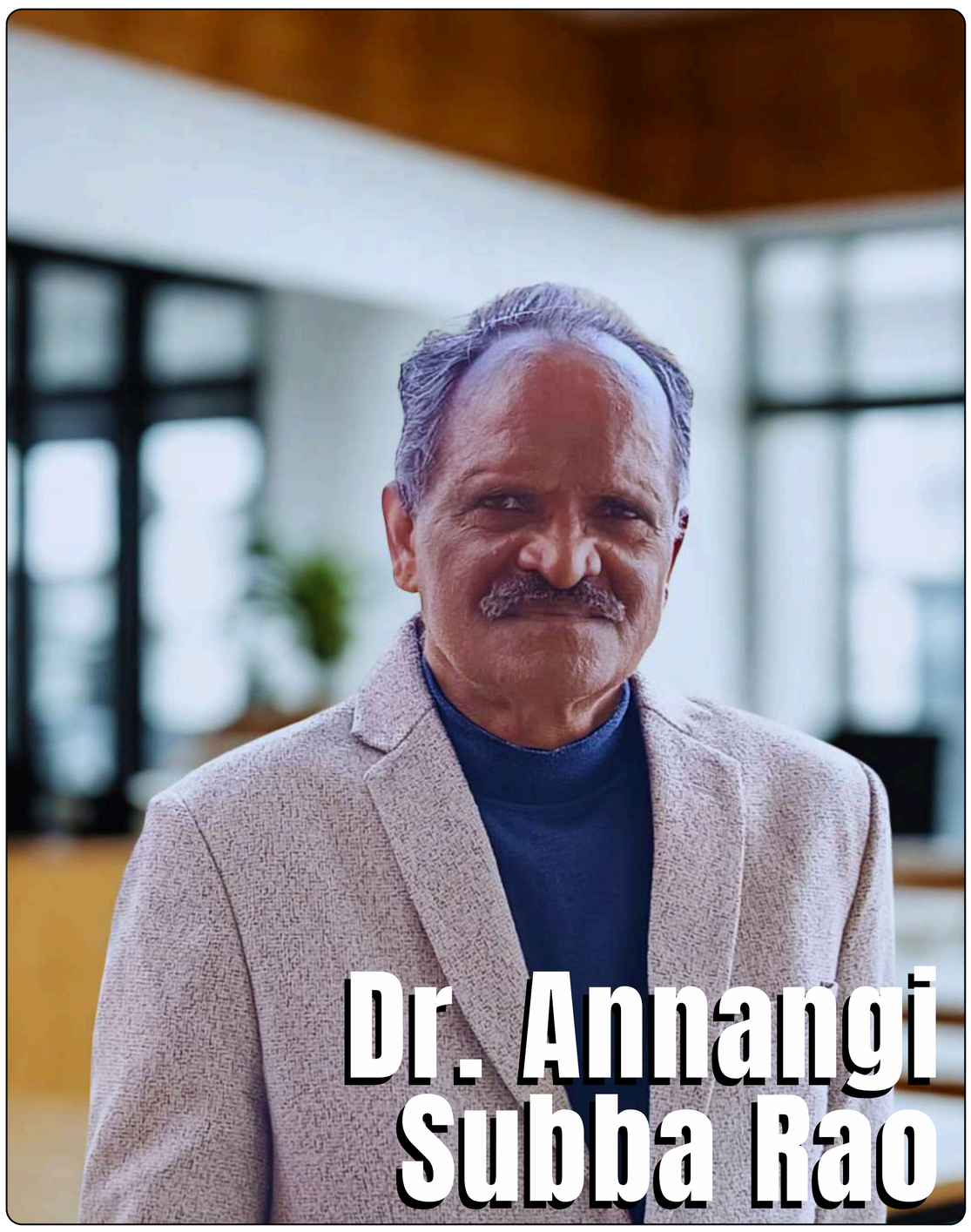
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Recycling **Nitrogen – Rich**

Organic Materials for **Enhanced N nutrition** & **Crop production**

By

Dr. Annangi Subba Rao

Former Director - ICAR–Indian Institute of Soil Science, Bhopal.

ABOUT THE AUTHOR

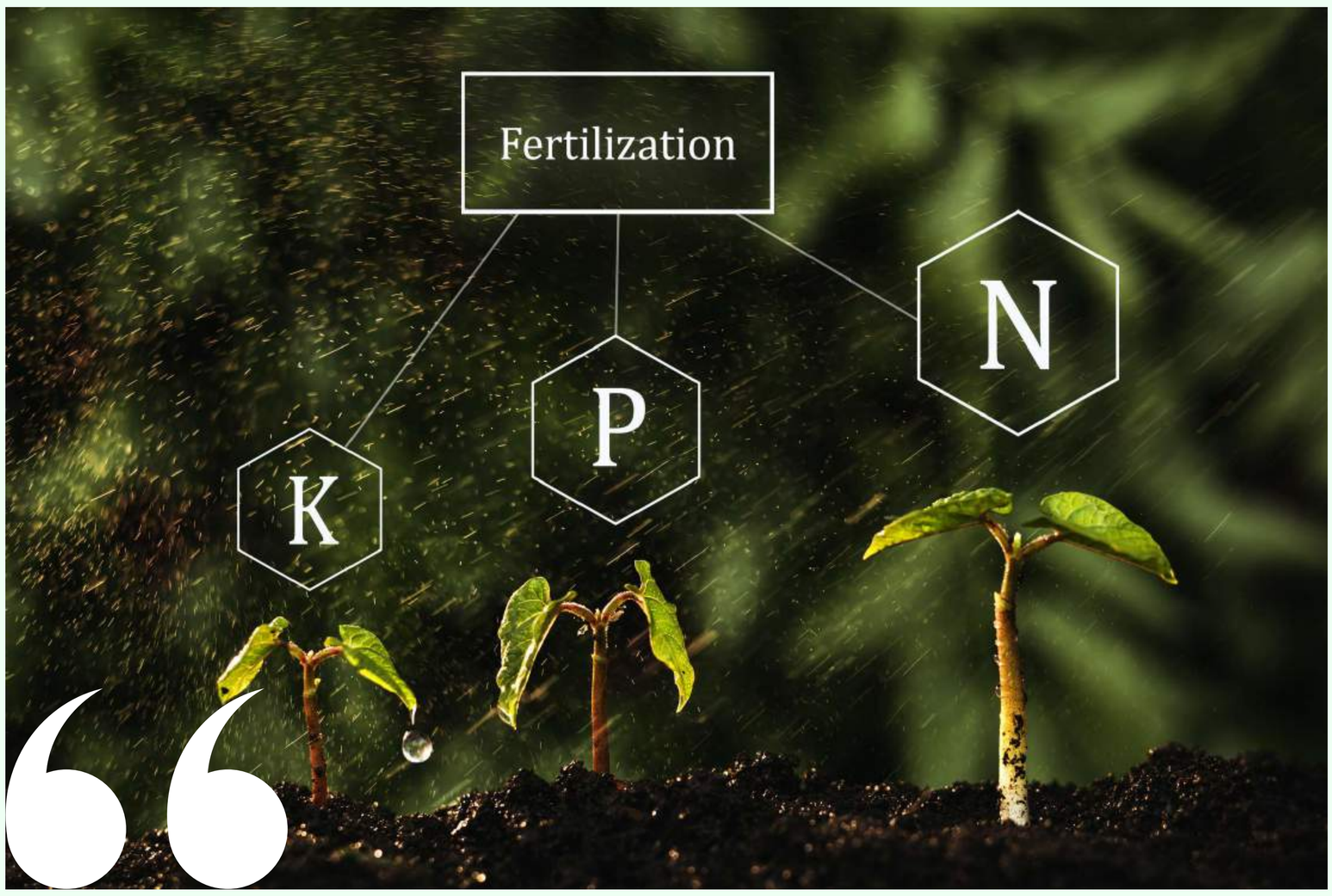
Dr. Annangi Subba Rao is a distinguished soil scientist and former Director of the ICAR–Indian Institute of Soil Science, Bhopal. He has a distinguished career in soil fertility, plant nutrition and sustainable nutrient management.

He has led several national and externally funded research projects and made significant contributions to developing farmer-centric technologies for balanced fertilization and soil health improvement.

Dr. Rao has authored and co-authored numerous scientific publications, technical bulletins, and extension materials, contributing to both academic research and field level application.

His work has been widely recognized for advancing integrated nutrient management practices and promoting resource-efficient and sustainable crop production systems across diverse agro-ecological regions of India.

> Guano was **historically** a very **important source** of N before the advent of the industrial production of N fertilizers.
>
> Now it is **a limited source** of N fertilizer





Nitrogen - A Lifeline Of Plants.

Nitrogen is an essential plant nutrient required in relatively large amounts for plant growth and development. It is a component of aminoacids, proteins, enzymes and chlorophyll etc. In plants nitrogen is required for photosynthesis, protein synthesis, energy transfer and cell growth and division. Inadequate amount of nitrogen results in poor growth of plants, depressed protein levels and low quality produce and inefficient water use.

Organic fertilizers/manures are increasingly being used in India to boost soil health, conserve biodiversity and reduce the dependency on costly chemical fertilizers.

The key organic sources include crop residues, cow dung manure/farmyard manure,vermicompost,compost(kitchen/garden),neem cake etc. Indian Government is promoting organic fertilizers through the Market Development Assistance (MDA) scheme, which helps to market fermented organic manures (FOM) and phosphorus-rich organic manure (PROM) from Compressed biogas plants (CBGplants)

Best Organic Nitrogen Sources (Fast-Acting)

Plant based products

The common plant sources are alfalfa meal from dried and ground alfalfa plants (2.5 -3%N),cotton- seed meal(6-7%N) ,corn gluten(9%N) and soybean meal(6-7%N) which contain reasonably high amounts of N.

Soya bean meal is a byproduct of oil extraction from soybean seeds and is rich in proteins, promoting healthy plant growth.

The phosphorus and potash contents in soya meal are 1.5% and 1.0 %, respectively. Soya meal has an alternative and competing use as an animal feed Cotton seed meal contains 6% N and fair amounts of P (1-3% P2O5) and K (1-2%).



They are natural fertilizers and undergo rapid decomposition and microbial mineralization in soil and supply readily available N, P and K to crops. The main constraint is their availability in sufficient quantity for recycling as they are also used as animal feed.

Animal byproducts

The common animal by-products which can supply nitrogen to crops are blood meal (12%-15N), seabird guano (8--12%N), feather meal (14-16%N,) fishmeal (6-14%N) and fish emulsion (2-5%N)

Blood meal is derived from slaughter house waste, dried, powdered and applied to fields.

It is a high nitrogen organic fertilizer and will mineralize rapidly to plant- available forms of N.

Blood meal also contains 1-2% P and 0-1% K.

Guano was historically a very important source of N before the advent of the industrial production of N fertilizers. Now it is a limited source of N fertilizer. There are two types of guano- seabird guano and bat guano. Seabird guano is gathered from islands that have low rainfall and arid climate, both of which help it to retain high levels of nutrients. Bat guano is harvested from caves where large bat populations roost.

The common guano based formulations contain 10-3-I NPK and are fast acting.

Fishmeal contains 6-12%N, 3-7%P and 2-5% K. Non-edible fish are cooked and pressed to separate the solid and liquid portion fractions. The solid one is used as fishmeal for fertilizer and animal feed.

The valuable fish oil is removed from the liquid fraction and the remaining solution is thickened into fish emulsion. The fish emulsion typically contains about 5% N along with some essential micronutrients but it contains little or no calcium and potassium.

The fish odour from the fishmeal may be unpleasant. Due to its high N concentration, fish meal is a fairly fast-acting natural fertilizer as the mineralization of fish based products in soil is rapid.

Fishmeal also contains fair amounts of P and Ca and is commonly used in coastal areas.

Organic Nitrogen Sources (Slow-acting & soil health-building)

Feather meal (14-16%N) is a byproduct of the poultry industry.

It is a non-soluble keratin stabilized by highly resistant disulphide bonds.

When treated with pressurized steam and animal derived enzymes, the feather-based protein becomes a good source of available N for crop plants. Feather meal is also pelletized before application to field for easy handling.

Compost

Composts generally contain low concentrations of N, P and K. They decompose slowly in soil and provide N over extended periods of time. Composts are made from farm wastes, municipal solid wastes and industrial byproduct sources. Compost made from kitchen scraps (vegetable peels, coffee grounds) and grass clippings etc may contain significant levels of N.

Vermicompost is nutritionally superior to ordinary composts based on farm wastes. Vermicompost contains 1.9%N, 2%P2O5 and O.8 % K2O.

It is also favored for improving soil structure and providing essential microbes. Rapid composting methods using farm wastes are now becoming popular in India

Manure

Adding manure to soil is one of the oldest practices to improve the soil fertility, soil structure, humus content, water retention and aeration. It also supplies plant-available micronutrients and enhances soil biodiversity.

Compared to cattle or farm yard manure, the chicken and poultry manures contain high amounts of nitrogen (3-4%), phosphorus (1-2%) and K (2%). Sheep and goat manures (3-4%N) are also being used by farmers wherever they are available. Sheep manure also contains 2-3% K and 0.5-1 % P.

Cheaper Nitrogen Sources

Grass clippings are rich in nitrogen (1-2%) and potassium (1-2%). These can be used as mulch to release nutrients slowly into soil as they breakdown

Green vegetable clippings and kitchen scraps can be placed directly in the soil or soaked in water for several days to create a liquid fertilizer.

Neem cake and oilcakes: Oilcakes are also used for animal feeds. Neem cake has natural pest control properties.

Biofertilizers

Bio-nitrogen fertilizers are products containing live microorganisms(bacteria) capable of biological nitrogen fixation(BNF) The key bacteria species include Rhizobium which forms symbiotic relationships with legumes(beans Bengal gram, soybean, groundnut ,lentils, alfalfa, clover etc.) and enriches the



soil by converting atmospheric nitrogen(N2) into ammonium. These microbes colonize the root zone or form nodules with legumes roots, converting N2 gas from the air into plant-accessible nitrogen. Azotobacter and Azospirillium are free–living or associative diazotrophs that fix nitrogen in the root zones of cereals, vegetable and non-leguminous crops.

Biological nitrogen fixation by these microbes reduces the dependency on synthetic fertilizers, lowers input costs and enhances soil biodiversity.

Green Manures & Cover Crops

Green manure crops are primarily grown for specified periods during a cropping season when a field is not in use, and are then ploughed under or incorporated into the soil before the succeeding crop is established. Leguminous green manures contain 2-4%N, 0.5%P and 2-3%K. Green manure crops add nutrients and organic matter to the soil, protecting and improving soil health.

They have multiple uses, providing several opportunities for inclusion in the crop rotation. Cover crops may be used as green manures, living mulches, residue mulches, catch crops and forages. Living mulches are cover crops planted for a living ground cover throughout the growing season.

Living mulches are established between the rows of main crops to suppress weeds by blocking sunlight and competing for water, nutrients and to reduce erosion.

Residue mulches are cover crop mulches that are left over residues which are laid on top of soil surface as mulch. The crop residue limits weed seed germination by intercepting sunlight, preventing it from reaching the soil surface.

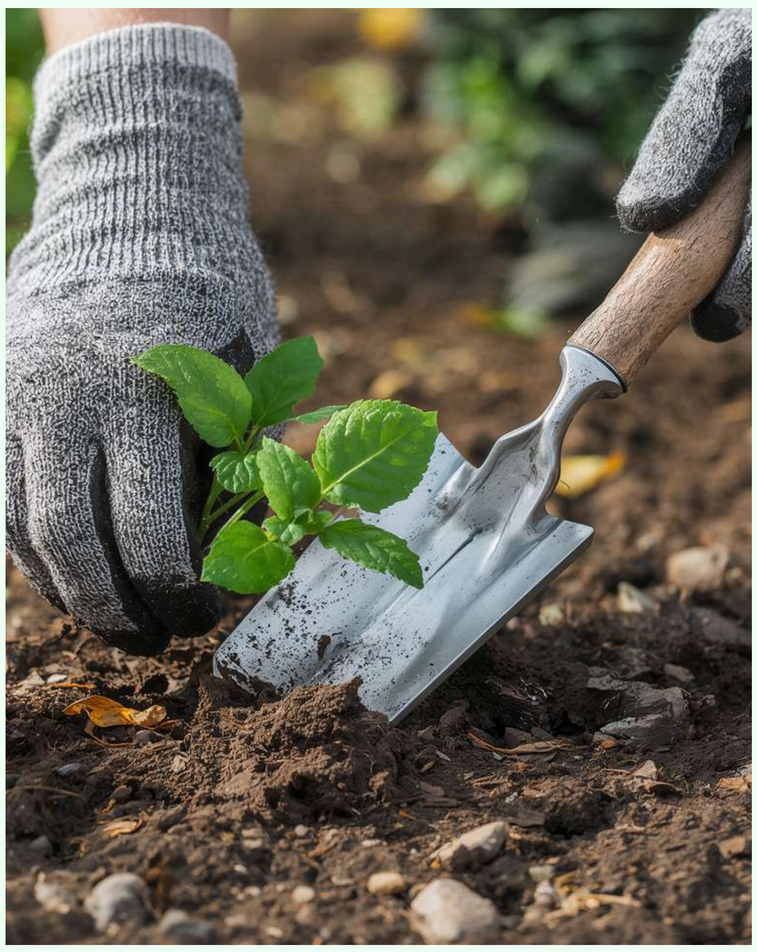
Catch crops are generally grown for a short time and these are established after the cash/main crop is harvested to reduce nutrient losses by leaching or by holding nutrients in the soil root zone.

Crop Rotations / Intercropping

Crop rotation is a cornerstone of regenerative and sustainable agriculture. Rotating crops with legume as a component crop provides a natural biological nitrogen boost.

Example, the inclusion of legumes (beans, peas, lentil) with cereals or vegetables.

The legume fixed N is used by both the legume crop and by the subsequent/inter crops.



Application Strategies

When organic sources of nitrogen are chosen for fertilizing a crop, some guidelines need to be followed. Soil testing helps to know the current status of nutrients in the soil and also any soil related constraint.

Knowledge of soil nutrient status helps to decide the amount of N to be applied. Add nitrogen to soil during the growing season when plants are in active growing or developing stage. Moderate the dose of application to prevent nutrient burn (of leaves) and ensure a balanced supply of essential nutrients.

Monitor the plant growth and adjust the nutrient additions as per the necessity at different growth stages.



Environmental Benefits

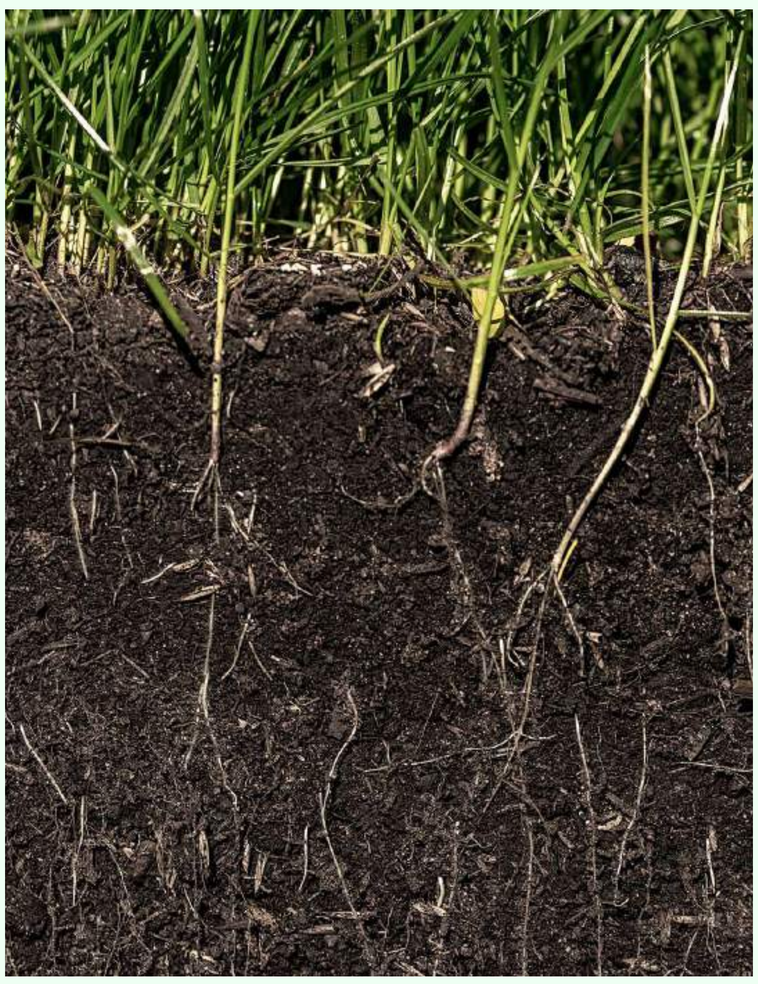
Organic sources of nutrients, without associated contaminants, are safe to the environment, water and soil health will be taken care of.

Conclusions -

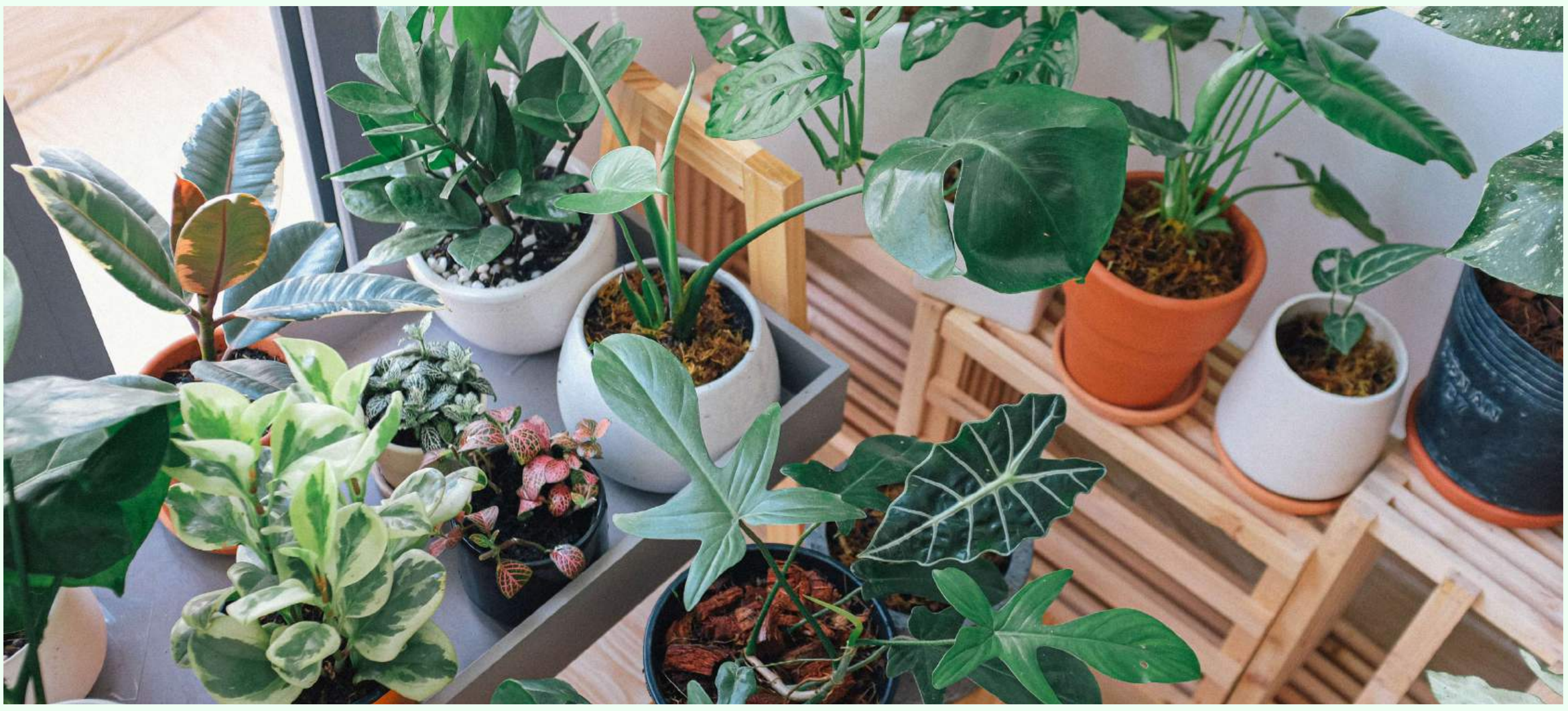
Choosing a right organic source of nutrients can significantly enhance plant growth, vigor and ultimately the quality of the produce.

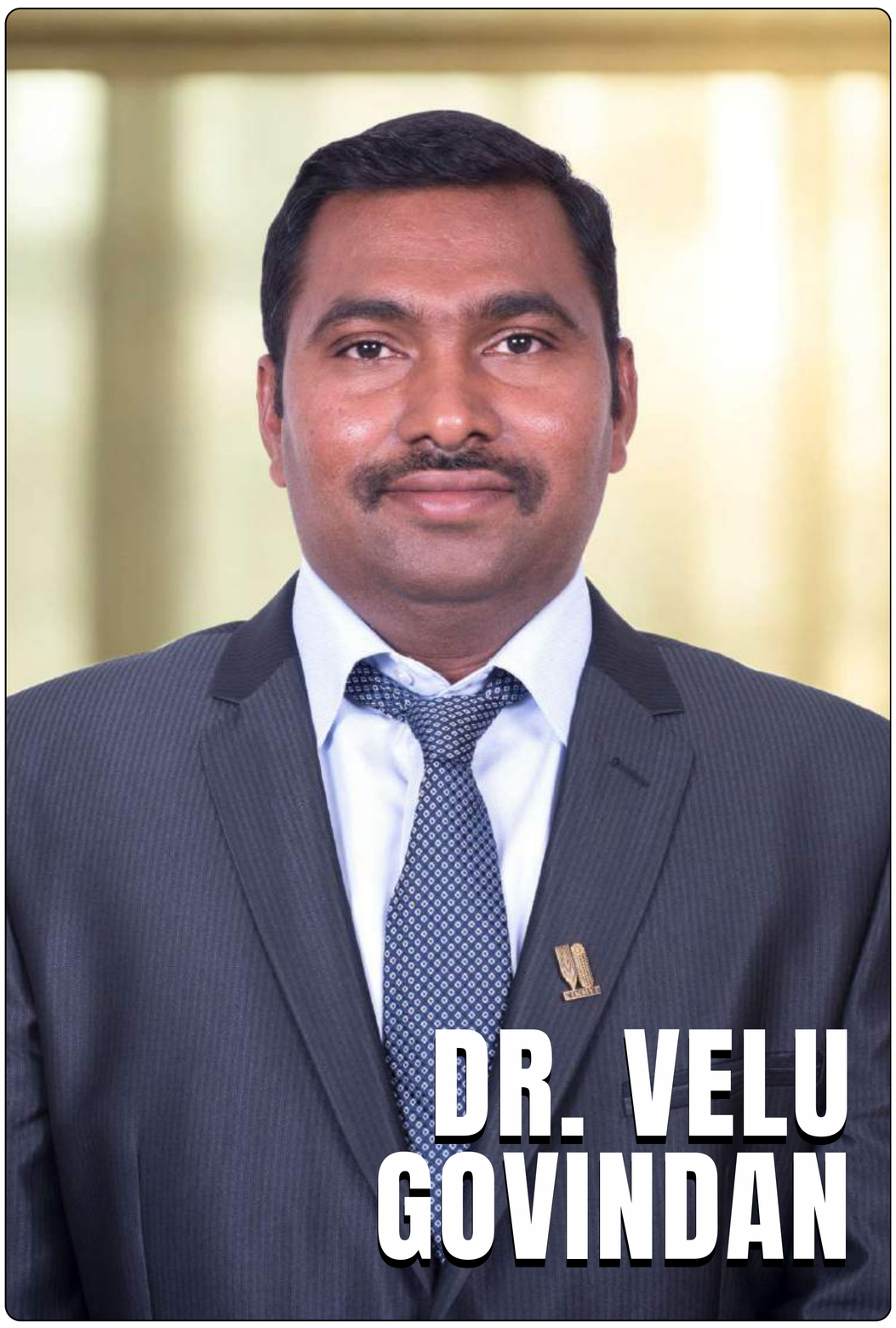
Also following the good or best agronomic practices help to get the best benefit out of the organic nutrient application .

Organic materials contribute to healthy soil, biodiversity conservation and a safe environment.









The New Breakthrough

High-Zinc Wheat & Its **Transformation** of **Nutrition** in India

By

Dr. Velu Govindan

Principal Scientist, Wheat Breeding and Biofortification International Maize and **Wheat Improvement Center (CIMMYT),** Mexico

ABOUT THE AUTHOR

Dr. Velu Govindan is a Principal Scientist and wheat breeder at the International Maize and Wheat Improvement Center (CIMMYT), Mexico.

He has over 20 years of international experience in wheat and cereal crop improvement, specializing in plant breeding, biofortification, and the development of climate-resilient, high-yielding varieties.

Dr. Govindan has led global efforts to mainstream grain zinc and iron in wheat breeding programs, resulting in the release and adoption of nutrient-dense wheat varieties across South Asia, Africa, and other regions.
His research integrates conventional and modern breeding approaches to enhance productivity, nutritional quality, and food security worldwide.

How Biofortified Wheat **Developed by CIMMYT and Indian Partners** Is Improving Nutrition, Strengthening Farmer Livelihoods & Reaching, **More Than 90 Million Consumers Every Day**





Wheat **Beyond** Food **Security**

For generations, wheat has been an integral part of daily life across northern India. From freshly prepared chapatis at breakfast to evening meals shared by farming families, wheat remains one of the country's most important staple foods. While wheat has played a critical role in ensuring food security, the challenge of nutrition security continues to affect millions of households.

Across South Asia, micronutrient deficiencies, particularly zinc deficiency, remain a major public health concern. Often referred to as "hidden hunger," zinc deficiency can weaken immunity, impair child growth and development, and increase vulnerability to infections and disease. Women and young children are among the most affected. Although wheat naturally contains some essential nutrients, many rural households are unable to access sufficiently diverse diets that provide adequate micronutrients on a regular basis.

Recognizing this challenge, scientists began exploring how staple crops themselves could become vehicles for improved nutrition. This vision gave rise to biofortification, an approach that enhances the nutritional value of crops through plant breeding, enabling farmers and consumers to benefit without changing dietary habits or increasing food costs.

The Birth of Ninga: A New Generation of **Biofortified Wheat**

To address micronutrient malnutrition, CIMMYT and Indian agricultural research institutions worked together to develop a new generation of wheat varieties capable of delivering higher levels of zinc through everyday diets.

One of the most significant outcomes of this effort is Ninga, a breakthrough high-zinc wheat variety and family of elite sister lines developed specifically for Indian farming systems.

Unlike conventional wheat varieties, Ninga was designed to combine enhanced nutritional value with the characteristics farmers value most: high yield potential, disease resistance, climate resilience, and excellent grain quality.

The objective was clear to produce a wheat variety that benefits both farmers and consumers.

Science Meets **Nutrition**

The development of Ninga represents more than a decade of scientific innovation and international collaboration.

Ninga originated from a carefully designed combination of three distinct parental lines: Neloki, Sokoll, and Excalibur. Neloki includes genetic contributions from India's widely cultivated PBW343 variety. Sokoll traces its origin to synthetic hexaploid wheat known for strong stress tolerance, while Excalibur, an Australian wheat variety, contributes high tillering ability and superior zinc uptake efficiency.

Researchers identified naturally occurring high-zinc traits in ancient wheat lines



landraces, and wild relatives before incorporating these traits into modern high-yielding wheat backgrounds. Through extensive breeding cycles and rigorous field evaluations, scientists successfully combined enhanced zinc concentration with strong agronomic performance and farmer-preferred characteristics.

The result was a new generation of wheat varieties capable of increasing grain zinc levels by approximately 20 to 40 percent compared with conventional wheat varieties, without compromising productivity.

High Performance in **Farmers' Fields**

For any agricultural innovation to succeed, it must perform well under real farming conditions. Ninga demonstrated exactly that.

Field evaluations showed strong grain yields, improved disease resistance, tolerance to heat stress, and increased grain zinc concentration. These qualities made the variety highly attractive to farmers facing increasingly unpredictable climatic conditions.

Importantly, consumers also benefit.

The additional zinc present in the grain is effectively delivered through everyday foods such as chapatis and rotis. Since wheat flour from different varieties is commonly blended within market supply chains, high-zinc wheat now contributes to improved nutrition at a population scale without requiring consumers to change their preferences or food preparation methods.

The additional nutritional value remains virtually invisible while delivering significant health benefits.

From **Research** Plots to **Millions of Farmers**

The impact of Ninga and its related varieties has been remarkable.

Sister lines from the Ninga family were released in India between 2021 and 2024 under the names DBW 327, PBW 826, HD 3386, and DBW 386. During the 2025-26 Rabi season, these varieties emerged as major cultivars across Punjab, Haryana, and Western Uttar Pradesh.

Collectively, they now cover an estimated 7 to 8 million hectares and occupy nearly 70 percent of the wheat-growing area within India's Northwestern Plain Zone.

This rapid adoption highlights both the agronomic value of the varieties and the effectiveness of India's agricultural research and extension systems in bringing innovations from research stations to farmers' fields.



Seeds, **Partnerships** & **Rural Entrepreneurship**

A major factor behind the successful expansion of high-zinc wheat varieties has been the coordinated effort of research institutions, public seed agencies, and local seed networks.

Organizations such as the Indian Institute of Wheat and Barley Research (IIWBR), Punjab Agricultural University (PAU), and several public and private seed partners played a vital role in accelerating seed multiplication and dissemination.

Because wheat is a self-pollinated crop requiring large quantities of seed for cultivation, varietal replacement is often a slow process. However, strategic breeder seed multiplication, foundation seed production, and decentralized seed distribution systems enabled these varieties to reach farmers much faster than traditional replacement cycles.

Small and medium-scale seed producers also played a crucial role. Their involvement strengthened local seed availability, generated rural business opportunities, created additional income streams, and accelerated the adoption of climate-resilient and nutrition-enhancing wheat varieties. This experience demonstrates how strong partnerships between research institutions and local entrepreneurship can successfully transform agricultural innovation into large-scale impact.

Advancing **Nutrition Security** Through **Agriculture**

India has increasingly recognized the importance of transitioning from food security to nutrition security.

To support this vision, the Government of India has encouraged the promotion of biofortified crops and mandated the inclusion of biofortified varieties in a portion of Frontline Demonstrations (FLDs) conducted across the country.

Between 2018 and 2025, India released 28 high-zinc wheat varieties adapted to different wheat-growing regions.

Today, biofortified wheat varieties occupy a significant share of India's wheat-growing area and reach millions of consumers annually.

Scientific studies have also validated their nutritional benefits. Research conducted in India found that children and mothers consuming high-zinc wheat experienced fewer days of illness, including reduced incidences of fever and other common health conditions, compared with those consuming conventional wheat.

These findings demonstrate the powerful role agriculture can play in improving public health outcomes.



A Small **Grain with a Big Impact**

The success of Ninga represents more than a breeding achievement. It reflects a new approach to agricultural development where productivity, nutrition, resilience, and farmer prosperity work together.

Today, farmers cultivating high-zinc wheat are doing more than producing grain. They are contributing to the fight against hidden hunger while benefiting from improved varieties that offer strong yields, disease resistance, climate resilience, and market acceptance.

As climate pressures intensify and nutrition challenges continue to affect vulnerable populations, biofortified crops offer a practical and scalable solution. Ninga demonstrates that even a small increase in zinc within a grain of wheat can have a profound impact on the health , well being & Future of Millions of People . For India, this breakthrough represents a powerful example of how scientific innovation, institutional collaboration, and farmer adoption can come together to build healthier communities and more resilient food systems for generations to come.





Medicinal & Aromatic Plants (MAPs) in Bioeconomy Era

Driving India's **Next Green Industrial Revolution**

By

Dr. Mahesh Mahadeo Kadam

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Dr. Mahesh Mahadeo Kadam is a Senior Scientist driving Marketing, Business Development, and Strategic Collaborations at CSIR-CIMAP, a premier national institute under the Council of Scientific & Industrial Research (CSIR).
With expertise spanning agrotechnology, product innovation, value-added processing, and technology commercialization, he works at the intersection of scientific research and industry deployment.

His role focuses on accelerating the translation of CSIR-CIMAP's R&D into scalable, market-ready solutions for the medicinal & aromatic plants (MAPs) sector.

Dr. Kadam actively engages with farmers, startups, industries, government bodies, and international partners to strengthen India's bioeconomy through science-enabled innovations, high-value plant-based products, and sustainable rural livelihoods.

..**The way forward** lies in fostering **a resilient, inclusive & innovation-driven MAP ecosystem** that integrates farmers, researchers, industry, and global markets.

By doing so, India can **position itself as a global leader** in the **natural products** economy..

Allure of , the ***Natural.***

Medicinal and Aromatic Plants (MAPs) are emerging as critical drivers in the global transition toward a sustainable bioeconomy, linking agriculture with high-value sectors such as pharmaceuticals, nutraceuticals, cosmetics, and wellness industries. With rising global demand for plant-based, eco-friendly, and health-oriented products, MAPs offer significant opportunities for economic growth, rural development, and industrial innovation. India, endowed with rich biodiversity, traditional knowledge systems, and strong scientific capabilities, is uniquely positioned to leverage this sector as a cornerstone of its green industrial transformation.

This article highlights the growing importance of MAPs within the global bioeconomy framework, supported by key trends, market insights, and policy initiatives such as the Biopharma Mission, National AYUSH Mission, and other Government of India programs. It underscores how the integration of biotechnology, digital tools, and value chain development is enabling the evolution of a “farm-to-pharma” ecosystem, enhancing value addition and global competitiveness.Despite the immense potential, challenges related to quality standardization, supply chain inefficiencies, and limited awareness persist.

Addressing these through strategic interventions—including research and innovation, capacity building, digital traceability, and strengthened market linkages—will be crucial.

The way forward lies in fostering a resilient, inclusive, and innovation-driven MAP ecosystem that integrates farmers, researchers, industry, and global markets.

By doing so, India can position itself as a global leader in the natural products economy, driving a sustainable and inclusive green industrial revolution.



Period of **Transitions**

The global economy is undergoing a profound transformation, shifting from fossil-based systems to sustainable, bio-based models. This transition, widely termed the bioeconomy, is expected to surpass USD 4 trillion globally by 2030, driven by innovations in biotechnology, sustainable agriculture, and natural product industries.

Within this paradigm, Medicinal and Aromatic Plants (MAPs) are emerging as a strategic resource, bridging agriculture, healthcare, and industry. For a biodiversity-rich country like India, MAPs hold the potential to catalyze what can be termed the next green industrial revolution—one that is inclusive, sustainable, and innovation-driven.

Global Bioeconomy Landscape & Rising Demand for **Natural Products**



Globally, there is a marked shift toward plant-based, eco-friendly, and sustainable products across sectors such as pharmaceuticals, nutraceuticals, cosmetics, and wellness industries. The World Health Organization estimates that nearly 80% of the global population relies on traditional medicine systems, many of which are plant-based. Simultaneously, the global herbal medicine market is projected to reach over USD 400 billion by 2030, while essential oils and plant-derived bioactives are witnessing double-digit growth rates.

Regions such as the European Unions & the United States have already positioned bioeconomy strategies at the core of their industrial policies.



The EU Bioeconomy Strategy, for instance, emphasizes renewable biological resources and their conversion into value-added products.

India, with its rich heritage of traditional knowledge systems like Ayurveda, Siddha, and Unani, coupled with vast agro-climatic diversity, is uniquely positioned to become a global leader in this domain.

MAPs: **Convergence** of Agriculture , **Industry & Healthcare**

Medicinal and Aromatic Plants represent a critical interface where agriculture meets high-value industrial applications.

These crops are not merely raw materials but serve as the foundation for a range of industries including pharmaceuticals, essential oils, perfumery, nutraceuticals, and functional foods. India is home to over 7,000 species of medicinal plants, and nearly 1,500 species are actively used in traditional & modern healthcare systems the Domestic ..



AYUSH industry alone is valued at over USD 20 billion and growing rapidly, while exports of medicinal plant-based products continue to expand in global markets.Aromatic crops such as mentha, lemongrass, citronella, and vetiver have transformed agricultural landscapes in several states by offering higher returns per hectare compared to traditional crops. For instance, India contributes more than 70% of the global mint oil production, making it a global leader in this segment. Such examples highlight the economic viability and scalability of MAP-based agriculture.

India's **Strengths:** Biodiversity, Traditional Knowledge & **Scientific Innovation**

India's strength in the MAP sector lies in its unique combination of biodiversity, traditional knowledge systems, and scientific research capabilities. Institutions like CSIR laboratories, agricultural universities, and research centers have played a pivotal role in developing improved varieties, cultivation practices, and processing technologies.

The integration of traditional knowledge with modern science has enabled the development of standardized extracts, value-added formulations, and quality assurance protocols. This is critical for enhancing global acceptance and competitiveness of Indian herbal products.

Moreover, initiatives such as the National AYUSH Mission and various government schemes supporting medicinal plant cultivation are fostering a conducive ecosystem for farmers, entrepreneurs, and industries.

Biopharma Mission & Innovation Ecosystem: **Catalyzing Growth**

India's Biopharma Mission, led by the Department of Biotechnology, represents a major step toward strengthening the country's bio-based innovation ecosystem. While traditionally focused on vaccines, biologics, and diagnostics, there is increasing recognition of the role of plant-based bioactives in drug discovery and development.

The convergence of biotechnology, phytochemistry, and digital tools is opening new avenues for MAP-based innovations. Startups and MSMEs are leveraging these advancements to develop novel products such as plant-based therapeutics, herbal supplements, natural cosmetics, and wellness products.

The rise of agri-biotech startups, coupled with incubation support and funding mechanisms, is accelerating the commercialization of MAP-based technologies. This ecosystem is crucial for translating research into market-ready products, thereby enhancing the overall value chain.





Economic **Opportunities:** From Farm to **Global Markets**

The MAP sector offers immense opportunities for income generation, rural development, and export growth. Unlike conventional crops, MAPs provide higher value realization through processing and value addition. The concept of "farm to pharma" is gaining traction, where raw plant materials are transformed into high-value finished products.

For farmers, MAP cultivation offers diversification, resilience against climate variability, and better profitability. For industries, it ensures a sustainable and traceable supply of raw materials. For the nation, it contributes to export earnings and strengthens the bioeconomy.

The global demand for natural and organic products is further boosting the market potential of MAP-based products. India's ability to supply high-quality, standardized, and certified products can significantly enhance its share in international markets.





Challenges & the Need for Strategic **Interventions**

Despite its immense potential, the MAP sector faces several challenges. These include issues related to quality standardization, supply chain inefficiencies, lack of traceability, and limited awareness among farmers. Additionally, fragmentation in the value chain often results in suboptimal value realization.

Addressing these challenges requires a holistic approach involving policy support, capacity building, infrastructure development, and market linkages.
Strengthening farmer-producer organizations (FPOs), promoting contract farming, and establishing processing clusters can significantly enhance efficiency and profitability.

Digital technologies such as blockchain, remote sensing, and AI-based advisory systems can further improve traceability, quality assurance, and decision-making across the value chain.





The Way Forward..

.. Building a **Sustainable MAP-** Based **Bioeconomy .**

The future of Medicinal and Aromatic Plants lies in their integration into a broader bioeconomy framework. This requires a multi-pronged strategy focusing on innovation, sustainability, and inclusivity.

First, there is a need to strengthen research and development efforts to develop high-yielding, climate-resilient varieties and efficient processing technologies. Second, fostering industry-academia partnerships can accelerate the translation of research findings into commercial products. Third, promoting digital ecosystems for market access, traceability, and value chain integration can enhance efficiency and transparency.

Equally important is the need to build awareness and capacity among farmers, entrepreneurs, and stakeholders to adopt best practices and leverage emerging opportunities.

Policy support in terms of incentives, infrastructure, and export facilitation will further catalyze the growth of MAPs.



Conclusion –

Medicinal and Aromatic Plants are no longer confined to traditional uses; they are at the forefront of a global transition toward sustainable and bio-based economies. For India, they represent a unique opportunity to drive economic growth, enhance farmer incomes, and establish global leadership in the natural products sector.

By leveraging its strength in biodiversity, traditional knowledge, and scientific innovation, India can position MAPs as a cornerstone of its bioeconomy.

This transformation has the potential to usher in a green industrial revolution—one that harmonizes economic development with environmental sustainability and societal well-being.





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COVER STORY INTERVIEW

KhetiValah
Global Agri Magazine

DR HIMANSHU PATHAK

Dr. Himanshu Pathak is the Director General of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and a globally respected agricultural scientist with more than three decades of experience in climate resilience, soil science, crop management, and sustainable agricultural systems. Prior to joining ICRISAT, he served as Secretary of the Department of Agricultural Research and Education (DARE), Government of India, and Director General of the Indian Council of Agricultural Research (ICAR), one of the world's largest agricultural research and education organizations.

A distinguished researcher and an able leader, Dr. Pathak holds a Ph.D. in Soil Science and Agricultural Chemistry from the Indian Agricultural Research Institute (IARI). Through his career, he led several national and international research initiatives, managed more than 50 research projects, and published over 200 scientific papers and numerous books. His contributions have significantly helped towards climate-smart agriculture, resource-use efficiency, and sustainable farming practices.

Dr Pathak has extensive experience in the global agricultural landscape and plays a key role in strategically aligning research efforts with global sustainable development goals. He also held various chairmanship positions, including those of the Governing Body of ICAR, the National Academy of Agricultural Sciences (India), the Food and Agriculture Division of the Bureau of Indian Standards, the Research Council of the Council of Scientific and Industrial Research, the G20 Meeting of Agricultural Chief Scientists, and the International Water Management Institute-ICAR Steering Committee, among others.

He also played a lead role in shaping agricultural research, policy, and innovation through various national and international committees, academies, and scientific platforms. His vision continues to drive transformative agricultural solutions that support farmers, strengthen food systems, and contribute to global sustainable development goals.

Dr Himanshu Pathak
Director General of ICRISAT
ICRISAT
INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

Prof. Vivekananda D is an academician, researcher, and technology expert associated with premier institutions including IITB, IIMB, IIST T'Puram, Chair of AICTE's Executive Commities, IEEE's Pre Std of OWOSOH Section's Secy B'lore Chapter.
Also Co-ordinator of IIRS-ISRO Dehradun's OUTREACH Programs.
His expertise spans in AI, Data Analytics, Antenna Design, space science, and emerging technologies.

He served as the Interview Coordinator and Academic Advisor for the exclusive Cover Story Interview with Dr. Himanshu Pathak, Director General, ICRISAT, featured in the June 2026 edition of KhetiValah Global Agri Magazine (e-magazine)



Prof. Vivekananda D



Exclusive INTERVIEW With

Dr Himanshu Pathak, Honorable **DG, ICRISAT,** Hyderabad, India

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a globally recognized agricultural research organization dedicated to improving food security, nutrition, and livelihoods in the dryland regions of Asia and Sub-Saharan Africa.

Headquartered in Hyderabad, India, ICRISAT works across 55 countries through a network of regional hubs, country offices, and research partnerships.

Its key focus areas include dryland farming, crop improvement, soil health, climate resilience, natural resource management, digital agriculture, and agribusiness innovation.

Through scientific research, capacity building, and multi-stakeholder collaborations, ICRISAT empowers smallholder farmers, strengthens food systems, and contributes to sustainable agricultural development and global food and nutrition security.



Dryland Agriculture & Global Food Security

Q 1 - Dr Vivekananda

Dryland regions support millions of smallholder farmers and play a critical role in global food production, yet they remain highly vulnerable to climate variability.
How do you see dryland agriculture contributing to future food security and resilient farming systems ?

Dr Pathak

Dryland agriculture is critical for future food security. By utilizing climate-resilient crops and varieties, water and soil management, and sustainable agriculture practices, drylands can anchor global food systems against increasing climate shocks.

Shifting to agro forestry and diversified cropping is vital for building resilience and improving smallholder livelihoods. Drylands cover 47% of the world’s land area, spreading across 110 countries. More than 2.3 billion people (1 in 3 globally) live in drylands. In Africa 60–65% is dryland, home to about 525 million people. Around 90% in low- and middle -income countries are in drylands. Most drylands inhabitants depend on natural resources, 30% of which are degraded.

In India drylands occupy 68% of the country's total cultivated land, producing 45% of India's food grains and supporting 40% of its human population.

Key regions in drylands include the Deccan Plateau, Central highlands and Deserts. Major states with substantial areas under drylands include Rajasthan, Maharashtra, Madhya Pradesh, Gujarat, Uttar Pradesh, Andhra Pradesh, Telangana, Jharkhand and Tamil Nadu. Thus dryland agriculture is the corner-stone of India's food security.

We at ICRISAT do not view drylands as marginal or harsh landscapes, but as one of the greatest opportunities to sustainably expand global food production.

With the right science, innovation, and partnerships, drylands can become engines of resilience, nutrition, and prosperity for millions. This is not new, historically, dryland farming has evolved by combining indigenous coping strategies with science-based innovations. The ancient water-harvesting in Mesopotamia and India to modern conservation tillage and drought-tolerant cultivars, innovation has consistently transformed challenges into opportunities.

Climate Resilience in Semi-Arid Regions

Q 2 - Dr Vivekananda

Climate change continues to affect crop productivity, water availability, and farmer livelihoods. What key strategies does ICRISAT prioritize to help farmers adapt to climate related risks in semi-arid ecosystems ?

To help smallholder farmers adapt to the compounding threats of climate change, ICRISAT prioritizes a holistic approach.

Firstly, the crops themselves.

Together with our partners, we develop short-duration, disease-resistant, drought- and heat-tolerant varieties that help farmers reduce risks and adapt better to climate variability. These improved varieties are critical in ensuring productivity even under



increasingly unpredictable weather conditions. Secondly, we focus on strengthening farming systems as a whole.
This includes addressing water and soil challenges, matching crops to local water availability, promoting sustainable agricultural practices, and deploying digital tools that support farm-level decision-making.
Our integrated landscape restoration work in Odisha, Bihar, and Bundelkhand in Uttar Pradesh has demonstrated how degraded lands can be transformed back into productive and resilient agricultural ecosystems.

A key component of this transformation is digital agriculture. Early warning systems for pests and diseases, localized climate and weather advisories, and AI-enabled pest and disease detection tools are becoming increasingly powerful in addressing climate-related risks.
These technologies improve preparedness, enable timely interventions, and help farmers make more informed decisions in the face of growing climate uncertainty.

Leadership Journey Across National & Global Institutions

Q 3 - Dr Vivekananda

Having served in key scientific leadership roles across India's agricultural ecosystem, including ICAR, NAAS & now ICRISAT, you have experienced both national and global research systems closely. What major lessons from these leadership journeys have shaped your vision for agricultural innovation and institutional impact ?

Dr Pathak

Scientific leadership has never been the ultimate goal; nation building has always been the larger mission.
Agriculture and the rural economy form the foundation of any nation's progress. Agriculture cannot operate in isolation. It must be linked to a broader vision for society. It must address nutrition and health, reduce poverty and hunger, and create inclusive growth that benefits everyone equally.

Passion for science must go hand in hand with a commitment to the Sustainable Development Goals and national economic development. Scientific innovation must ultimately improve lives on the ground.

Today's challenges are global, but their solutions must be locally adapted. That is why partnerships at every level are essential. As I navigate roles across ICAR, NAAS, and now the CGIAR system through ICRISAT,
I increasingly see the need for partnerships to move beyond individual 'impact' towards 'impacts at scale.'

India's agricultural progress itself stands as evidence of what collaborative science can achieve through partnerships between CGIAR institutions, ICAR, NAAS, and national systems.
I remain optimistic that stronger collaborations will further accelerate agricultural research, innovation, and sustainable development in India.



Leadership Journey Across National & Global Institutions

Q 4 - Dr Vivekananda

ICRISAT is headquartered in India and holds a unique position in supporting dryland agriculture. Under your leadership, engagement with Indian farmers, startups, researchers, and state governments appears to have strengthened. How do you view ICRISAT's evolving relationship with India and its growing accessibility to local stakeholders ?

Dr Pathak

ICRISAT's journey with India spans more than five decades and is deeply rooted in a shared mission to reduce poverty, hunger, malnutrition, and environmental degradation across the drylands.
In 2026, we will proudly mark 50 years of partnership with ICAR, a collaboration that has significantly shaped agriculture and food systems in India.
Over the years, ICRISAT has played an important role in supporting India's pulses mission, the ongoing oilseeds mission, and the global positioning of millets as crops of nutrition, resilience, and economic opportunity. In the past year alone, we have launched several strategic initiatives, including the Global Resilient Drylands Strategy, CATALYST -our platform for deeper industry engagement and ISSCA, the ICRISAT Center of Excellence for South–South Cooperation, designed to accelerate impact through the exchange of knowledge, resources, innovation, and expertise across the Global South.

Through our global partnerships and scientific networks, ICRISAT remains committed to supporting India's vision of Viksit Bharat while contributing to resilient and sustainable agri-food systems worldwide.

Millets, Pulses, and Climate-Smart Crops

Q 5 - Dr Vivekananda

Millets and pulses are increasingly gaining global recognition for their resilience, nutrition, and sustainability benefits.
How do you see these crops shaping future agricultural systems and contributing to climate adaptation ?

Dr Pathak

Millets and pulses are redefining the future of agriculture by shifting the focus from resource-intensive monocultures to climate-smart and diversified farming systems.

Together, they form a cornerstone for food security, climate adaptation, sustainable nutrition, and resilient livelihoods.
Millets offer superior nutritional quality, while pulses enrich soils through natural nitrogen fixation.

Together, they support both on-farm and on-plate diversification, creating farming systems that are productive, sustainable, and nutritionally balanced.

Importantly, millets and pulses also hold immense potential in addressing the global burden of malnutrition. This is why several national and international initiatives are working to integrate them into nutrition programmes, including school meal schemes and public food systems.
Equally significant is their climate resilience.

Millets and pulses can thrive in marginal and rainfed lands with limited inputs, making them vital crops for smallholder farmers and a lifeline for sustaining both lives and livelihoods across the drylands.

Soil Health & Sustainable Productivity

Q 6 - Dr Vivekananda

With your scientific background in soil science and agricultural chemistry, how do you see the role of soil health in improving crop productivity, nutrient-use efficiency, and long-term climate resilience ? What priorities should farmers and policymakers focus on to restore and sustain soil fertility ?

Dr Pathak

Soil health today is no longer just about soil, it is about One Health.
Healthy soils lead to healthy plants, and healthy plants ultimately support human health and nutrition. This makes soil health fundamental to the future of dryland agriculture and sustainable food systems.





We are now moving beyond conventional approaches to soil management.
The era of generalized fertilizer application is rapidly giving way to precision agriculture, where nutrient management is guided by the specific needs and conditions of the soil. Increasingly, we are recognizing the importance of the soil microbiome and the living biological systems that sustain productivity and resilience.

Practices such as organic cultivation, conservation agriculture, reduced tillage, cover cropping, and crop diversification are fundamentally about restoring soil health.
For farmers, restoring and sustaining soil fertility must become a long-term strategic priority. This includes adopting regenerative practices such as reduced or zero tillage multi-species cover cropping, and diversified crop rotations to minimize erosion and continuously nourish the soil ecosystem.
Soil science must reach the last mile.
Farmers need greater awareness, easier access to soil testing and advisory services, and stronger policy support that promotes regenerative and soil-centric agriculture in the same way we support organic farming.

Partnerships, Startups & Innovation Ecosystems

Q 7 - Dr Vivekananda

Agricultural transformation often depends on collaboration among research institutions, governments, private sector players, startups, and farmer organizations. How does ICRISAT foster partnerships to accelerate innovation and field-level impact ?

Dr Pathak

ICRISAT is part of the CGIAR system, which collectively drives global scientific leadership in agricultural research and innovation. At the national level, we work closely with National Agricultural Research Systems (NARS), spanning ministries and government departments, ICAR institutes, State Agricultural Universities (SAUs), industries, Krishi Vigyan Kendras (KVKs), and ultimately reaching last-mile institutions such as Farmer Producer Organizations (FPOs) and women's Self-Help Groups (SHGs).

Each of these partnerships plays a critical role in translating science into meaningful impact on the ground.
Agricultural transformation cannot be achieved in isolation — it requires strong collaboration across research, policy, industry, extension systems, and farming communities.

Our partnerships operate at multiple levels, from research and implementation to skilling, capacity building, and technology transfer. This strong global-to-local linkage is what enables innovation to move beyond laboratories and create scalable, sustainable change for farmers and food systems.







Vision for the Next Decade

Q 8 - Dr Vivekananda

Looking ahead over the next 10 years, what is your vision for ICRISAT's global role in addressing climate resilience, food security, and sustainable agriculture ?
What major changes do you hope to see in farming systems by the next decade ?

Dr Pathak

ICRISAT's vision remains steadfast: Building prosperous, food-secure, and resilient drylands.As global temperatures continue to rise ,the importance of dryland agriculture and dryland crops will only grow stronger. These crops will no longer remain on the Margins of global agriculture — they will become central to future food and nutritional security.
Climate-resilient crops such as pearl millet and pigeonpea already demonstrated the potential to withstand extreme heat and harsh growing conditions.
Developing future-ready varieties capable of tolerating rising temperatures is critical to strengthening global preparedness for climate change.

At the same time, farming systems themselves are undergoing a major transformation towards more science-led and data-driven agriculture.

Digital tools, AI, climate advisories, precision agriculture, and real-time decision-support systems will increasingly empower farmers to maximize productivity while using fewer inputs and resources.
The future of agriculture will depend on resilient crops, intelligent farming systems, and stronger integration of science and technology.

Message to the Next Generation of Agricultural Leaders

Q 9 - Dr Vivekananda

As agriculture evolves amid climate and food system challenges, what message would you like to share with the next next generation of scientists, entrepreneurs, policymakers, and farmers working toward a sustainable agricultural future ?



Dr Pathak

To the next generation of agricultural scientists, innovators, entrepreneurs, policymakers, and farmers, the future of global food systems will increasingly rest in your hands. Your mission is not only to produce more food, but to transform agriculture from a vulnerable system into a regenerative and resilient one. For entrepreneurs and startups, agriculture presents one of the world'slargest opportunities for impact.
The future belongs to innovations that can scale, such as digital advisory systems, climate services, farm mechanization, seed systems, traceability, value addition, or circular economy models that minimize waste and maximize sustainability. The challenge is not simply to invent new technologies, but to make them accessible and practical for smallholder farmers who form the backbone of global food systems. For policymakers and development leaders, future agricultural policies must move beyond production alone and incentivize soil health, water conservation, biodiversity restoration, carbon sequestration, and equitable access to technologies and markets, finally farmers will remain at the heart of this transformation. Regenerative practices, climate-resilient crop varieties, integrated farming systems, sustainable livestock management and efficient soil and water management will be essential for shaping the future of agriculture, a future where farming not only feeds people, but also restores ecosystems, strengthens climate resilience, and secures the health of the planet for generations to come.

With Respect & Gratitude

We sincerely thank **Dr. Himanshu Pathak, Director General, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT),** for sharing his valuable insights through this exclusive Cover Story Interview and for gracing the **cover of the June 2026 edition of KhetiValah Global Agri Magazine** (e-magazine).

We also extend our sincere appreciation to **Mr. Ramon Peachey, Director – Communications, ICRISAT,** for his valuable support, guidance, and coordination throughout the interview process.

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Their contributions greatly facilitated this meaningful exchange of knowledge and perspectives on agricultural innovation, climate resilience, sustainable farming systems, food and nutrition security, and the future of global agriculture.

At KhetiValah Global Agri Magazine (e-magazine), we remain grateful for the opportunity to share such valuable insights with our global readership of farmers, researchers, students, policymakers, and development practitioners.

Thank you

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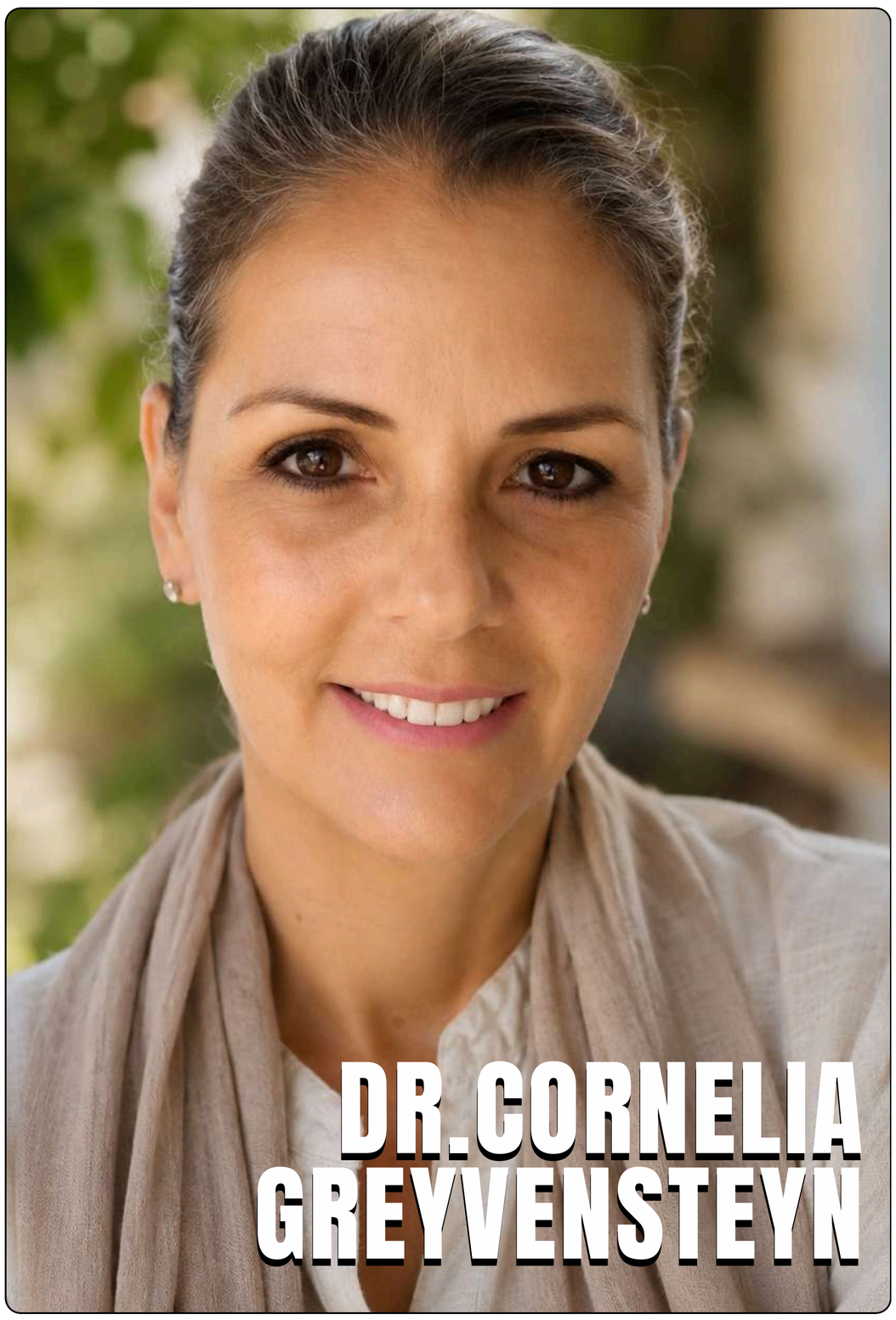


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From Soil to Soul:

Women **Remembering** the **Wisdom of the Land**

By

Dr.Cornelia Greyvensteyn
A regenerative systems thinker based in South Africa

ABOUT THE AUTHOR

Behind every idea, strategy, and article is a woman who believes that people matter.

Cornelia Greyvensteyn is driven by the conviction that every person deserves the opportunity to be seen, valued, and connected to a future they can help create. Passionate about Africa's people, she believes the continent's greatest resource is its human potential.

Her work focuses on building connected ecosystems where collaboration, transparency, innovation, and opportunity create lasting prosperity.

By bridging communities, business, technology, traditional leadership, and investment, she seeks practical solutions that empower generations rather than create dependency. At her core, Cornelia is a builder of connections, believing that meaningful progress is measured not only by what we build, but by how many lives we uplift together.

Across continents, **women in agriculture** are returning to **principles** that are not new but remembered.

Regenerative Agriculture, in this sense, is not simply a method. **It is a Remembering.**





Modern systems have brought efficiency and scale but *often at a cost.*

Why **Sustainability** in Agriculture **Matters** Today

There was a time when humanity understood that the land was not merely a resource to be managed, but a living system to be honoured. Soil was not something to be corrected by force, but something to be understood, nurtured, and respected. It carried memory, life and intelligence.

Today, as the world searches for solutions to climate pressure, food insecurity and declining soil health, there is a quiet but powerful shift taking place, led in many cases by women. Across continents, women in agriculture are returning to principles that are not new but remembered. They are asking deeper questions, not only about how we farm, but how we relate to the land, to food and to each other.

Regenerative agriculture, in this sense, is not simply a method. It is a remembering.

Mutual **Partnership**

For generations, our ancestors farmed in partnership with nature. The observed seasonal rhythms, understood plant relationships, worked with animals, and respected the balance of ecosystems. Agriculture was not separate from life it was embedded in it. Women, in particular held much of this knowledge. They were seed kee-pers, healers, caregivers of soil and community alike. They understood that what grows from the earth feeds more than the body; it sustains families, cultures and identity.

Modern systems have brought efficiency and scale but often at a cost. In many parts of the world, soil has become depleted, compacted and dependent on external inputs. Farmers are under pressure to produce more from less, while the land itself becomes increasingly fragile. This has created a cycle of dependency, more fertilisers, more chemicals more intervention often with diminishing returns.

But soil is not broken, it's alive. Healthy soil is a living ecosystem, rich with microbes, roots, fungi and organic matter. It stores water, supports biodiversity and produces nutrient-dense food. When we restore soil biology, we restore resilience and this is where regenerative thinking changes everything.

Instead of asking, "what do we need to add to fix the soil?" we begin asking, "What natural processes have we interrupted?" From there, solutions become simpler, more elegant and often more affordable.

Plants play a remarkable role in this restoration. Some plants break through compacted ground, other fix nitrogen, others draw minerals from deep layers, and many protect and feed the soil surface. What modern agriculture often treats as an input problem, is in many cases a design opportunity. The right plants, working together, can rebuild soil in ways no chemical system can replicate.

What natural processes have **We interrupted ?**



Women Leaders At **Forefront**

Women farmers and leaders are increasingly at the forefront of this thinking. Across Africa and globally they are implementing practices that work with biodiversity rather than against it from mixed cropping systems to cover planting from community gardens to regenerative grazing models. Their approach is often more holistic, considering not just yield but family nutrition, ecosystem health and long-term sustainability.

Animals too return to their rightful place within this system.

When managed thoughtfully, they contribute to fertility, support plant growth, and reduce the need for mechanical and chemical intervention. Chickens for example can provide natural pest control. Grazing animals can stimulate regrowth and cycle nutrients. Nature operates in cycles, not waste.

Every element has a role.

Beyond the ecological dimension lies something just as important – the human story. Agriculture is deeply connected to dignity. When people are disconnected from land, they often lose not only livelihoods but confidence, identity and a sense of belonging. Regenerative agriculture offers a pathway to restore this connection. It brings learning back into practice, returns ownership to individuals and communities, and rebuild self-reliance from the ground up.

This is where the role of women becomes even more significant. In many regions, women are central to food systems, yet often under-recognised. When women are empowered in agriculture, the benefit extend far beyond the farm. Families become more food secure; knowledge is shared across generations and communities become more resilient.

In Africa, this opportunity is especially profound. The continent holds both deep agricultural challenges and extraordinary potential. But it also holds memory, ancestral knowledge, ecological understanding and cultural systems that have sustained communities for generations. The future of agriculture here does not lie in copying external models alone, but in integrating modern insights with indigenous wisdom.





Beyond the Ecological Dimension lies something just as important – **the human story**

Regeneration is not about going backwards.

It is about forward with awareness.

It is about designing systems that restore soil while creating livelihoods. It is about building farm that function as ecosystems, not extraction points. It is about recognising that food security economic resilience and environmental health are not separate issues, but interconnected outcomes of how we treat the land.

Sucess in **Agriculture – Redefined**

Success in agriculture must also be redefined. It cannot only be measured in yield or short-term productivity. True success includes soil health, water retention, biodiversity, farmer independence and whether the land will be more alive for the next generation.

Women leaders in agriculture are helping shift this definition, bring a longer-term, more integrated vision into the conversation.

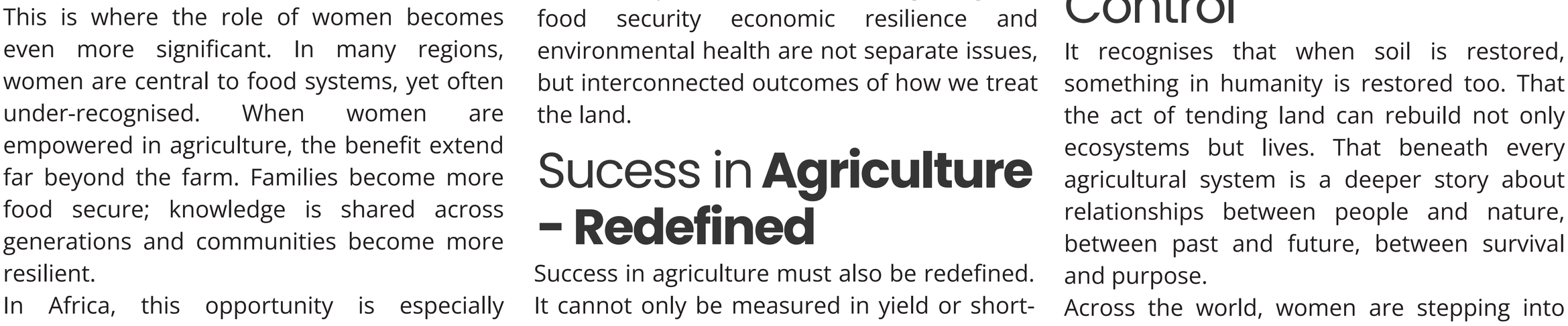
From soil to soul is more than a philosophy. It is a way of seeing the world.

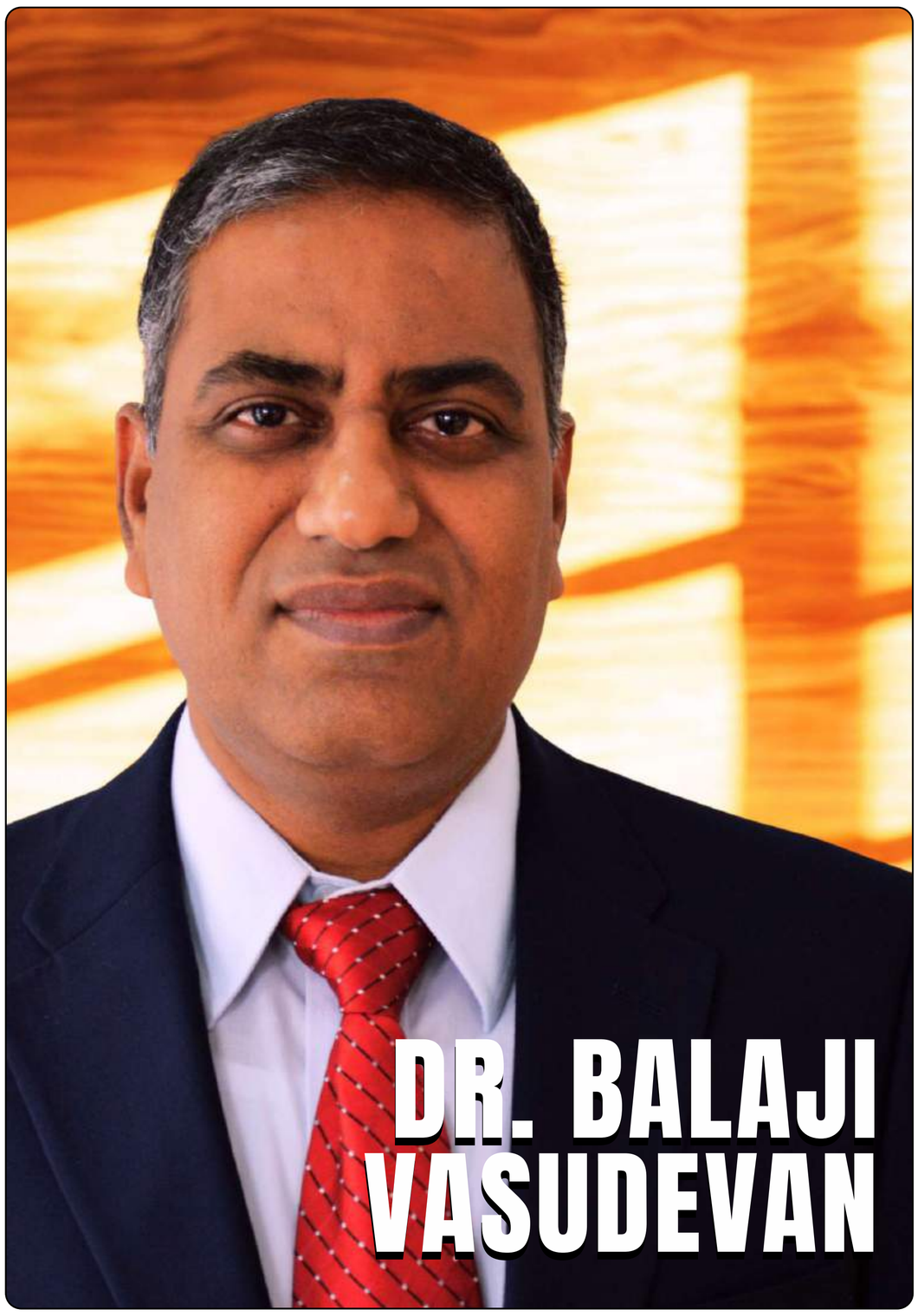
Collaboration Over Control

It recognises that when soil is restored, something in humanity is restored too. That the act of tending land can rebuild not only ecosystems but lives. That beneath every agricultural system is a deeper story about relationships between people and nature, between past and future, between survival and purpose.

Across the world, women are stepping into this space not just as farmers, but as stewards, innovators and leaders of a new agricultural narrative. One that value collaboration over control, regeneration over extraction, and memory over forgetfulness.

If we listen carefully, the land still remembers and through the hands of those willing to care for it, many of them women that memory is coming back to life.





From Lab to Field to Fork

By

Dr. Balaji Vasudevan Director of Programs, **First Flight Venture Center (FFVC)**, Research Triangle Park (RTP), North Carolina, USA
Senior Venture Partner, Brumas Venture Capital , USA

Brumas. Venture Capital

FIRST FLIGHT VENTURE CENTER

8B+ People on Earth today	**$16.2B** Global AgFoodTech funding 2025	**$700B** SynBio market projected by 2040

ABOUT THE AUTHOR

Dr. Balaji Vasudevan is a scientist-turned-venture-builder at the frontier of global AgriFood innovation.

As Director of Programs at First Flight Venture Center (FFVC) in Research Triangle Park, NC, he accelerates deep-tech startups across AgriFood, Synthetic Biology, Biotech, and Climate Tech, connecting founders to capital and markets across six continents.

His career spans the research lab (Cornell, Tel Aviv University, Noble Research Institute), commercial biotech (GreenLight Biosciences, Cibus and more), and venture capital (UM6P Ventures, BIV, Brumas VC and more) Being , Senior Venture Partner at Brumas Venture Capital .

With 17 publications, 2 patents, and 50+ due diligence assessments, he brings rare bench-to-boardroom depth to the future of food.

He serves on Scientific Advisory Boards and Boards of Directors globally, and mentor agrifoodtech companies through leading incubators and accelerators worldwide.

> The global SynBio market was **valued** at **$6.9 billion** in 2019 and is projected to reach **$700 billion by 2040.**
>
> In 2021 alone, global SynBio investment **reached $18 billion.**



The Imperative **Has Never Been** Greater

Let me start with the numbers that keep me up-at night. Global population **has crossed 8 billion** and we are tracking toward 10 billion by 2050.
That means a 70% surge in caloric demand within just 25 years. UN data already shows 690 million people going to bed hungry today; if current trajectories hold, that number exceeds 840 million by 2030.

Meanwhile, agriculture accounts for 26 to 30% of total global greenhouse gas emissions, and climate change has already quietly eroded wheat yields by 3.8%, maize by 1.8%, and soybeans by 3.1% since the 1960s.

One estimate warns that global water supply shortage will reach 40% by 2030.

The conclusion is unavoidable: we cannot feed 10 billion people using the agriculture of the 20th century. What we need and what is now actually being built is a fundamentally new paradigm. **I call it FAST: Food and Agricultural Sustainable Transformation**



The FAST Paradigm: Transitioning from Resource-Intensive 20th-Century Agriculture to Sustainable, Tech-Enabled Farming Systems.

It demands innovation at every layer of the food system, from the seed in the soil to the product on the shelf.

Climate change, shifting consumer preferences for healthy and sustainable foods, and a rapidly evolving agriculture market will together drive the future of global agrifoodtech.

Synthetic Biology : The Platform of Platforms

McKinsey published in 2019 that the bio-economy and life science revolution will dominate the Next Three to Five Decades the Way-digital technology dominated the previous two to three.
Eric Schmidt of Schmidt Futures stated publicly that if he had to start all over again, he would invest in synthetic biology, not internet-based digital tech.

The global SynBio market was valued at $6.9 billion in 2019 and is projected to reach $700 billion by 2040. In 2021 alone, global SynBio investment reached $18 billion.

Synthetic biology is, at its core, the application of engineering principles to biology. It applies to either enhancing or improving what an organism naturally does, or totally refining and repurposing it using genetic engineering, gene editing, and molecular biology tools for new human applications.

The past decade's toolkit explosion, spanning DNA and gene synthesis, precision fermentation, strain engineering, CRISPR-Cas9 gene editing, RNAi, and cell-free manufacturing, has matured SynBio into a full manufacturing paradigm.

It threatens three fundamental disruptions simultaneously: product substitution, process improvement, and new input creation.

The commercial milestones of the past decade have been nothing short of extraordinary. Impossible Foods expressed leghemoglobin in yeast to make their burger bleed like meat.

Perfect Day produces animal-free whey protein via precision fermentation.

Pivot Bio's engineered nitrogen-fixing bacteria deliver a reported 25 to 40% reduction in synthetic nitrogen fertilizer use at commercial scale. GreenLight Biosciences' Calantha is the world's first commercially approved spray-based RNA biopesticide for Colorado Potato Beetle control, a product I helped pioneer from the company's earliest days, now EPA-approved and in the market.

GoodMeat and Eat Just received the world's first commercial approval for cultivated chicken from Singapore's SFA.
These are not proofs of concept. These are products on shelves and in the field.

The Technology Stack: **What Is Being Built Right Now**

Six technology vectors are actively reshaping the agrifoodtech landscape for the decade ahead.

RNA-based biopesticides represent one of the most exciting frontiers in agricultural SynBio, and one I have been directly involved in building.

The principle is elegant: double-stranded RNA sequences designed to silence specific target genes in pest organisms, delivered as a topical spray

The result is species-specific pest control with no toxicity to non-target organisms, no soil residue, and a regulatory profile that is fundamentally different from conventional chemistry.

Nanotechnology including lipid nanoparticles and exosomes is now solving the delivery and stability challenge that previously limited RNA biopesticide efficacy under field conditions.

The shift from synthetic chemical inputs to biological crop inputs is one of the most commercially accessible and rapidly scaling segments in global agrifoodtech.

Microbial consortium-based biocontrol, seaweed-based biostimulants, and NPPs such as mustard-derived compounds from MustGrow for Tropical Race 4 banana wilt are all actively deployed or in late-stage development. The gene editing in agriculture market stands at $6 billion today and is projected to reach $20 billion by 2030.

More than 20 countries now treat gene-edited crops differently from GMOs, and commercial varieties, including HB4 drought-tolerant wheat, Calyno high-oleic soybean, and GABA-enriched tomatoes in Japan, are already reaching consumers.



Next-Generation Biocontrol: AI-Driven dsRNA Target Optimization for Species-Specific Pest Management.

The fusion of artificial intelligence with synthetic biology is creating an entirely new class of capability.

Deeptech's share of agrifoodtech deals has climbed from 22% to 32% over the past decade. BrightSeed's Forager platform uses AI to mine plant metabolite databases.

Shiru uses AI and precision fermentation together as its core ingredient discovery engine. Ginkgo Bioworks has embedded AI and ML across its entire organism engineering platform.

DeepMind's AlphaFold has democratized protein structure prediction at a scale that was unimaginable five years ago.

Precision fermentation has graduated from concept to commercial reality, though the sector has been through a capital cycle that weeded out companies with weak unit economics.

The survivors, including Perfect Day, EVERY Company, Motif FoodWorks, and Upside Foods, did so by solving the cost curve and securing real CPG partnerships.

Plant molecular farming deserves particular attention as an extraordinarily capital-efficient production platform:

Medicago's plant-based COVID vaccine demonstrated pandemic-scale PMF; Moolec Science produces animal proteins directly in soybean seeds; ORF Genetics produces growth factors for the cultivated meat industry in barley.

The pipeline across all six vectors is extraordinary





MILESTONE

GreenLight Biosciences' Calantha, the world's first EPA-approved spray-based RNA biopesticide, is commercially available for Colorado Potato Beetle control. Dr. Balaji Vasudevan was part of the company's R&D team when it started in RTP, North Carolina, USA and helped pioneer dsRNA platform from its earliest days.

2025 Investment Landscape:
The Era of Selective, Science-Led Capital

The AgFunder Global AgriFoodTech Investment Report 2026 tells a nuanced story. Global agrifoodtech funding reached $16.2 billion in 2025, essentially flat versus the prior year, down just 3%.

Look deeper and you see a decisive quality shift in where capital is flowing. Upstream startups, those working on farms, food production systems, and biological platforms, drew $9 billion in 2025, up 7% year over year, even as overall deal count fell 12%.

The era of growth-at-all-costs funding for food delivery apps and eGrocery platforms is clearly fading.

Investors are writing fewer, larger, more deliberate checks directed at companies with tangible science, real unit economics, and credible paths to revenue.

The deeptech signal is striking. Deeptech's share of agrifoodtech deals has climbed from 22% to 32% over ten years. At the seed stage, deeptech rounds now close at a 78% premium over non-deeptech equivalents.

Investors are literally paying more to back science-led companies early. This is exactly the validation that those of us who have spent careers in plant biotech, synthetic biology, and precision fermentation have been waiting for. That said, no deeptech agrifood company broke $200 million in a single round in 2025, while seven non-deeptech companies did.

Bridging this Series B desert for science-led companies is the sector's central challenge.

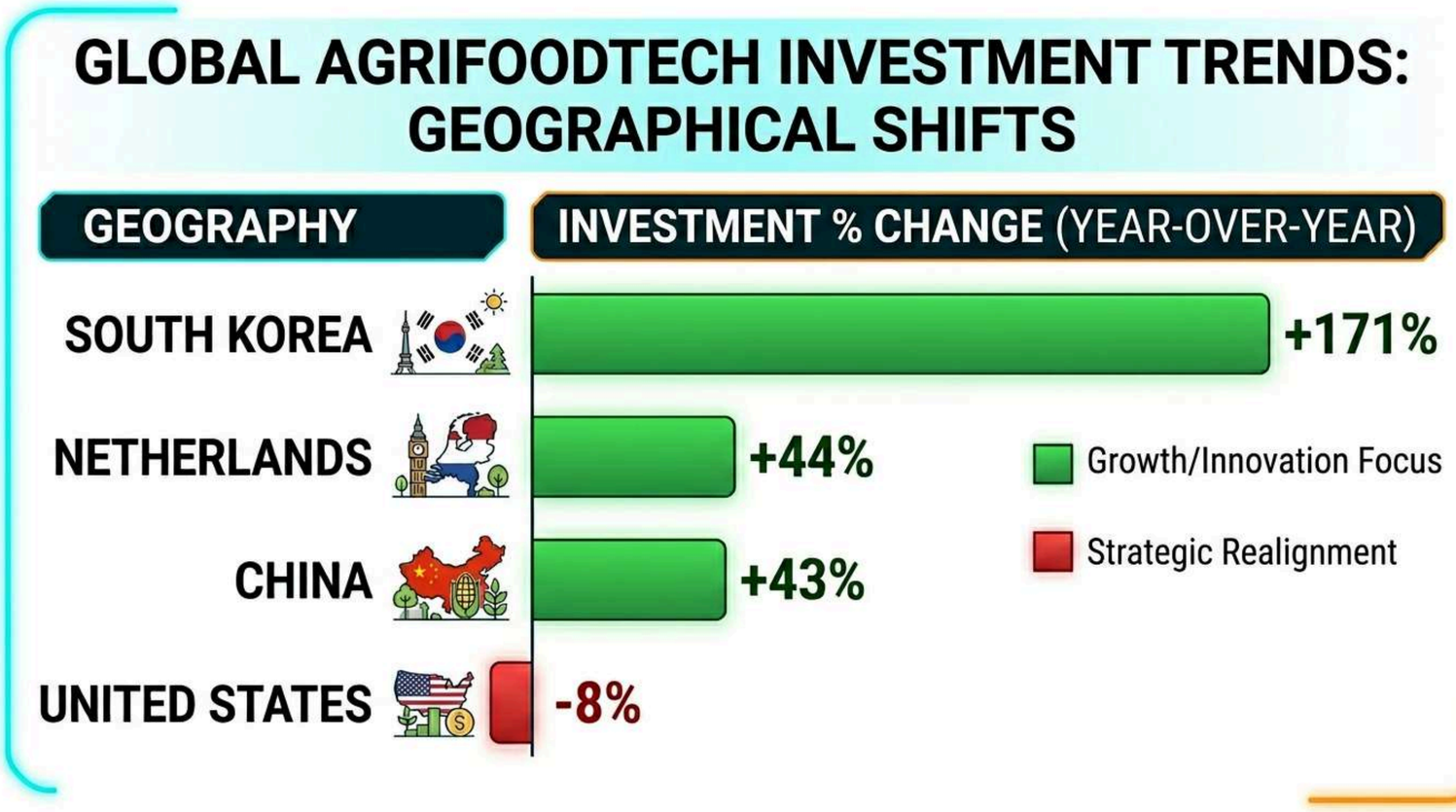
$9B	**+171%**	**78%**
Upstream startups (2025, +7%)	South Korea investment surge	Deeptech seed-stage premium

Geography is reshaping the innovation map. China was up 43%, cementing its position as the number three agrifoodtech market globally.

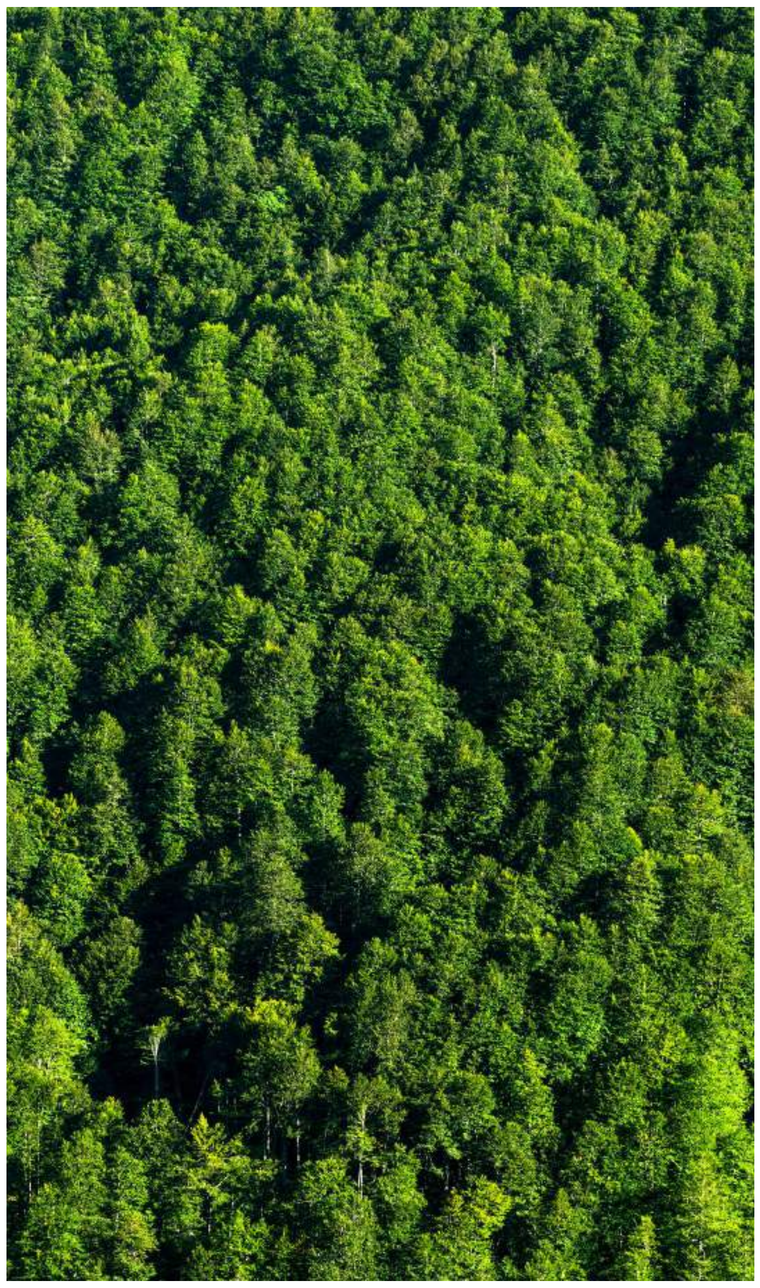
South Korea surged 171%, driven by AI-robotics and a government mandate that AI is no longer optional for agriculture.

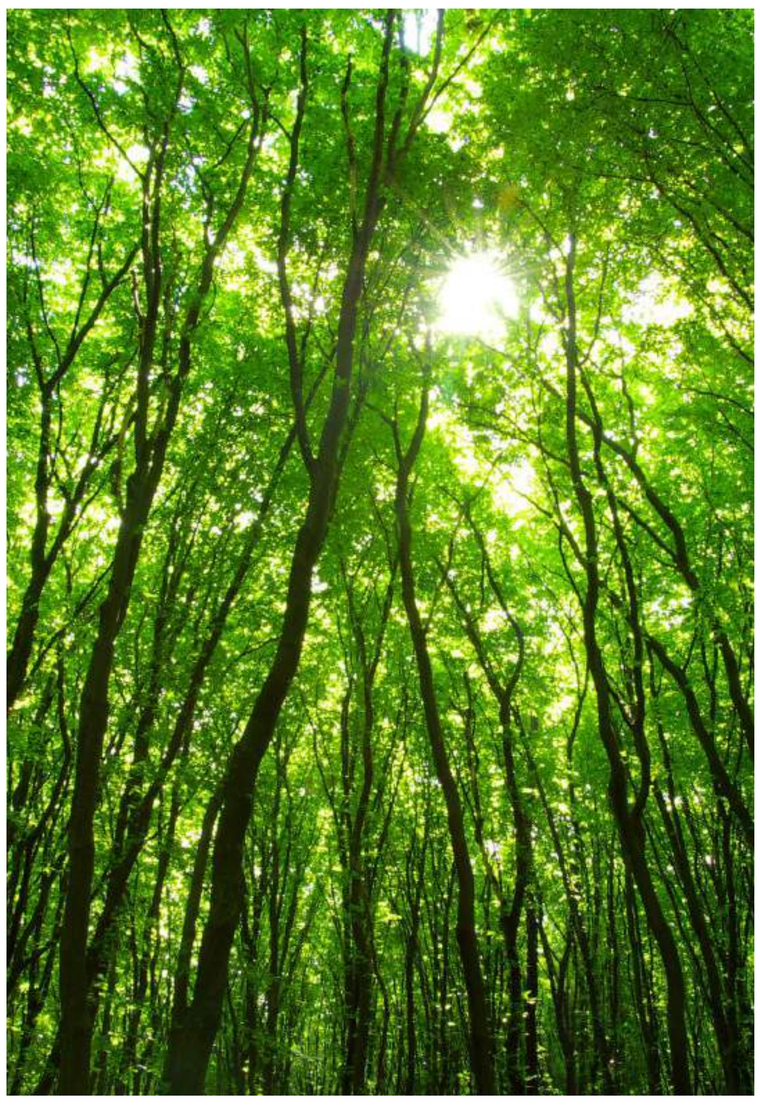
Netherlands posted a 44% surge.

The United States, still number one globally, was down 8%



Global AgriFoodTech Investment Trends: Year-Over-Year Geographical Shifts and Regional Innovation Mandates.







Developing markets showed encouraging 63% funding growth, particularly in Southeast Asia and India around supply chain digitization and smallholder connectivity platforms.

DigitalFoodLab's Q1 2026 tracker confirms approximately $3.6 billion raised in the first quarter, a slight uptick versus the end of 2025.

Corporate appetite is returning through accelerated partnerships, acquisitions, and co-development agreements. Climate tech within agrifood recovered strongly to $3.9 billion from $2.8 billion in 2024.

The share of deals going to first-time-funded companies ticked up to 46% for the first time on record. **The ecosystem is fragile but directionally positive.**

HARD LESSON	The 2019 to 2021 bull market poured $54 billion into agrifoodtech. Vertical farming and alternative proteins alone absorbed 42% of that capital without the unit economics to sustain it. Deeptech agrifoodtech funding fell 62% from 2021 to 2023. The lesson is not that these technologies failed. The business models failed. Disruptive biology requires patient capital, realistic timelines, and genuine cost-reduction roadmaps before scaling.



Five Macro-Trends for 2026:
Food Security & Climate Resilience

- Science-Led Deeptech Moves from Lab to Market. The companies attracting capital in 2026 are those pointing to EPA approvals, USDA clearances and other regulatory bodies in respective countries, commercial sales contracts, and real farmer adoption data. Expect accelerated corporate-startup partnerships, strategic acquisitions of proven technology platforms, and increased grant-to-commercial pathways for the most credible science.

- Asia-Pacific Becomes a Global Innovation Powerhouse. South Korea's 171% surge and China's 43% growth signal a decisive rebalancing of global agrifoodtech innovation. India and Southeast Asia are scaling supply chain digitization platforms serving hundreds of millions of smallholder farmers. The innovation conversation is no longer US-Europe-centric.

- Climate Resilience Goes Commercial. Drought-tolerant and heat-resilient crop varieties are moving from field trials to licensed commercial releases. Biological nitrogen fixation is reducing synthetic fertilizer dependency at scale. Carbon markets are creating new revenue streams for regenerative farming. This opportunity is no longer speculative. It is deployable today.









The Scaling Desert: Navigating the Biomanufacturing Transition from 5L Lab Pilot Scale to Commercial-Scale Production

- Biomanufacturing Scale-Up Is the Critical Bottleneck and the Critical Opportunity. For precision fermentation, cultivated meat, plant molecular farming, and RNA-based biocontrol, the science is largely proven. In my experience, 90% of SynBio firms that succeed at lab scale fail at industrial scaling. The companies, regions, and governments that invest in biomanufacturing capacity now will capture disproportionate value from the SynBio revolution. North Carolina's Research Triangle Park, where FFVC is headquartered, is uniquely positioned to lead this buildout at the intersection of biotech, life sciences, and advanced manufacturing.



Inclusive Innovation: Scaling Cloud-Connected Drone Analytics and FAST Biological Inputs for Smallholder Farming Ecosystems.

- Inclusive Innovation: Emerging Markets Move from Periphery to Priority.
- Developing market agrifoodtech grew 63% while global agrifoodtech declined 4% in 2023 to 2024. The 500 plus million smallholder farmers who produce 70% of the world's food remain systematically underserved by technology. Every accelerator, VC, and corporate innovation team that ignores this geography is leaving both impact and returns on the table.

The **Responsibility** of **This Moment.**

I want to close with something I believe deeply. We are living through the most consequential period in the history of food and agriculture.

The convergence of biotech, biologicals, synthetic biology, AI, climate urgency, and global population pressure is creating both a crisis and an extraordinary window of opportunity simultaneously. The data from 2025 and Q1 2026 gives me genuine optimism, not the naive optimism of a bull market, but the grounded optimism of a sector that has been stress-tested, has shed its excesses, and is rebuilding on a foundation of real science, real economics, and real farmer needs.

The technology stack is real, proven, and deployable: RNA biopesticides approved by EPA; gene-edited crops commercially released in Japan, the US, and Argentina; precision fermentation proteins in consumer products; plant molecular farming producing animal-free dairy proteins; AI-optimized breeding cutting decades from trait development timelines.
The bottlenecks are not scientific. They are infrastructure, capital, regulatory harmonization, and ecosystem connectivity.

At First Flight Venture Center, through our Test Flight, Propeller, Wingspan, Navigator, Itineraries and many other programs, we are actively building the pipeline of startups that will deliver on this potential, connecting founders from six continents to the North Carolina and global ecosystem, helping them navigate from idea to investable company to commercial-scale impact.

The work is urgent. The tools have never been more powerful. The moment demands our very best.

Let us build the food system, the next 10 billion people deserve.

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Global Initiative for Regenerative Agriculture
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CIRDAP

KhetiValah Knowledge Forum

Rural Development For Asia Pacific

Rural Heart Beat *20*

4 **WEEKS**
THEMES
MESSAGES

To Rural Development in Asia & Pacific



Dear Partners

April was the most vibrant month for CIRDAP with four International Programs on four important themes in Rural Development which were attended by 17 countries. Major participation came from CIRDAP member countries.

Thanks to FAO and Ministry of Rural Development, Government of India. Indian Government supported three international programmes on themes namely Geo Informatics in Rural Development, Community Led Rural Development and Climate Change in the context of Rural Development. Inspite of war impacting international travel, ten CIRDAP member countries took part in these training programmes organzied at the National Institute of Rural Development and Panchayati Raj, Hyderabad, India. Whereas FAO funded programme on Global Guidelines for National Aquaculture Investment Plan organized at Jakarta, Indonesia attracted the participation of 17 countries from Asia, Africa and America.

Geo Informatics Technology has the modern Technological solutions to grass root level problems related to soil, water, Pest and Diseases, crop Forecasting, Planning, Geo Spatial planning of Agriculture markets.
Direct Benefit Transfers, Forest coverage, Disaster Management, which decides the fate of villagers. Research gaps are not visible much however; adoption gaps are prominently observed.

Hence, the role of Rural Development machinery is to take the technology to the doorstep of villagers through sensitization and integration into the job chart of Rural Development extension workers.
Inspiring community led Rural Development initiatives were discussed where not only government played important role but also NGOs, Cooperatives, FPOs, SHGs, Rural entrepreneurs brought innovations and sustainable solutions.
However, these success stories need upscaling. Massive sensitization on climate change impacts was felt necessary, not only to Rural communities but also to all stakeholders including scientists and institutions which are supposed to work on solutions.
All the country representatives were encouraged to work out BACK AT WORK PLANS to take the learnings forward in their respective countries.

Fisheries continue to play important role in south Asia and Pacific, ensuring the livelihood to large population, providing nutrition security to society and income security to rural communities. Hence, naturally attracts investment from public and private sectors.

The Investment plan which is being worked out decides the direction and magnitude of investment to various sectors in Fisheries which is customized to country specific situation. Again, acceptance and adoption by member countries is critical point in success of this mission.

Hope the seeds of change sown in the programmes would definitely yield results over a period benefitting rural communities.

With Warm Wishes

Dr. P. Chandra Shekara

Director General, CIRDAP

FAO–CIRDAP Workshop on **National Aquaculture Investment Plan** in Jakarta, Indonesia



The Centre on Integrated Rural Development for Asia and the Pacific in collaboration with the Food and Agriculture Organization of the United Nations and the Government of Indonesia successfully organized the FAO-CIRDAP Workshop on Sustainable Aquaculture Investment in Jakarta from 13th to 16th April 2026. The workshop was convened under the theme “Toward a Global Framework for National Aquaculture Investment Plans Lessons and Insights from Asia” and brought together 36 experts and policymakers from 17 countries along with representatives from leading international organizations.

The inaugural session featured opening remarks from HE. Dr. P Chandra Shekara Director General of CIRDAP, Rajendra Aryal, FAO Representative in Indonesia, and HE. TB Haeru Rahayu, Director General of Aquaculture at the Ministry of Marine Affairs and Fisheries, Indonesia. In his address, Dr Shekara emphasized the transformative potential of aquaculture in strengthening food security, enhancing rural livelihoods, and promoting inclusive economic growth across the Asia Pacific region.

He highlighted the importance of National Aquaculture Investment Plans as strategic instruments to translate policy priorities into bankable and sustainable investments that benefit rural communities, women, and youth.

The FAO Representative underscored the growing demand among countries for structured investment frameworks and reaffirmed FAO’s commitment to supporting member states through global guidelines and its Blue Transformation Roadmap. Dr TB Haeru Rahayu stressed the importance of inclusive aquaculture development, noting that small scale producers must have equitable access to finance, resources, and markets.

Over four days, the workshop facilitated rich discussions on global and regional aquaculture investment trends, challenges, and opportunities. Country presentations from across Asia including Bangladesh, China, India, Indonesia, Lao PDR, Maldives, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam provided valuable insights into national priorities, institutional frameworks, and investment gaps.

A major achievement of the workshop was the review and validation of three key documents: the Regional Synthesis Report, the NAIP Model Framework, and the Conceptual Framework for Pilot Implementation.

These outputs will serve as practical tools for countries to design, implement, and scale sustainable aquaculture investment strategies. The validation process ensured strong regional ownership, while expert panel discussions explored innovative financing mechanisms and public private partnerships to transform strategies into viable investment projects.

The workshop concluded with a forward looking roadmap emphasizing the promotion of structured, inclusive, and financially viable National Aquaculture Investment Plans. Participating countries expressed commitment to pilot the framework, strengthen regional collaboration ,and align aquaculture investments with global development priorities.

This workshop marks a significant step toward building a coherent global framework for aquaculture investment.

By fostering collaboration, innovation, and inclusive planning, it reinforces the role of aquaculture in contributing to food security, resilient livelihoods, and sustainable development across the region and beyond.

CIRDAP



Transforming Governance: Institutionalizing Gender Responsive Budgeting in Nepal

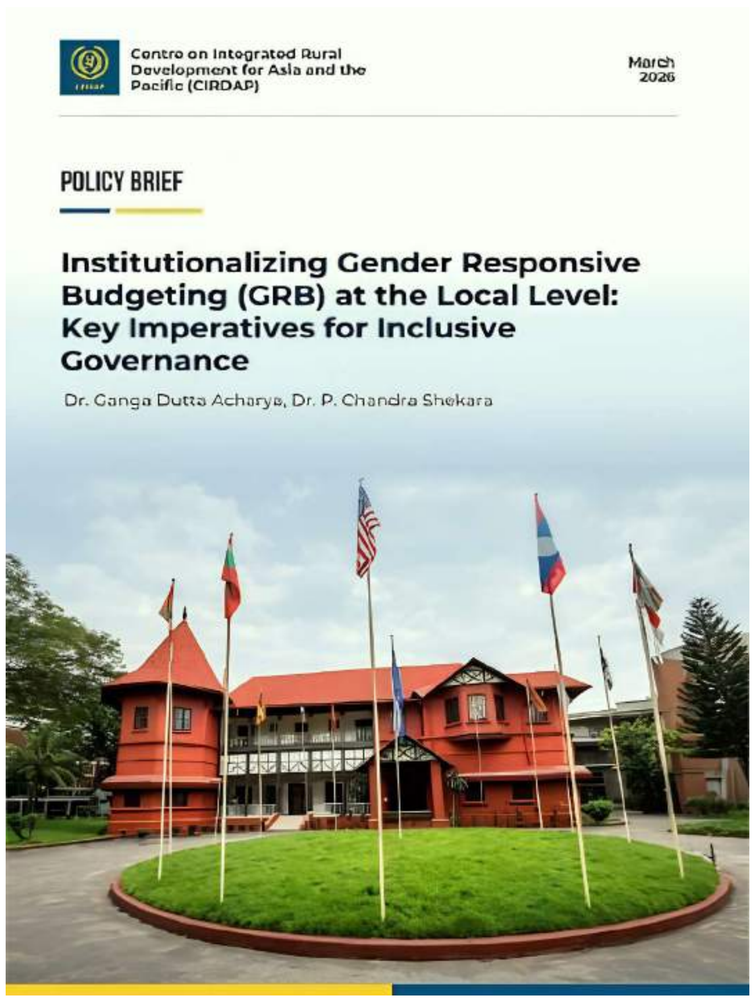
The Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP) has released a pivotal policy brief documenting the success of its 2025 pilot initiative in Nepal, In partnership with the Local Development Training Academy (LDTA), Nepal, this program empowered 117 elected representatives and officials, including Mayors and Chief Administrative Officers, to bridge the gap between gender equality commitments and actual public financial management.

The results were remarkable, with participant knowledge scores doubling from an initial 4.09 to a post-test average of 8.29.

By providing practical tools and simplified guidelines, the initiative demonstrated that local governments can effectively dismantle structural inequalities when supported by systemic reforms.

Moving forward, the brief calls for integrating GRB into mandatory budget procedures and fostering multi-stakeholder coordination with NGOs and the private sector.

This successful Nepal model now serves as a scalable roadmap for all CIRDAP member countries to ensure that regional development is truly inclusive and gender-accountable.



IRD Model Series – **Breathing Life into Care:** Transforming **Oxygen Access** in Fiji



In The island nation of Fiji, where geography often challenges health service delivery, access to life saving oxygen has long been a critical issue.

For nurses like Udila Tawake, caring for patients with respiratory conditions meant confronting a daily reality of uncertainty due to unreliable oxygen supply.

Cases of Hypoxemia were common, yet the tools to manage them were not always available, particularly in remote and hard to reach communities.

The situation became even more urgent during the global crisis of COVID-19, when oxygen demand surged worldwide.

However, as Ms Tawake observed, these challenges were not new. They were deeply rooted in systemic issues such as logistical barriers, fragile infrastructure, and frequent power outages that rendered conventional oxygen systems ineffective.

Recognizing the urgency, the Ministry of Health and Medical Services Fiji, in partnership with Cure Kids, launched a transformative initiative known as the Oxygen Project. This innovative intervention aimed to decentralize and modernize oxygen delivery across the country's health facilities.

At the heart of this initiative is the deployment of oxygen concentrators. These compact and portable devices extract oxygen from ambient air and deliver it in a purified form suitable for medical use.

By eliminating the dependence on bulky oxygen cylinders, the project significantly reduces the logistical burden of transporting oxygen to remote islands and rural health centres.

Sustainability lies at the core of this innovation. To ensure uninterrupted oxygen supply, especially in areas prone to electricity disruptions, the project integrates solar power systems into health facilities.

This approach guarantees that oxygen concentrators remain functional even in off grid settings, thereby enhancing the resilience of the health system.

Equally important is the project's investment in human capacity.

Local biomedical engineers, solar technicians, and nurses are trained to operate, maintain, and repair both the concentrators and solar systems.

For Ms Tawake, who also serves as the National Coordinator of the initiative, this component is vital.

It addresses a common shortcoming of past interventions where equipment was installed but eventually abandoned due to lack of technical expertise.

By empowering local professionals, the project ensures long term functionality and ownership.

The Oxygen Project stands as a compelling example of how innovation, when combined with collaboration and sustainability, can transform health outcomes.

Supported by the World Health Organization under its regional push for health innovation, this initiative aligns with broader efforts to strengthen health systems across the Western Pacific.

Fiji's experience offers valuable lessons for other countries facing similar challenges.

It demonstrates that context appropriate technology, renewable energy integration, and local capacity building can together create resilient and inclusive health solutions.

As Ms Tawake envisions, the true success of such initiatives lies in collective commitment. When governments, partners, and communities work together, innovation becomes more than a concept.

It becomes a lifeline, ensuring that even the most remote populations can breathe easier and live healthier





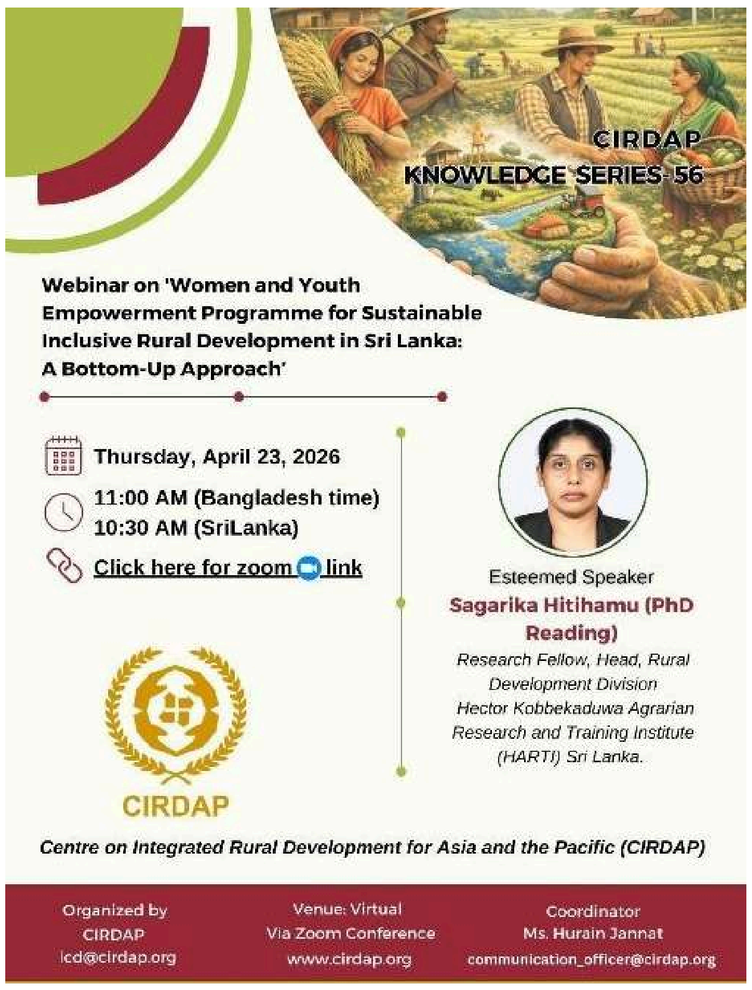
CIRDAP Knowledge **Series 54:** Webinar **on Agri Extension** For Impactful **Innovations in South Asia**

CIRDAP successfully organized an insightful webinar titled Agri Extension Impactful Innovations in South Asia and Cross Learning Possibilities on Thursday, 9 April 2026.
The webinar featured an enriching presentation by Dr Radhey Krishna Tripathi, Coordinator Programs and Partnerships at AEPSA, who shared valuable perspectives on emerging extension models, cross learning opportunities, and the importance of knowledge driven services to enhance the sustainability of the farm sector.

Key discussions emphasized the need for demand-driven and gender-responsive extension services, stronger research–extension linkages, and increased use of information and communication technologies (ICTs). And highlighted the importance of capacity building for extension professionals and farmers, greater stakeholder convergence and partnerships, and the promotion of innovative and pluralistic extension models.

The session was chaired by HE. Dr. P Chandra Shekara, Director General of CIRDAP.
The session brought together distinguished experts and stakeholders from across CIRDAP Member Countries to discuss innovative and people centered approaches to strengthening agricultural extension systems in the region.

The webinar can be accessed in CIRDAP YouTube Channel.



CIRDAP Knowledge **Series 55:** Webinar on **Empowering Women & Youth** For Inclusive **Rural Development** in **Sri Lanka**

CIRDAP successfully organized an insightful webinar on Women and Youth Empowerment Programme for Sustainable Inclusive Rural Development in Sri Lanka A Bottom Up Approach on Thursday, April 23, 2026.

The session featured an enriching presentation by Sagarika Hitihamu, Research Fellow and Head of the Rural Development Division at Hector Kobbekaduwa Agrarian Research and Training Institute Sri Lanka.

She shared valuable insights on grassroots driven strategies that empower women and youth and demonstrated how community led initiatives can drive inclusive and sustainable rural development.

Key Highlights from the Presentation

- Global context and emerging challenges
- Project methodology and implementation approach
- Beneficiary experiences and case insights
- Sector wise challenges and enterprise development
- Financial upgrading strategies
- Stakeholder engagement and collaboration

The webinar emphasized the importance of bottom up approaches in strengthening rural livelihoods, fostering entrepreneurship, and ensuring that women and youth play a central role in development processes.

The session was chaired by HE Dr. P Chandra Shekara, Director General of CIRDAP, and brought together distinguished experts and stakeholders from across CIRDAP Member Countries.

CIRDAP extends sincere appreciation to the speaker and all participants for contributing to a meaningful and engaging knowledge sharing session.
The webinar can be accessed in CIRDAP YouTube Channel.

AGRI FACTS

- **Agricultural diversification into high-value horticulture, medicinal plants, and niche crops is increasingly shaping rural income systems.**
- **Circular agriculture models promote resource reuse, nutrient recycling, and reduced waste, improving long-term farm sustainability.**
- **Women farmers often invest a larger share of farm income into family nutrition, education, and household well-being.**
- **Satellite-based remote sensing can now estimate crop yield, soil moisture, and drought stress at field level.**
- **Digital twins in agriculture are emerging to simulate farm conditions virtually, helping predict crop performance, irrigation needs, and risks.**
- **Global warming is increasing the spread of crop pests and invasive species into new geographic regions, affecting biosecurity systems.**
- **Studies show that integrated pest management (IPM) can significantly reduce pesticide use while maintaining crop productivity.**
- **Controlled-release fertilizers improve nutrient-use efficiency by synchronizing nutrient release with crop demand.**
- **Blue foods (fish, seaweed, shellfish) are increasingly recognized for their role in nutrition security and lower environmental footprints.**
- **Heat stress can reduce pollen viability in crops, directly affecting grain formation and fruit yields.**



KhetiValah
Global Agri Magazine

ASIAN PGPR

Asian **PGPR Society** for **Sustainable Agriculture**

A Global Platform for Advancing PGPR, BioAg Inputs, Soil Health, Regenerative Agriculture, Farmer Empowerment, and Sustainable Farming Systems

BioAg Inputs (BioSolutions) for the Second Green Revolution

Advancing Plant - Microbe Science, **PGPR Technologies** & BioAg Inputs to build Climate - Resilient, Farmer - Centric and **Sustainable Food Systems**

9TH ASIAN PGPR INTERNATIONAL CONFERENCE

GOA - 2026

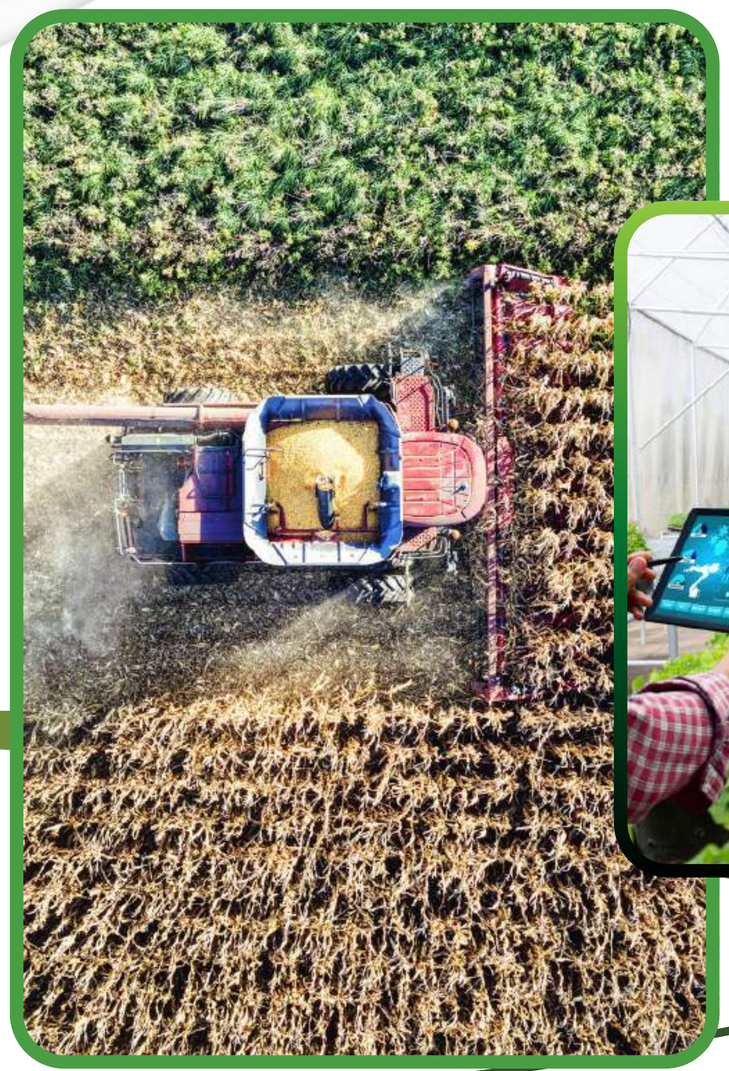
Duration- 23rd - 25th October - 2026

Venue - Hotel Vivanta , Panaji ,Goa-India

SCAN to Register

asianpgpr.eventsdashboard.in

asianpgpr2026@gmail.com













Answer to the Challenges

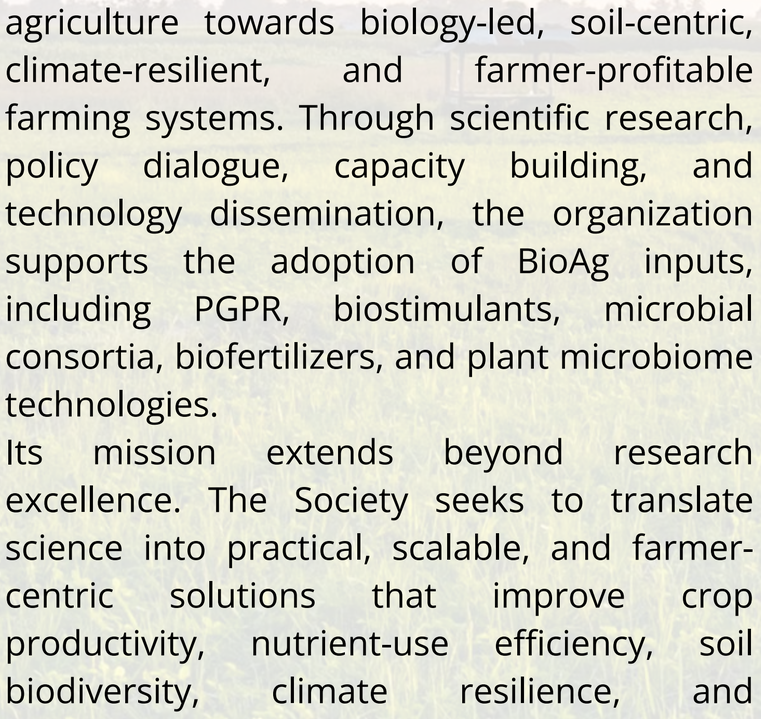
The Asian PGPR Society for Sustainable Agriculture has emerged as one of the world's most influential scientific platforms dedicated to advancing Plant Growth-Promoting Rhizobacteria (PGPR), plant microbiomes, BioAg solutions, and sustainable agricultural development. Established in 2009 and formally registered in both India and the United States, the Society serves as a bridge between scientific innovation and practical agricultural applications, connecting researchers, industry leaders, policymakers, extension professionals, entrepreneurs, and farmers, across the globe.

At a time when agriculture faces challenges related to soil degradation, climate change, declining biodiversity, rising production costs, and food security concerns, the Society continues to advocate for a biology-driven approach that promotes soil health, environmental sustainability, farmer profitability, and resilient food systems.

A Vision beyond the First Green Revolution

The Society strongly promotes what it describes as the "Second Green Revolution" - a transition from chemical-intensive agriculture towards biology-led, soil-centric, climate-resilient, and farmer-profitable farming systems. Through scientific research, policy dialogue, capacity building, and technology dissemination, the organization supports the adoption of BioAg inputs, including PGPR, biostimulants, microbial consortia, biofertilizers, and plant microbiome technologies.

Its mission extends beyond research excellence. The Society seeks to translate science into practical, scalable, and farmer-centric solutions that improve crop productivity, nutrient-use efficiency, soil biodiversity, climate resilience, and agricultural sustainability.







Major Milestones & Global Impact

Since its inception in Hyderabad, India, in 2009, the Asian PGPR Society has successfully established itself as a leading international platform for plant-microbe science and sustainable agriculture. Over the years, it has organized a continuous series of major international conferences across India, China, Philippines, Vietnam, Indonesia, Uzbekistan, Malaysia, and Taiwan.

These events have brought together thousands of scientists, industry leaders, policymakers, students, and agricultural professionals from around the world.

Today, the Society has more than 2,000 life members, representing universities, research institutions, industries, NGOs, government agencies, and farmer organizations from multiple countries.

It has also established expanding national chapters and collaborative networks throughout Asia and beyond.

Besides conferences, the Society has contributed significantly to:

- Advancing global research on PGPR and plant microbiomes
- Promoting BioAg technologies and biological crop inputs
- Strengthening academia-industry partnerships
- Supporting policy discussions on sustainable agriculture
- Capacity building among students, researchers, extension professionals, and entrepreneurs
- Encouraging farmer-centric innovation and technology adoption
- Supporting regenerative and climate-smart agricultural systems.

Farmer Outreach & Knowledge Transfer

A distinctive feature of the Society is its commitment to ensure that scientific innovations reach farming communities. Through workshops, training programs, extension activities, webinars, national conferences, and farmer-focused initiatives, the Society actively promotes practical solutions that improve soil health, crop productivity, and farm profitability.

The organization has also championed large-scale farmer engagement programs, including Maha Kisan Mela initiatives that facilitate direct interaction between scientists, technology providers, policymakers, and farmers.

These platforms help bridge the gap between laboratory research and field-level implementation.

Leadership Driving a Global Mission

The Society was founded under the visionary leadership of Prof. M. S. Reddy, Professor at Auburn University, USA, who is the Founder and Chairman. A globally respected scientist and an advocate for sustainable agriculture, Prof. Reddy has dedicated decades to advancing research on PGPR, biological crop protection, plant-microbe interactions, and BioAg innovations. Under his leadership, the Society has evolved into a globally recognized platform for driving the sustainable agricultural transformation.

The Society's governance framework includes an Executive Council, Advisory Boards, National Chapters, scientific committees, industry representatives, and regional leadership teams that collectively guide strategic initiatives, partnerships, conferences, publications, and outreach activities.







Goa 2026: A Global Gathering for the 2nd Green Revolution

One of the Society's most anticipated upcoming milestones is the **9th Asian PGPR International Conference, scheduled to be held in Goa, India, from 23-25 October 2026** under the theme:

"BioAg Inputs (BioSolutions) for the Second Green Revolution."

The conference is expected to bring together scientists, policymakers, entrepreneurs, industry leaders, extension professionals, startups, students, and farmers from more than 25 countries. Discussions will focus on plant microbiomes, soil health, microbial technologies, biofertilizers, biopesticides, climate-resilient agriculture, regenerative farming systems, commercialization pathways, regulatory frameworks, and the future of biological agricultural inputs.

The event will also feature international speakers, scientific presentations, awards, industry exhibitions, networking opportunities, and collaborative discussions aimed at accelerating the adoption of biology-driven agricultural solutions worldwide.

Shaping the **Future of Sustainable** Agriculture

As agriculture enters a new era, defined by sustainability, climate resilience, environmental stewardship, and farmer well-being, the Asian PGPR Society for Sustainable Agriculture continues to play a pivotal role in connecting science with impact.

Through research, partnerships, policy engagement, farmer outreach, and global collaboration, the Society is helping to build a future where biological solutions become central to agricultural production systems.

Its journey from a regional scientific initiative to a globally respected movement demonstrates the power of collaboration, innovation, and shared commitment toward a healthier planet, prosperous farmers, and sustainable food systems for generations to come.

ABOUT IT ALL

- **Founded:** 2009
- **Founder & Chairman:** Prof. M. S. Reddy
- **Global Membership:** 2,000+ Life Members
- **Focus Areas:** PGPR, Plant Microbiomes, BioAg Inputs, Soil Health, Climate-Resilient Agriculture, Farmer Empowerment
- **Upcoming Flagship Event:** 9th Asian PGPR International Conference, Goa, India (23-25 October 2026)
- **Website:** www.asianpgpr.org



A Message -

Healthy Soil, Healthy Farmers, Healthy Food, and a Healthy Globe.

Agriculture is the foundation of civilization, health, economy, culture, and national prosperity. Farmers are our true Annadatas, working every season under climate uncertainty, water scarcity, pests, diseases, market risks, and rising input costs. My life's mission has been to bring science closer to farmers and promote agriculture that improves productivity, farmer income, soil health, food quality, and environmental safety.

For more than four decades, I have worked as a professor, researcher, trainer, consultant, entrepreneur, and global advocate for sustainable agriculture and biological agri-inputs. My journey in plant pathology, soil microbiology, biological control, PGPR, and plant–microbe interactions has expanded into a broader mission of advancing BioAg inputs, regenerative agriculture, organic and natural farming support systems, climate resilience, water conservation, and farmer empowerment.

In 2009, this vision led to the creation of the Asian PGPR Society for Sustainable Agriculture, which has grown into a global platform connecting scientists, universities, industries, policymakers, students, entrepreneurs, women, youth, and farmers.

The images accompanying this article reflect our mission: science moving from laboratories to living soils, beneficial microbes strengthening roots, and global collaboration supporting farmers. The future of agriculture lies in a biology-led Second Green Revolution—soil-centered, climate-resilient, farmer-profitable, scientifically regulated, and environmentally responsible. We must feed the hungry with healthy food, help farmers make a decent living, create employment, empower women and youth, and support our Annadatas.

I warmly invite scientists, industry leaders, policymakers, entrepreneurs, students, and farmers to join us at the 9th Asian PGPR International Conference, October 23–25, 2026, at Vivanta Hotel, Panaji, Goa, India.

I strongly appreciate Mr. K. Lakshman and KhetiValah for their vision, which aligns with this mission.

Let us join hands for healthy soil, healthy farmers, healthy food, and a healthy globe.













Forests by Algorithm

How AI Is Supercharging the *Miyawaki Method*

宮脇

When a 70-year-old Japanese botanist's vision meets machine learning, the result could be the fastest path to planetary healing we have ever mapped.

By

Tarun Kumar

420M	10×	30×	62%
Hectares of forest lost globally since 1990 (FAO, 2020)	Faster canopy formation in Miyawaki forests vs. conventional planting	Higher biodiversity density compared to monoculture plantations	Of degraded agricultural land could benefit from micro-forest integration (IPCC 2022)

ABOUT THE AUTHOR

Tarun Kumar is a Computer Science and Engineering graduate specialising in Artificial Intelligence and Machine Learning. With a strong foundation in AI-driven systems and a growing passion for applying technology to real-world environmental challenges, Tarun sits at the intersection of cutting-edge computing and sustainable ecological practice.

His research interest lies in exploring how machine learning, remote sensing, and large language models can be harnessed to solve pressing problems in agriculture, reforestation, and climate resilience.

His article "Forests by Algorithm: How AI Is Supercharging the Miyawaki Method" reflects his belief that the next generation of technologists must look beyond screens and toward the soil.

Tarun aspires to contribute to building intelligent, accessible, and community-led agri-tech solutions for India and the Global South.

> Rapid reforestation is **not an** environmental **luxury.** It is **an agricultural imperative.** Farms without tree cover lose topsoil, groundwater, and pollinators.
>
> The **ecological debt** compounds faster than any financial one.

The Urgency We Can No Longer Ignore

A common question in environmental education is: How long does it take nature to grow a dense, self-sustaining forest ? how long does it take nature to grow a dense, self-sustaining forest ? The answer — several centuries — is met with the same silence each time.
That silence is where the crisis lives.

The planet is losing forest cover at a rate the FAO estimates at 10 million hectares per year. Agriculture accounts for roughly 80% of global deforestation (FAO, 2022). Concurrently, land degradation affects 3.2 billion people and costs the global economy an estimated USD 6.3 trillion annually in lost ecosystem services (IPBES, 2018). The numbers are familiar. The urgency, somehow, still does not match them.
In this context, rapid reforestation is not an environmental luxury.
It is an agricultural imperative. Farms without tree cover lose topsoil, groundwater, and pollinators. The ecological debt compounds faster than any financial one.
What we urgently need is a method of forest creation that is dense, species-diverse, fast — and now, scalable at a precision that only technology can provide.

The Science **Behind Miyawaki**

Dr. Akira Miyawaki, a Japanese botanist and plant ecologist, spent decades studying what he called Potential Natural Vegetation (PNV) — the community of native plant species that would naturally dominate a given site if left undisturbed by human activity.
His insight was profound in its simplicity: plant what belongs there, plant it densely, and let it compete.

A classical Miyawaki patch involves four layers — shrubs, sub-trees, trees, and canopy trees — planted at densities of 20,000–30,000 seedlings per hectare, drawn entirely from regionally native species. The absence of alien cultivars means no irrigation dependency, no chemical inputs, and no management beyond the first three years.

The results are well-documented: 10× faster growth, 30× more biodiversity, and forests that are self-sustaining within a decade (Miyawaki & Box, 2006).
Over 3,000 such forests have been created across 15 countries. Yet the method's full promise has been throttled by a set of very human limitations.

THE **Bottleneck**

Where Traditional Miyawaki **Hits Its Ceiling**

To scale the Miyawaki method across diverse agro-climatic zones — from the Deccan Plateau to the Mekong Delta to the Sahel — demands a granularity of ecological knowledge that no team of botanists can reasonably supply by hand.
The bottlenecks are structural, not incidental.



Manual Soil Profiling
Site-specific soil microbiome assessment is labour-intensive, expensive, and rarely comprehensive enough to predict species-soil compatibility at scale.

Species Selection Errors
PNV database gaps in tropical and semi-arid regions mean practitioners default to generic lists, increasing seedling mortality rates by 20–40%.

Agro-climatic Mismatch
A species mix successful in Kerala may fail entirely in Rajasthan. Customisation requires ecological expertise that is unevenly distributed globally.

Monitoring Gaps
Post-planting canopy tracking is largely visual and infrequent, making early intervention in failing patches rare. Failures are discovered late and expensively.

Scaling Costs
High-quality Miyawaki implementation costs USD 15,000–25,000 per hectare in expert-intensive contexts, placing it out of reach for most smallholder farmers.

Knowledge Accessibility
The methodology requires ecology training, which most farming communities have never had access to. The knowledge gap is as significant as the land gap.

THE **AI CONVERGENCE**

Where Artificial **Intelligence Steps In**

To scale the Miyawaki method across diverse agro-climatic zones — from the Deccan Plateau to the Mekong Delta to the Sahel — demands a granularity of ecological knowledge that no team of botanists can reasonably supply by hand.
The bottlenecks are structural, not incidental.

The convergence of remote sensing, machine learning, and large language models with the Miyawaki methodology is not a theoretical exercise. It is already happening in research stations and pilot farms across Asia, Europe, and Africa. Here is how each AI capability addresses a specific ecological bottleneck.

ML for Soil Microbiome Profiling
Machine learning models trained on metagenomic soil data can identify microbial community signatures that predict native species compatibility.
Startups like Trace Genomics are already deploying soil-ML pipelines that reduce site assessment time from weeks to hours.

Remote Sensing & NDVI Mapping
Normalized Difference Vegetation Index (NDVI) data from Sentinel-2 and Landsat satellites enables site suitability scoring at 10-metre resolution.
AI-driven land-use change detection can flag degraded agricultural parcels ideal for Miyawaki patches in real time.

Computer Vision for Canopy Tracking
Drone-mounted computer vision systems, using YOLO-class object detection architectures, can track individual seedling health, chlorophyll stress indices, and canopy closure progression monthly — replacing expensive and infrequent ground surveys

Predictive Survival Modelling
Gradient boosted regression models (XGBoost, LightGBM) trained on historical Miyawaki patch data can predict first -year

"Nature doesn't plant one species in a row. She layers, competes, and cooperates. We are simply learning to read her instructions more precisely."

INSPIRED BY DR. AKIRA MIYAWAKI'S FOUNDATIONAL PNV PHILOSOPHY

seedling survival rates with up to 84% accuracy (Saraogi et al., 2023), enabling pre-intervention species substitution before failures occur.

AI Irrigation Scheduling

IoT soil moisture sensors combined with weather API integration and reinforcement learning agents can optimise the critical 3-year irrigation window, reducing water use by 35–45% while maintaining seedling establishment rates (ICLEI Asia, 2024)

LLM Advisory Tools

Large Language Models integrated with local botanical databases can deliver native species recommendations, planting calendars, and troubleshooting guidance in Hindi, Swahili, Bahasa, and 40+ regional languages — democratising expert knowledge at the farm gate.

"The most important thing AI does in this context is not replace the ecologist — it replaces the excuse that ecological precision is too expensive to scale."

RESEARCH SYNTHESIS, KHETIVALAH EDITORIAL TEAM, 2026

RESEARCH MATRIX

AI-Miyawaki Research Matrix: Methods, Evidence & Impact

COMPARATIVE RESEARCH ANALYSIS — AI INTEGRATION IN MIYAWAKI AFFORESTATION

AI Method	Miyawaki Application	Key Research / Source	Measured Outcome	Geographic Context	Scalability
Soil ML (Metagenomics)	Species-soil compatibility mapping	Trace Genomics, 2023; ICRAF Working Paper	38% reduction in first-year seedling mortality	India (Maharashtra), Kenya	High
NDVI / Sentinel-2	Site suitability & degradation scoring	ESA Copernicus Agriculture Programme, 2024	91% accuracy in identifying degraded parcels suitable for micro-forests	Southeast Asia, Sub-Saharan Africa	High
Computer Vision (YOLO-v8)	Seedling health & canopy closure monitoring	Saraogi et al., IIT Bombay, 2023	Canopy tracking accuracy: 89%; cost savings: USD 3,200/ha vs. manual survey	India (Mumbai, Pune urban patches)	Medium
XGBoost Survival Model	Pre-planting species substitution	Miyawaki Forest Foundation Japan, 2022	84% accuracy in predicting year-1 survival; 27% improvement in patch success rate	Japan, Netherlands	Medium
RL-based Irrigation AI	Critical 3-year irrigation optimisation	ICLEI Asia Urban Resilience Report, 2024	39% water reduction; 94% seedling establishment rate maintained	Singapore, Chennai (India)	Medium
LLM Advisory (GPT-class)	Farmer-facing species & planting guidance	Digital Green / CGIAR Pilot, 2025	43% increase in practitioner confidence; 6 regional languages deployed	India, Ethiopia, Bangladesh	High
Carbon ML (BiomassNet)	Sequestration quantification & MRV	WRI / Verra Verified Carbon Standard, 2024	AI-estimated vs. ground-truth carbon: 94% correlation (R^2=0.94)	Brazil, Indonesia, India	High

Real World **EVIDENCE**

The following examples synthesize findings from published research, pilot initiatives, and emerging AI-assisted ecological restoration projects.

Case Studies: **From Pilots to Proof**





1 INDIA · URBAN & PERI-URBAN AGRICULTURE

IIT Bombay + Municipal Corporations: **AI-Guided Urban Miyawaki Patches (2022–2024)**

A collaboration between **IIT Bombay's Centre for Urban Science and Engineering and several Maharashtra municipal bodies** deployed drone-based computer vision to monitor 34 Miyawaki patches **across Pune and Mumbai.**

Species selection was augmented by an ML model trained on Western Ghats native plant databases.

Average canopy closure was achieved in 26 months versus the conventional 36-month benchmark.

Carbon sequestration measured at 11.4 tCO_2/ha/year — significantly above standard plantation baselines of 3–5 tCO_2/ha/year.

Observations/Results/Logs

- 26-month canopy closure
- 11.4 tCO_2/ha/year
- 89% seedling survival
- 34 patches monitored

2 NETHERLANDS · AGROFORESTRY INTEGRATION

Wageningen University & IVN: **Predictive Modelling for Farmland Micro-Forests (2023–2025)**

Wageningen University's Environmental Sciences Group deployed XGBoost-based survival models across 18 Miyawaki sites on Dutch agricultural margins.

The AI pre-selected species substitutions for 23% of planned plantings where model confidence in survival fell below 70%.

Result: patch failure rates dropped from 31% (control group) to 9% (AI-guided group) over two growing seasons.

Cost per successful hectare fell by EUR 4,100, attributed to reduced replanting cycles.

Observations/Results/Logs

- 31% → 9% failure rate
- €4,100/ha cost saving
- 18 sites monitored

3 **SOUTHEAST ASIA · SMALLHOLDER ENGAGEMENT**

Digital Green + CGIAR: **LLM-Powered Native Species Advisory in Bangladesh & India (2025)**

A pilot by Digital Green in collaboration with CGIAR deployed a Bengali and Hindi-language LLM advisory tool integrated with regional botanical databases and soil atlas data.

1,240 smallholder farmers received AI-generated Miyawaki species lists, planting calendars, and irrigation schedules via a feature-phone WhatsApp interface. Practitioner confidence in species selection increased by 43%.

Early canopy establishment data from 6-month post-planting surveys shows 78% patch viability — above the 65% regional average for non-AI implementations.

Observations/Results/Logs

- 1,240 farmers reached
- 43% confidence increase
- 78% patch viability
- 2 languages deployed

Benefits for **Adjacent Farmland**

The case for AI-Miyawaki integration extends beyond the forest patch itself. Research consistently demonstrates that dense native micro-forests adjacent to cropland generate cascading agricultural benefits that compound over time.

Microclimate regulation is the most immediate: surface temperatures within 50 metres of a mature Miyawaki patch are 2–4°C lower than open field equivalents (CIFOR-ICRAF, 2023). For heat-sensitive crops in a warming world, this margin is agronomically significant.

Pollinator abundance increases of 60–80% have been recorded within 200 metres of native forest patches (Potts et al., 2016), directly translating to yield improvements in horticultural crops. Groundwater recharge rates in degraded soils adjacent to Miyawaki sites improved by 34% within five years in Maharashtra case studies (WWF India, 2022).

Agroforestry integration is the natural endpoint of this convergence.

When AI tools can identify the precise native species that maximise both forest density and agricultural border utility — timber, fodder, medicinal, nitrogen-fixing — the Miyawaki method ceases to be purely ecological and becomes an agricultural production asset.





Challenges & **Ethical Dimensions**

It would be intellectually dishonest to present this convergence without accounting for its genuine limitations. The research community must grapple with several unresolved tensions.

Indigenous species databases remain critically incomplete for tropical Africa and South Asia. ML models trained on temperate-zone botanical data produce biased recommendations when applied to underrepresented geographies — a form of algorithmic monoculture that could ironically replicate the very problem Miyawaki sought to solve.

The digital divide is structural. Satellite-based monitoring and LLM advisory tools assume connectivity and device access that 2.9 billion people currently lack (ITU, 2023).

Deployment strategies that centre urban and peri-urban pilots risk leaving the most ecologically vulnerable farming communities behind.

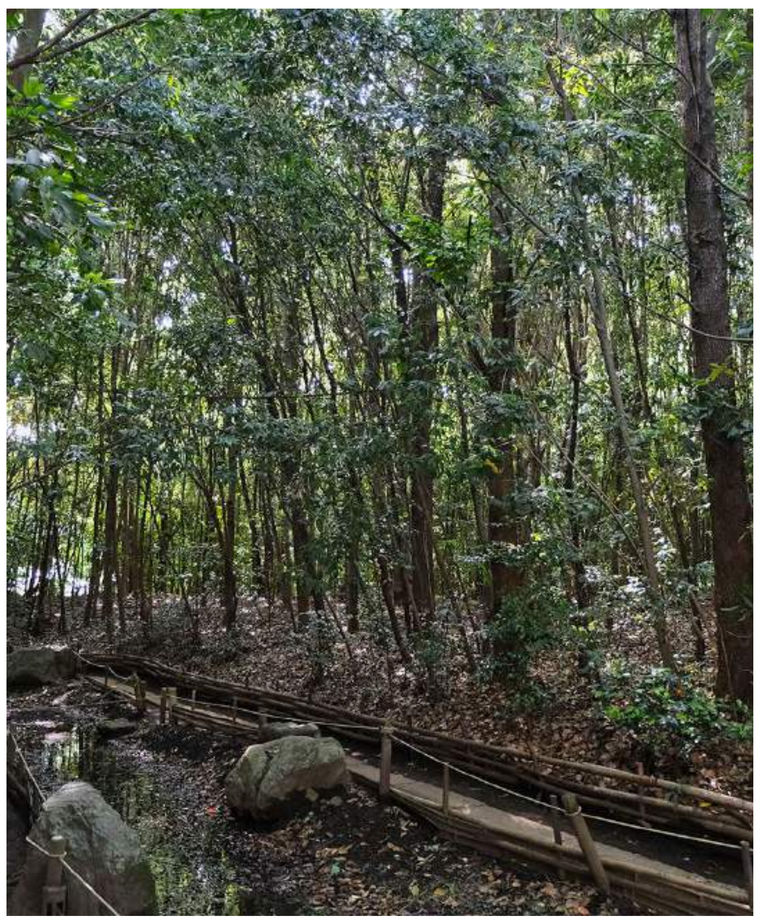
Community-led validation is non-negotiable. AI species recommendations that override indigenous ecological knowledge without participatory verification risk eroding local trust and introducing ecologically inappropriate selections that no model has yet been trained to detect.

The **Road Ahead**

A Researcher's **Vision for the Next Decade**

The field is at an inflection point. The technical tools exist. The ecological method is proven.





The missing ingredient is coordinated, interdisciplinary institutional will — and **a policy environment that incentivises their integration.**

- Governments must invest in open-access, geo-tagged native species databases as public infrastructure — comparable to how road mapping data was democratised. The FAO and GBIF have frameworks; they require sustained funding and mandatory national contributions.

- Agricultural universities must integrate AI-ecology interdisciplinary curricula. The next generation of extension officers needs to be conversant in both soil science and model interpretation — the two can no longer be taught in separate buildings.

- Carbon credit markets and ecosystem service payment schemes must recognise AI-verified Miyawaki forests with the same rigour as industrial carbon projects. High-integrity MRV (Measurement, Reporting and Verification) using BiomassNet-class ML tools should become standard, enabling smallholder farmers to access global climate finance directly.

- Offline-capable, vernacular LLM advisory tools must be a research priority — not an afterthought. The farmer with a feature phone in Vidarbha deserves the same quality of native species guidance as an urban ecologist with a satellite subscription in Singapore.

- South-South research partnerships between institutions in India, Brazil, Nigeria, and Indonesia — countries that collectively hold the majority of the world's remaining biodiversity — should drive AI-Miyawaki protocols that are built for tropical realities from the ground up, not adapted from temperate-zone models as an afterthought.

The Forests
WE Choose to Build

Every century, humanity discovers that the solution to one of its greatest problems was living in the soil beneath it. Dr. Miyawaki found one such solution in the logic of native vegetation. Artificial intelligence is now giving us the instruments to read that logic at planetary scale, with precision that no previous generation of researchers could imagine.

The question is not whether AI can help us grow forests faster.

It demonstrably can. The question is whether we choose to deploy it equitably — for the smallholder in Nagaland and the pastoralist in Mali, not only for the corporate agroforestry project with satellite access and venture capital. That choice is not a technical one.

It is a moral one. And it is ours to make — now, before another 10 million hectares of forest becomes a statistic.

AGRI FACTS

Agricultural diversification into high-value horticulture, medicinal plants, and niche crops is increasingly shaping rural income systems.

Circular agriculture models promote resource reuse, nutrient recycling, and reduced waste, improving long-term farm sustainability.





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KhetiValah's

KhetiSwags

Farm. Fashion. Future.

Wear the Soil. Live the Roots

Launching web & mobile application Feb 2026

Inviting state wise partners

KhetiSwags
Farm. Fashion. Future.

Our vision

Celebrating India's rural identity through fashion
Empowering farmers
Connecting rural and urban hearts

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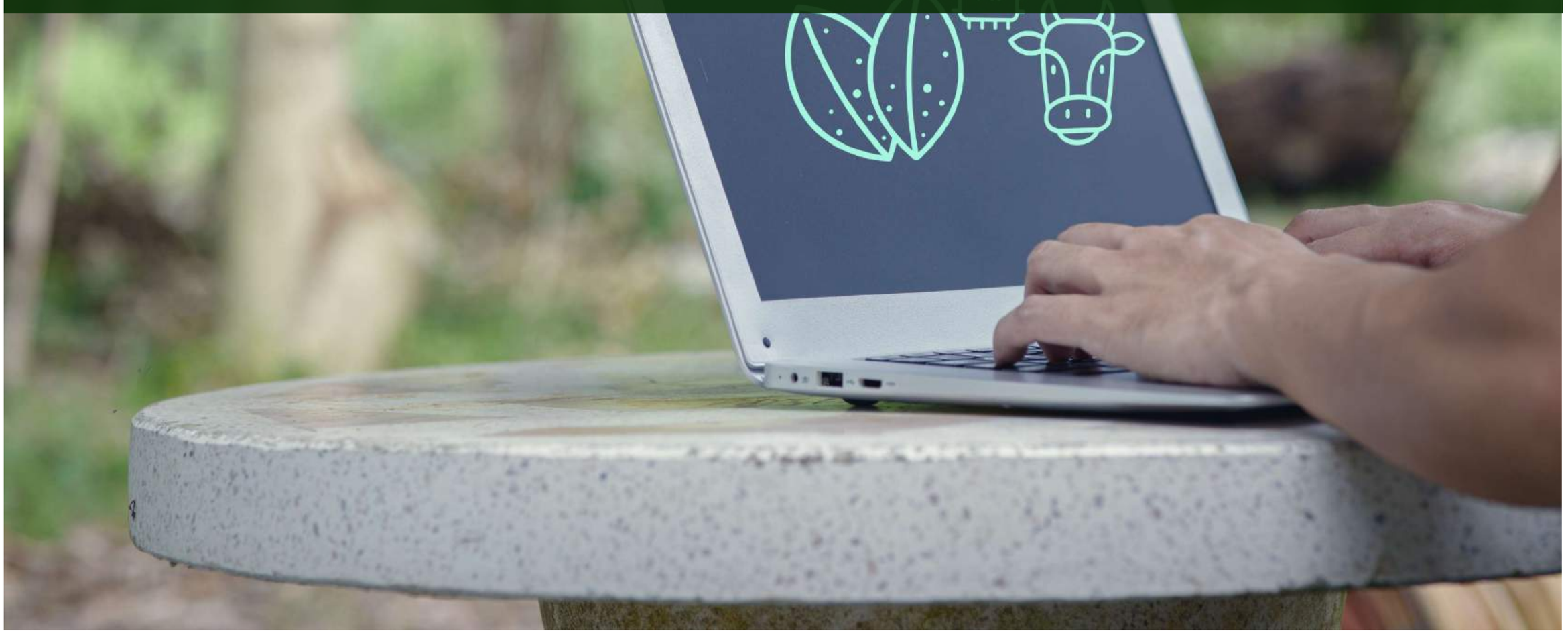
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GLOBAL AGRI DEVELOPMENTS

June 2026

AI Agents Enter Farm Management Systems



Field Focus

Artificial Intelligence is rapidly moving beyond data analysis and advisory services into a new phase of agricultural decision-making.

Across global agriculture, AI-powered systems are increasingly supporting crop planning, pest detection, irrigation scheduling, nutrient management, and farm-level risk assessment.

Recent advances in machine learning, remote sensing, and digital agriculture platforms are enabling farms to process weather, soil, satellite, and market data in real time. Rather than simply providing information, next-generation AI tools are helping farmers make faster and more informed management decisions.

Industry estimates suggest that the global AI in agriculture market, valued at around US$2 billion in 2024, could exceed US$8 billion by 2030 as adoption expands across developed and emerging agricultural economies. Investments are increasingly focused on precision farming Crop diagnostics, autonomous monitoring systems, and digital farm management solutions.

Research organizations, agri-tech companies, and international institutions are also exploring how AI can improve productivity while strengthening climate resilience and resource-use efficiency. New applications are helping farmers optimize inputs, respond to weather variability, and reduce production risks through data-driven insights.

While adoption continues to grow, experts emphasize that AI should complement—not replace—farmer knowledge and agronomic expertise. As digital technologies become more accessible, AI-powered farm management is expected to play an increasingly important role in building efficient, resilient, and sustainable food systems.

Source

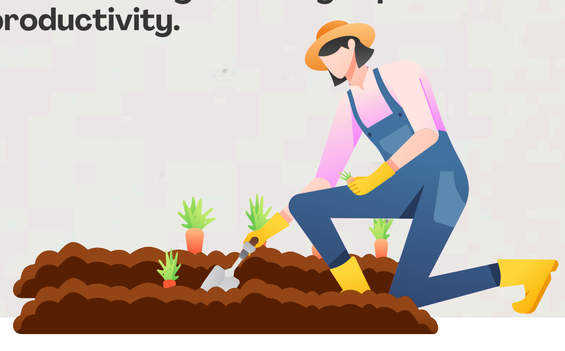
FAO, CGIAR, World Bank, International Data Corporation (IDC), Global AgriTech Market Reports.

AGRI FACTS

Nearly one-third of the world's soils are moderately to highly degraded, affecting productivity, nutrient-use efficiency, and climate resilience.

Rice cultivation contributes nearly 10% of global agricultural methane emissions, driving innovations in water-saving irrigation and low-emission farming.

Women contribute substantially to agricultural labor globally, yet studies show that equal access to land, finance, and inputs could significantly improve farm productivity.



KhetiValah
Global Agri Magazine

GLOBAL AGRI DEVELOPMENTS

Gene Editing Accelerates Climate-Resilient Crop Development



Field Focus

Gene-editing technologies are rapidly emerging as an important tool for developing crops that can better withstand climate-related challenges. Researchers worldwide are using advanced techniques such as CRISPR to improve drought tolerance, disease resistance, heat resilience, and nutrient-use efficiency in major food crops.

Unlike conventional genetic modification, gene editing enables scientists to make precise changes within a plant's existing genetic makeup. Several countries have introduced regulatory pathways that support research and commercialization of gene-edited crops, creating new opportunities for agricultural innovation.

Research organizations and breeding programs are increasingly focusing on crops that can perform under changing climatic conditions while maintaining productivity.

Efforts are underway to develop improved varieties of rice, wheat, maize, millet, and legumes that can help farmers adapt to rising temperatures and unpredictable rainfall patterns.

Supporters view gene editing as a promising approach to strengthen food security and accelerate crop improvement.

However, discussions continue regarding regulation, consumer acceptance, accessibility, and equitable deployment of these technologies.

As climate pressures intensify, gene-editing tools are expected to play an increasingly important role in building resilient agricultural systems and supporting future food production.

Source

FAO, CGIAR, ICRISAT, International Service for the Acquisition of Agri-biotech Applications (ISAAA)

AGRI FACTS

- **Climate-resilient agriculture increasingly integrates traditional knowledge with modern science for adaptive farming systems.**
- **Studies show that diversified cropping systems often improve long-term resilience against pests, market shocks, and climate variability.**
- **Nearly one-third of fish stocks are overexploited globally, increasing pressure on sustainable aquaculture systems.**



KhetiValah
Global Agri Magazine

GLOBAL AGRI DEVELOPMENTS

Bioeconomy Opens New Opportunities for Agriculture



Field Focus

The global bioeconomy is creating new opportunities for farmers, agribusinesses, and rural communities by expanding the use of biological resources in industrial production.

Agricultural crops, residues, medicinal plants, and biomass are increasingly being utilized to produce bio-based materials, renewable energy, specialty chemicals, pharmaceuticals, and sustainable consumer products.

Governments and research institutions are investing in bioeconomy strategies that aim to reduce dependence on fossil-based resources while creating additional income streams for agricultural producers.

The sector is also supporting innovation in circular agriculture, waste utilization, and value-added processing.

Medicinal and aromatic plants, biofertilizers, biopesticides, and plant-based products are gaining attention as industries seek sustainable alternatives.

Many countries are strengthening policies and partnerships that encourage bio-based enterprises and rural entrepreneurship.

Experts believe the bioeconomy can contribute to economic growth, environmental sustainability, and job creation, particularly in rural regions. However, success will depend on technology access, market development, and sustainable resource management.

As global demand for renewable and environmentally responsible products increases, agriculture is expected to play a central role in the expanding bioeconomy landscape.

Source

OECD, FAO, European Commission Bioeconomy Strategy, World Bioeconomy Forum.

AGRI FACTS

The "One Health" approach increasingly connects soil, plant, animal, and human health, influencing modern agricultural policies.

Salinity now affects over 20% of irrigated land globally, threatening productivity in major food-producing regions.

Genome editing tools such as CRISPR are being explored to develop crops with improved climate resilience and disease resistance.



GLOBAL AGRI DEVELOPMENTS

Water Security Becomes a Strategic Priority for Agriculture



Field Focus

Water security is emerging as one of the most critical challenges facing global agriculture.

With rising temperatures, changing rainfall patterns, groundwater depletion, and increasing competition for water resources, governments and agricultural institutions are placing greater emphasis on water-efficient farming systems.Agriculture accounts for nearly 70% of global freshwater withdrawals, making improved water management essential for long-term food security.

Across many regions, investments are increasing in precision irrigation, micro-irrigation systems, water harvesting structures, soil moisture monitoring technologies, and climate-smart water management practices.

Several countries are expanding programs that encourage farmers to adopt drip irrigation, sprinkler systems, and digital water advisory services to improve water-use efficiency while maintaining productivity.

Advances in remote sensing and satellite-based monitoring are also helping producers make more informed irrigation decisions.

Research organizations are working to develop crop varieties that require less water and can better withstand drought conditions. At the same time, policymakers are promoting integrated approaches that combine technology, conservation practices, and community-based water management.

Experts warn that future agricultural growth will depend not only on land availability but also on the ability to manage water resources sustainably. As climate variability continues to influence farming systems, water security is increasingly becoming a strategic priority for governments, researchers, and agricultural stakeholders worldwide.

Source

FAO, World Bank, International Water Management Institute (IWMI), United Nations Water Reports.

AGRI FACTS

Climate-induced pollinator decline is becoming a hidden risk for fruit, vegetable, and oilseed productivity worldwide.

Precision livestock farming uses wearable sensors and AI to monitor animal health, feeding behavior, and disease risks in real time.

Agricultural insurance powered by satellite data and weather indices is expanding protection for smallholder farmers against climate shocks.



GLOBAL AGRI DEVELOPMENTS

Agricultural Carbon Markets Continue to Evolve



Field Focus

Agricultural carbon markets are gaining attention as governments, businesses, and investors seek practical solutions to address climate change while supporting sustainable farming.

These markets provide opportunities for farmers to generate additional income by adopting practices that reduce greenhouse gas emissions or increase carbon storage in soils and vegetation.

Regenerative agriculture, cover cropping, reduced tillage, agroforestry, and improved grazing management are among the practices being explored for carbon credit generation. Several pilot projects across North America, Europe, Asia, and Africa are assessing how farmers can participate in carbon programs while maintaining productivity and profitability.

Private companies and climate-focused investors are increasingly supporting initiatives that measure and verify carbon sequestration on agricultural land.

Advances in digital monitoring, remote sensing, and data analytics are helping to improve transparency and accountability within carbon projects.

Despite growing interest, experts note that challenges remain regarding measurement standards, verification costs, market access, and long-term financial viability for smallholder farmers.

Discussions continue on how to make carbon markets more inclusive and accessible.

As climate policies evolve, agricultural carbon markets are expected to become an increasingly important component of sustainable agriculture and climate-resilient rural development.

Source

FAO, World Bank, Verra, Gold Standard, CGIAR.

Agri Facts

Black Soldier Fly larvae are increasingly used in feed systems as a sustainable protein source for poultry and aquaculture.

Urban agriculture contributes not only to food production but also to heat reduction, biodiversity, and urban resilience.

In many countries, farmer producer organizations (FPOs) help smallholders improve bargaining power and market access.



GLOBAL AGRI DEVELOPMENTS

Seed Innovation Accelerates Climate Adaptation Efforts



Field Focus

Seed innovation is playing a critical role in helping agriculture respond to climate change, resource constraints, and evolving food security challenges.

Researchers worldwide are accelerating efforts to develop crop varieties that can withstand drought, heat stress, emerging pests, and changing weather conditions.

International agricultural research centers, national breeding programs, and private-sector companies are investing heavily in advanced breeding technologies and genetic improvement programs.

Improved varieties of cereals, pulses, oilseeds, and horticultural crops are being developed to enhance resilience while maintaining productivity and nutritional quality.

Climate-resilient seeds are becoming increasingly important in regions facing erratic rainfall, prolonged dry spells, and rising temperatures.

Farmers are seeking varieties that can perform reliably under uncertain growing conditions while reducing production risks.

Alongside breeding advancements, seed systems are also evolving to improve access, quality assurance, and distribution. Strengthening local seed networks remains a priority for many developing economies.

As climate pressures continue to grow, innovation in seed development is expected to remain one of the most effective tools for strengthening agricultural resilience and supporting future food production.

Source

CGIAR, ICRISAT, CIMMYT, IRRI, FAO.

AGRI FACTS

Global demand for biological crop inputs such as biofertilizers and biostimulants is rapidly increasing in sustainable farming systems.

Women farmers often invest a larger share of farm income into family nutrition, education, and household well-being.

Satellite-based remote sensing can now estimate crop yield, soil moisture, and drought stress at field level.



GLOBAL AGRI DEVELOPMENTS

Women Continue to Drive Agricultural Transformation



Field Focus

Women are playing an increasingly important role in shaping the future of agriculture through leadership, entrepreneurship, research, education, and farm management.

Across many regions, women are contributing significantly to food production, value addition, innovation, and rural development initiatives.

Governments, development agencies, and agricultural organizations are expanding programs that support women farmers, agripreneurs, researchers, and community leaders.

Investments in training, digital literacy, financial inclusion, and market access are helping create new opportunities for women across agricultural value chains.

Women-led enterprises are also contributing to sustainable agriculture, food processing, agritech innovation, and climate-resilient farming practices.

Their growing participation is strengthening local economies and improving household food security.

Despite progress, challenges related to land ownership, access to finance, technology adoption, and decision-making opportunities remain in many parts of the world.

Addressing these barriers continues to be a priority for inclusive agricultural development.

As agriculture evolves, empowering women is increasingly recognized as essential for building resilient food systems and achieving long-term sustainability goals.

Source

FAO, UN Women, IFAD, World Bank.

Agri Facts

I-driven forecasting models are helping reduce food supply chain inefficiencies and post-harvest losses.

Soil organic matter acts like a natural sponge, significantly improving water retention during drought conditions.





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